

Contents

Development and implementation of an Activity-Based Costing (ABC) model in private Higher Education Institutions (HEI) Sorinel Căpușneanu, Bogdan Ionuț-Nicolae Stolojescu, Maria Măgurean	5
Capital, coal, and change: modelling India's energy substitutability with a translog production framework Tanzeem Hasnat, Umer Jeelanie Banday	31
Unemployment in Ghana: analyzing the asymmetric effects of export processing zones in dealing with the problem Alexander Quaicoe	53
A PRISMA-based systematic literature review on the mismatches between the Romanian higher education system and the labor market needs Daria Elisa Vuc	71
Transition effect from deposit and policy interest rates to credit interest rates in Türkiye: detecting asymmetry Kadir Karagöz, Suzan Ergün	87
The effect of fiscal decentralization and monetary policy on economic resilience in Indonesia: a panel data Syahrimi, Anna Yulianita, Ariodillah Hidayat	101
The implications of demographic changes on economic performance – a comparative analysis of RO vs EU 27 Ioana-Victoria Bădicioiu, Ionuț Jianu	123
Pensions under pressure: economic and demographic drivers of Romania's public retirement system Mădălina-Gabriela Anghel, Elena Ioniță	133
Productivity shocks, exchange rate and migration: a new open economy macroeconomics approach Wataru Johdo	149

The role of total assets in financial performance in North America: evaluating econometrics and machine learning approaches Nargis Sultana, Fahad Zeya, K.M. Zahidul Islam, Antonio J. Rodriguez.....	161
Energy vulnerabilities among Europeans in the Ukrainian war context Andreea-Monica Munteanu, Maria-Bianca Bolboacă	177
Empirical analysis of the relationship between FDI and economic growth in Morocco Anas Mossadak	191
Climate-driven monetary policy: a new Keynesian DSGE analysis for Ghana Komlan Olakossan Gbegnon, Mikémina Pilo, Kounagbè Odilon Boris Lokonon	203
Monitoring the implementation of the Sustainable Development Goals in Romania Maria-Daniela Tudorache, Ionuț Jianu.....	217
Insurance and sustainable structural transformation: Does renewable energy matter? Geneviève Christel Kamdoun Mapa, Yunchawou, Gouwouo Emmanuel Nso Fils	239
Natural resources and the price of freedom. A concise analysis of Ukraine's natural resources and who wins more from their direct exploitation? Raluca Iuliana Georgescu, Dumitru Alexandru Bodislav	257
Assessing the macroeconomic impact of fiscal deficit in India: evidence from ARDL approach Prakhar Pandey, Rajnish Pande.....	271
Non-linearity and market behavior in the Romanian capital market: a rescaled range analysis of BET index Genia-Iulia Tabără	287
From adversity to triumph: Türkiye's economic resilience and adaptation strategies amidst disasters Erick Okoth	301
Trust at first reply and how AI-language systems alter human trust calibration Dumitru Alexandru Bodislav, Raluca Iuliana Georgescu, Ionuț Valeriu Andrei	323
The economic value of data. From data to decisions in the public sector Florentina Pană-Micu.....	337

Note: The authors are responsible for the content of their articles and for obtaining necessary permissions.

Mircea Dinu

Tel.: (+4) 031.432.96.02

Fax: (+4) 021.210.73.10

E-mail: comenzi@edecon.ro

Data base indexation:

EconLit

<http://www.aeaweb.org>

Research Papers in Economics (RePEc)

<http://www.ideas.repec.org>

<http://econpapers.repec.org>

Directory of Open Access Journals (DOAJ)

<http://www.doaj.org>

EBSCO Publishing

<http://www.ebscohost.com>

**International Consortium for the Advancement
of Academic Publication (ICAAP)**

<http://www.icaap.org>

Cabell's Directories

<http://www.cabells.com>

CNCIS B+

www.economieteoreticasiaplicata.ro; www.ectap.ro

Reception of texts: economia.ta@edeconomica.com

ISSN 1841-8678 (Print)

ISSN 1844-0029 (Online)

Development and implementation of an Activity-Based Costing (ABC) model in private Higher Education Institutions (HEI)

Sorinel CĂPUȘNEANU

“Titu Maiorescu” University of Bucharest, Romania
sorinel.capusneanu@prof.utm.ro

Bogdan Ionuț-Nicolae STOLOJESCU

“1 Decembrie 1918” University of Alba Iulia, Romania
bogdan.stolojescu@uab.ro

Maria MĂGUREAN

“1 Decembrie 1918” University of Alba Iulia, Romania
betea.maria.sdc2024@uab.ro

Abstract. *The current context requires institutions and organizations to manage costs using advanced cost calculation models effectively. This study aims to test and implement an ABC model for determining the academic costs of teachers and students in a private higher education institution organized into three faculties. Through this created model, three research hypotheses were tested. The results indicated that the proposed and tested model could be implemented within private higher education institutions, as evidenced by the implementation stages covered by the researched case study. The general conclusions highlight the possibility of successful implementation and application of the ABC model in other higher education institutions as well, the model being flexible and perfectly adaptable to the customers' requirements, or the products offered.*

Keywords: Activity-Based Costing, higher education institutions, cost drivers, activities, performance.

JEL Classification: M41, I23.

1. Introduction

Regardless of the application sector, public or private, the need for cost rationalization becomes the inevitable reason for applying practical accounting and control systems designed to satisfy all stakeholder requirements. One such important management tool is Activity-Based Costing (ABC) which can help higher education institutions to effectively manage costs and modernize their management (Gosselin and Journeault, 2022), but also to evaluate the life cycle of products (Jourdain et al., 2021). This requires higher education institutions to have reliable information (Mazbayeva et al., 2022) on the cost of each course of each student, each teaching staff, research project, or any external services provided to local or international clients or communities but also knowing the ratio between income and costs for each element to produce results (Lima, 2011). Traditional costing systems have been unable to provide university managers with accurate data on costs, control, and performance evaluation for decision-making (Bourn, 1994a; Hentschek, 2021).

Adopting a more complex management model that involves planning, monitoring, and the correct and precise allocation of resources implies the existence of a management accounting system (Briciu and Căpușneanu, 2011) that can only be achieved with additional human and material efforts. The English model in higher education is an example of recommending a model based on an approximation of management-based activity, characterized by stages that include the description of costs with resources, activities, cost drivers, and results (Cropper and Cook, 2000; Brusca et al., 2019). Concerns about identifying an effective cost accounting system in university administration have increased through management accounting (Jarrar et al., 2007; Ostadi and Zare, 2022). The phenomenon of the economic recession triggered in 2008 affected the university environment. Although public colleges and universities have been able to stabilize or increase their operating income per Full-Time Equivalency (FTE) student since 2011, many community colleges have continued to experience losses in this department compared to previous years (Khalid and Ismail, 2019). Higher education institutions must find viable solutions to keep costs and prices affordable for students. Starting from those mentioned above, the research aimed at identifying an activity-based cost model that would meet the needs of higher education institutions to manage their academic costs effectively, thus covering a gap in the literature. Most of the studies carried out are based on determining the costs of academic programs or departmental costs from public or private universities (Del Río Sánchez et al., 2019; Stouthuysen et al., 2010; Garcia Valderrama and Del Rio Sanchez, 2006; Kissa et al. 2010), while the present research aims to determine the academic costs related to teaching staff and students.

The research aims to develop and test an activity-based costing (ABC) model that can be used within private higher education institutions to determine academic costs with teaching staff and students. The research includes the following objectives: i) Development of an activity-based costing model to measure the academic costs of teaching staff and students in a private higher education institution; ii) Demonstrating the feasibility of using the model in a private higher education institution; iii) Identifying the advantages and barriers in successfully implementing the ABC concept in a private higher education institution. This study mainly consists of six parts. In the second part, the limits of traditional computing systems, the evolution of ABC within higher education institutions, and the advantages and

limits of ABC within higher education institutions are mentioned in the specialized literature. The third part presents the research methodology and the ABC test model for implementation in higher education institutions. The fourth part presents the results of applying the ABC principles through specific stages at a higher education institution. The fifth part is dedicated to discussing and analyzing the obtained results. The sixth part presents the general conclusions, highlighting the contribution to specialized literature and future research directions.

2. Literature review

2.1. Limits of Traditional Cost Systems

The impossibility of adopting clear decisions on the part of the managers of an institution or organization, as well as the difficulties regarding the control of general expenses, are attributed to the use of inefficient cost calculation systems (O'Guin, 1991; Islam et al., 2019), which in today we call them traditional computing systems. They were not focused on providing world-class cost information such as: focusing on customers, revealing sources of profit, identifying opportunities, and encouraging product quality improvement (Turney, 1991; Buttross and Schmelzle, 2020). These accounting systems collect all information about the resources used in an organization in the form of inputs (Anthony and Young, 1999). Over the years, management accepted this information even though it was unreliable (Hicks, 1992).

Traditional accounting is at best useless and at worst dysfunctional and misleading (Cokins, 1996; Mahesha, 2022), as it has not yet adapted to changes in the business environment through the shift from direct labor to automated labor (Cokins et al., 1993; Cokins, 2002). According to a traditional accounting system, indirect cost accounting was done in two stages (Horngren et al., 1997; König et al., 2020), and direct costs were tracked accurately while indirect costs were incorrectly allocated to products using allocation bases arbitrary, the decisions made by management being erroneous (Cooper and Kaplan, 1988; König et al., 2020). In many organizations, financial accounting information remains the primary source of management information (Garrison and Noreen, 2000). One of the significant problems that the traditional costing system faced in the manufacturing environment was the allocation of overheads (Pierce and Brown, 2006). Traditional costing systems only use a cost driver based on production volumes, such as labor hours or the number of products made (Ismail, 2010).

Traditional cost systems tend to overestimate or underestimate the costs of products and services (Chan and Lee, 2003; Mioč et al., 2014; Cheng et al., 2018), not using specific cost drivers in the distribution of indirect costs, not having the possibility to focus on processes and activities, but also measuring performance and customer satisfaction, product reliability, flexibility, and productivity. In other words, the information provided by traditional cost systems is not valuable for planning, management, and control. Based on what was presented, the following research hypothesis emerges:

H₁: Traditional costing systems have a negative impact on the reliability of cost information.

2.2. The evolution of ABC within Higher Education Institutions

Within higher education institutions, there have been some methods of allocating indirect costs to chosen cost drivers like ABC, as evidenced by the University of Bradford. Thus, some costs, such as those of technicians, were allocated according to the surface of the laboratories, and administrative costs were allocated according to the number of students, etc. (Bottomley, 1972; Devlin et al., 2022). This allocation was aimed at creating budgets and plans based on study programs, not on expenditure categories (direct and indirect), which is considered a partial ABC approach. The decision-making relevance is influenced by the nature of the costs (variable and fixed), and the first classification of expenses appears in primary activities (university teaching, postgraduate teaching, and research) and secondary activities (library and information services) (Sims, 1973). The purpose of this classification was to explain the allocation of resources between research and teaching. Determining the balance between teaching and research is a strategic "product" issue typical of the ABC approach. The academic justification for including research costs in teaching costs (Bottomley, 1976; Devlin et al., 2022) became unsustainable when their funding was made separate in the UK from the 1990s, and separate cost justification was also called for. As a result, independent research expenditures increased research excellence but did not increase teaching excellence (Jenkins and Gibbs, 1995; Rezapour et al., 2021). Similar cost allocations were made through a system implemented at Ohio State University, where the cost drivers were more refined. However, the correlation of allocations with fairness and ability to pay could have been better, failing to achieve accurate costing (Young and Geason, 1982).

Some subsequent studies described the detailed costs of the operations of specific university libraries and helped identify the costs of certain activities, which later led to specific process changes and the emergence of activity-based cost management (Weaver-Meyers et al., 1985; Ninerola et al., 2021). The need to determine the unit costs of the courses is the subject of a study based on measuring the efficiency of the Staff-Student Ratio (SSR). The study's results indicated that operating costs differ significantly between full-time and part-time courses, but this is not recognized in budgets or funding (Jones, 1986). With all the allocation refinements approaching the ABC approach, the average costs used were used more for making comparisons at the total cost level than at the unit cost level. The method of allocating costs was maintained even later. However, proposals for additional guidelines for colleagues appear, starting from comparisons between them at the level of costs of specific activities and programs (Birch, 1988).

When allocating the costs related to the research, only the contact hours of the staff and FTE and not the number of courses were selected and used as cost drivers as they do not have a direct effect on the costs of the educational institution (Port and Burke, 1989). From a researcher's perspective, the existence of a course involves the organization of courses and their management, examination processes, examination fees of external examiners, and publication of teaching materials (course materials, books). The first attestation of the application of the ABC methodology in higher education is attributed to a study carried out at the University of Technology Sydney, which involved determining the relative costs of teaching part-time versus full-time students (Doyle, 1991; Hansen et al., 2021). The study's

findings revealed that the cost of educating a part-time student was high compared to FTEs because many of the activities identified referred to the number of students and not the number of FTEs. Given the decentralized nature of universities, the need for acceptance by the cultural milieu, academic departments, and the resource requirements necessary to implement ABC, he envisions the realization of the strategy whose success will depend on the skillful use of power as an objective analysis (Hardy, 1991; Bres et al. al, 2018).

Increasing price pressures with rising academic and administrative costs have led to increased interest in choosing appropriate costing methods and using reliable information in academic decision-making. Compared to traditional costing methods that allocate indirect costs using simple and arbitrary cost drivers (number of students, laboratory area etc.), ABC proposes a refinement of the activities and costs that can be allocated to the final product using specific cost drivers. This has been demonstrated in US universities where the refinement of the process of allocation of student admission costs has contributed to the creation of a more accurate image of it, to the creation of information that allows the examination of possibilities for improving efficiency within the various departments of a higher education institution (Turk, 1992). An activity-based costing system to be developed must be simple to understand and implement, and it is based on some concepts of rational allocation of overheads according to specific cost drivers such as students, staff, or venue space courses (Scapens et al., 1994; Luther and Robson, 2001). In this sense, the resource centers have better control over the business (activities) carried out, being stimulated to generate new revenues. Other studies by specialists reduced the number of cost drivers to three (students, staff, and course facilities), indicating that simple cost allocation systems met their needs, while the complexity of ABC allocation was unnecessary (Berry, 1994; Bourn, 1994b). A non-ABC system was described at Leeds Metropolitan University, where the costing system appeared to be working, but problems were detected in identifying and controlling unallocated overhead (Burnett et al., 1994a). By estimating the time allocated to each activity by the staff of a university, the problem of distributing the major operating cost of the academic teaching staff was solved, and costs such as those related to library services or computerization (computers) were allocated directly academic activities (undergraduate studies) (Groves et al., 1994). Although the implementation of ABC was supported, the results obtained proved that ABC is not a high priority for a university wishing to apply the cost allocation methodology.

There are also proponents of ABC implementation who have demonstrated the fundamental changes this allocation model brings using FTE staff or FTE students, helping to identify cross-subsidies in different areas of university courses (Carr, 1994; Barr and McClellan, 2018). By attaching the cost of an activity there is an increase in user awareness of the price and value of that activity, changing user behavior and better design of university courses and resources used and ultimately minimizing these activity-related costs (Carr, 1994; Barr and McClellan, 2018; Du, 2021). The terminology used was apparent, using terms such as "allocation" in identifying and separating costs and "re-allocation" or apportionment in reallocating costs based on cost drivers, excluding projected costs.

The cost allocation process for admissions and library services continued to determine the cost per enrolled student within US schools (Acton and Cotton, 1997). Although a better

allocation of service costs to schools was achieved (lowly promoted popular courses subsidized highly promoted unpopular courses), the information obtained could have contributed to effective cost management or reporting of course or student diversity. Available data on higher education revenues and expenditures make it difficult to establish direct relationships between cost drivers and price growth (NCCHE, 1998), which calls for improved transparency and understanding of the costs and price structure. Improving overhead allocation efficiency can be achieved with ABC, but specific political considerations may block or prevent its successful implementation within the university (Goddard and Ooi, 1998).

Interesting results were obtained by applying ABC in an accounting department of a US university: (1) the annual cost of educating a Ph.D. student is more than three times higher than the cost of a student enrolled in a 5-year accounting program (bachelor + master); (2) support costs for a Ph.D. student were much lower than support costs for an MBA student; (3) ABC can provide administrators with useful information in carrying out programs and activities (Granof et al., 2000). Recognition of the proportion of services that Australian public universities provide to their community that the government must fund is shown in a study using ABC as cost objects: research, teaching, and professional/community services (Heskin and Sharma, 2001). Through better analysis of costs per activity, the possibility of better planning and eliminating non-value activities for a university is provided, mainly when a comparative study is carried out between traditional costing methods and the ABC method (Krishnan, 2006).

The development of activity-based management in a UK university has provided helpful information on strategic decision-making within specific processes, better tuition pricing, and evidence of cross-subsidization (McChlery et al., 2007). The direct costs (expenditure with teachers' salaries and administrative expenses) were allocated to specific activities. In contrast, the indirect costs, divided into nine categories, were allocated to activities using specific cost drivers. The implementation of ABC determined the reduction of a library's budget at a university in the USA. As a result, the information obtained contributed to making strategic decisions regarding eliminating certain non-value-adding activities and reallocating tasks to other responsible persons (Novak et al., 2011). The decline in productivity in higher education is due to the lack of a management accounting model that allows for continuous improvement (Gordon and Fischer, 2011). Higher education institutions in the United States and abroad face demands to control costs and allocate resources efficiently (Yakhou and Ushafer, 2012). Determining the margins between departments and identifying cross-subsidies was done at Riverside University in California, where teaching costs were allocated to courses based on cost drivers, and indirect costs (facilities and administration) were allocated according to the consumption of non-teaching resources (Anguiano et al., 2017). The implementation of ABC within higher education institutions is also influenced by several factors (Hoang et al., 2020), such as the size of the institution (Gosselin, 1997; Al-omiri, 2003; Brierley, 2009), the level of competitiveness (Kaplan and Cooper, 1998; Pham et al., 2020; Sorros et al., 2022); managerial support (Aldukhil, 2012; Elagili, 2015); ABC training (Elagili, 2015); the variety of products

offered (Schoute, 2011; Clarke et al., 1997); reliability and importance of cost information (Gosselin, 1997; Baird et al., 2004; Rankin, 2016). The following research hypothesis emerges from the presented:

H₂: ABC has a positive impact on the reliability of cost information.

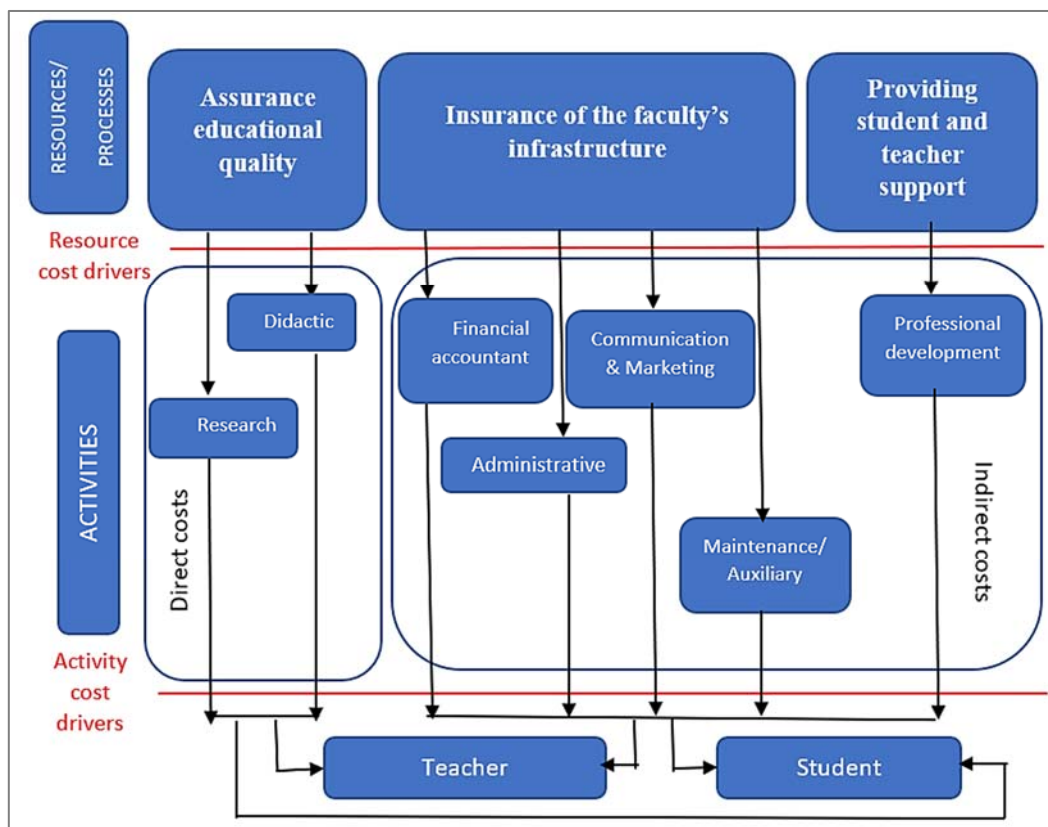
According to the opinion of specialists, ABC recorded several advantages in the case of implementation in higher education institutions, such as (1) performance measurement by identifying non-value activities and analyzing activity cost trends (Port and Burke, 1989; Turk, 1992) ; (2) portfolio management (identification of successful courses, subsidized courses, market orientation, and investment justification); (3) pricing policy (impact of discounts, course preparation costs, etc.); (4) strategic decisions (identification of high or limited cost resources, recognition of complex costs, ability to manage course proliferation, use of success factors, etc.) (Port and Burke, 1989); (5) the ability to assess the cost of a degree by adding the costs of all courses in which a student was enrolled (Anguiano et al., 2017), and to decide whether the non-financial gains offset any financial losses generated by the principal or degree (Yakhou and Ushafer, 2012). Like any other costing system, ABC has certain limitations that are mainly related to (1) the large amount of work involved in determining costs and establishing benefits (Turk, 1992); (2) difficulties in classifying activities between research, teaching, and other services (Groves et al., 1994), (3) difficulties in allocating overheads to courses (Burnett et al., 1994b); (4) high implementation cost, need for information accuracy, lack of management support (McChelery et al., 2007; Sumrall, 2019). Based on what was presented, the following research hypothesis emerges:

H₃: The implementation of ABC has a positive impact on the achieved performances.

3. Research Methodology

To carry out this research, the following three previously mentioned hypotheses were considered: H₁: Traditional cost systems have a negative impact on the reliability of cost information; H₂: ABC has a positive impact on the reliability of cost information; H₃: The implementation of ABC has a positive impact on the achieved performances. Considering the three working hypotheses, the research aims to develop and test an activity-based costing (ABC) model that can be used within private higher education institutions to determine academic costs with teaching staff and students.

The objectives of the research started from the research of national and international specialized literature to implement ABC in higher education institutions through searches and queries in international databases such as Web of Science, SCOPUS, or EBSCO. Thus, the objectives of the research consisted in i) the development of an activity-based cost model for measuring the academic costs related to teaching staff and students in a private higher education institution; ii) demonstrating the feasibility of using the model in a private higher education institution; iii) identification of the advantages and barriers to successfully implementing the ABC concept in a private higher education institution.

Figure 1. The ABC model according to a private higher education institution

Source: Created by authors.

In this sense, an ABC model was created (Figure 1), which was the basis for testing and developing ABC within a private higher education institution. The research team of the article's authors and several ABC implementation specialists put ABC principles into practice through a phased implementation of ABC within a higher education institution.

The private higher education institution is accredited by ARACIS and has been operating for over 25 years in this field of education. The higher education institution is divided into three faculties, each of which has several accredited undergraduate and dissertation study programs: the Faculty of Finance, the Faculty of Accounting, and the Faculty of Marketing. In this sense, the database of the analyzed private higher education institution was consulted, and the data from the last ten years, which were the basis of our research, were processed. The data were collected from the Financial-Accounting Department of the university and the faculties' departments. In particular, the university's total budget, the departments' budgets, and the university's organizational chart were considered. To apply the principles of ABC, at an initial stage, the transversal reorganization of the institution was resorted to, starting from its organizational chart. To correctly allocate the costs to the final carriers, it is necessary to delimit them to direct and indirect costs according to the

principles of the activity-based cost method (ABC). Within a higher education institution, this delimitation can be done at the faculty and department levels, and the way it is done will be described in the following.

For a higher education institution, direct costs, i.e., those costs that can be directly identified on a cost bearer (teaching staff, student, etc.), are mainly composed of the costs of the teaching activity or didactic activities and represent the majority percentage of the total cost. The distribution of costs for the teaching staff is based on the time spent by them. It consists mainly of teaching time (teaching activity), research time (research activity to publish specialized materials, participating in various research projects, or preparing individuals), the time allocated to consultations with students (the activity of guiding bachelor theses, dissertation, doctorate, or the tutoring activity). For a higher education institution, indirect costs, i.e., those costs that cannot be directly identified on a cost carrier but can be directly identified on an activity (various departments, functional services, etc.), are mainly composed of the costs of the following identified services: financial services, maintenance, and auxiliary services, IT support services, administrative services, communication, and marketing services. The following briefly describes the main characteristics of the activities mentioned above, the specific cost drivers, and the possibilities of allocation to the final cost carriers.

The application of ABC within a higher education institution involves going through several stages as follows: identifying and describing processes and activities, establishing specific cost drivers and their quantity, allocating the indirect costs of the processes to the activities, and distributing the costs of the activities to the cost bearers (Căpușneanu et al., 2024).

4. Results

4.1. Identifying and Describing Processes and Activities in a Private Higher Education Institution

In the case of the private higher education institution under analysis and which is organized into three faculties (Faculty of Finance, Faculty of Accounting, and Faculty of Marketing), the following processes and activities were identified, starting from the organizational chart and its transversal reorganization (Table 1).

Table 1. *The status of the processes and activities*

Processes	Activities	Services/departments
The educational quality assurance process	Didactic education Research and publication	Faculties/specializations
The process of ensuring the infrastructure of the faculty	Financial, maintenance and ancillary activities, IT support, communication, and marketing, administrative, accounting	Financial services Maintenance and auxiliary services IT support services Communication and marketing services Administrative services
The process of providing support for students and teachers	Professional Development	International mobility service Academic and professional integration service Psychological counseling service Library

Source: Created by authors.

Within the institution of higher education, three processes were identified: the process of ensuring educational quality, the process of ensuring the infrastructure of the faculty, and the process of ensuring support for students and teachers. In what follows, a brief description of the identified processes and activities is provided (Table 2).

Table 2. *Description of the activities and services of a higher education institution*

Activities	Services/ Departments	Composition/Features
Financial, maintenance and support activities, IT support, communication and marketing, administrative, accounting	Financial services	They are intended to highlight the operations carried out by the accounting, treasury, procurement, inventory, and financial management services. The identified costs are composed of personnel costs, depreciation of equipment, purchase of goods and services, and costs of other faculties within the university. Cost allocation can be done by setting a weight to the teaching part (depending on the number of students enrolled in each course), the research part (depending on the ongoing research projects), and the service part provided to external clients (depending on the services provided).
	Maintenance and auxiliary services	They are intended for the provision and maintenance of equipment, the repair and safety of installations, the provision of health and emergency services, and the provision of the necessary support for the conduct of courses, seminars, and laboratories within the faculty/university in optimal conditions. This includes the costs of auxiliary staff, depreciation of equipment, the purchase of subcontracted goods and services, and the costs intended for other faculties within the same university. Cost allocation will be done in the same way as in the case of financial services.
	IT support services	They are intended to ensure the configuration of all IT systems within the faculty/university, starting with the server communications part and all associated services available to other faculties, departments, teaching staff, and students. The costs identified according to the provision of these services are mainly composed of personnel costs, purchase and replacement of parts and consumables, purchase of appropriate tools, depreciation of equipment (computers, laptops, servers, printers, scanners, etc.), and other specific costs. This service can be divided into the following activities: technical support and printing/multiplication, IT equipment management, and development and use of IT applications.
		Technical and printing/multiplication support consists of providing IT support to the entire university, being practically the main activity of the IT support service. If this technical support is addressed to secretarial or management services or offices within a faculty or even teaching staff, the costs must be attributed directly to the faculty. If this technical support is provided directly to students, then these costs will be allocated directly to the courses taken by the students.
		IT equipment management refers to repairing damaged equipment identified within the university's various departments, services, and offices. The cost will be distributed according to the location of the equipment (faculty, department, office, etc.).
		The development and use of computer applications refer to the construction or development of computer applications required by various departments, services, or offices, including applications required by teaching staff and students necessary to conduct laboratories (installation and license-based use of various applications). The costs will be distributed according to the final destination of the requested applications.
	Communication and marketing services	— The communication and marketing services are intended to support and organize external communication and promote the image of the faculty by maintaining links with the mass media, with various social networks and other entities responding to their requests, or even from the general public. The identified costs are mainly related to personnel costs, machinery depreciation, and purchasing goods and services. They can be divided into the following offices: advertising and brochure communication and event organization.
		The advertising and brochures communication office is responsible for advertising the taught courses and study programs through brochures and various advertisements. The costs will be allocated according to the final object of the cost bearer (a course or several courses, faculty, number of participating students, etc.).
		The event organization office handles scientific events (conferences, symposia, publications). The costs will be allocated in the same manner as in the case of the advertising and brochure communication office.
	Administrative services	Administrative services are intended to highlight the operations carried out by human resources offices, archives, and other administrative and secretarial work.

Activities	Services/ Departments	Composition/Features
Professional development activities		The human resources office is responsible for all operations related to university personnel management (records, contracts, staffing, time attendance, payroll, etc.). The costs identified at this level are related to personnel, purchase of goods and services, depreciation of used equipment, and costs to various internal services (administrative works office or secretariat).
		Archive and other administrative work are intended for processing (recording-forwarding) correspondence, keeping administrative work, daily archiving (secretarial documents, bachelor theses, dissertation, or doctorate, etc.), and other specific work.
		The secretariat is intended to perform activities related to student activity, such as applications, registrations, records, and follow-up of students during the academic course (issuance of grades, school fees, certificates, general correspondence, transfers, issuance, and issuance of study diplomas).
	Other services for students and visitors	They are intended to assist students in activities related to the management of international mobility programs (ERASMUS), professional and academic integration, psychological counseling support, informational support (library), etc. The identified costs are generally related to personnel costs (administrative, specialized psychological), depreciation of the equipment used, and costs to the other offices of the faculty/university.
		The international mobility service connects with other educational institutions based on collaboration protocols in the context of student exchange. Identified costs may be allocated based on the number of students in the program or the courses that faculty students take abroad.
		The academic and professional integration service is based on providing support in the case of the reception of newly admitted or transferred students, but also in the management of internships and career counseling. Identified costs will be allocated based on the number of students enrolled in courses or the number of students who have received a response to job offers.
		The psychological counseling service is carried out at the request of students for those who require such guidance and counseling. The identified costs will be allocated according to the courses for which the students request this psychological support.
		The library offers services to internal users (students, teachers) and external users (visitors) in the form of book loans for teachers and students, inter-library book loans, book purchases, monographs, magazines, library website management, and internal and external user training services. The record is kept to ensure connections with publishing houses, the purchase of specialized books, the preservation of library materials, etc. The identified costs include personnel costs, equipment depreciation costs, publication acquisition costs, costs of online subscriptions to newspapers and databases (Web of Science, various virtual libraries), costs of other faculty services, etc. Costs will be allocated according to hours worked or activities performed.

Source: Created by authors.

The educational quality assurance process. The quality of education depends on the degree of compliance of the education system with the established requirements and the quality of educational services offered by the educational institution (Sergeeva et al., 2019). The quality of education also depends on the development of students' intelligence, creativity, and ability, the preparation of students for integration into the labor market, and the level of scientific research (Figlewicz, 2002). Improving the level of higher education can help strengthen the talents to shape the national economy, promoting prosperity and social progress (Du et al., 2017).

The process of ensuring the infrastructure of the faculty. The infrastructure of the faculty is ensured by all those activities that contribute to the smooth running of the education and research processes within a higher education institution. Financial, maintenance and auxiliary activities, IT support, communication, and marketing, administrative, and accounting help to interconnect the processes and to streamline the information flows necessary to determine the final costs according to the chosen cost carriers.

The process of providing support for students and teachers. This process addresses two essential components: professional development and community development. Professional development considers the training, certification, and continuous education of teachers and students through permanent updates carried out by the management of the higher education institution. Professional development can also be achieved through the programs offered by higher education institutions, professional organizations, or even by the management of the institutions.

4.2. Establishing Process Costs and Process Cost Drivers

To establish the costs of the processes and the cost drivers of the processes identified within the institution of higher education, it was based on the income situation obtained by the faculties and the weight held by the expenses related to its activities as follows (Table 3 and Table 4):

Table 3. *Revenue earned by faculty and university*

Revenues	Faculty of Finance (Eur)	Faculty of Accounting (Eur)	Faculty of Marketing (Eur)	University (Eur)
Admission fee revenues	29500	38500	19480	87480
Revenues from tuition fees	552000	722000	349000	1623000
Revenues from the student arrears fee	2580	3460	1580	7620
Revenues from school/archive status fees	40	120	60	220
Revenues from fees for completing studies	198000	258000	136000	592000
Revenues from transfer fees	200	600	300	1100
Total revenues	782320	1022680	506420	2311420

Source: Created by authors.

Table 4. *Planned expenses by faculties and at university level*

Expenses	Faculty of Finance (Eur)	Faculty of Accounting (Eur)	Faculty of Marketing (Eur)	University (Eur)	Revenue share (%)
Teaching and auxiliary staff expenses	391160	511340	253210	1155710	50.00
Utility expenses, of which:	187756.8	245443.2	121540.8	554740.8	24.00
<i>Electricity</i>	168981.12	220898.88	109386.72	499266.72	21.60
<i>Water</i>	18775.68	24544.32	12154.08	55474.08	2.40
Scientific research expenses	46939.2	61360.8	30385.2	138685.2	6.00
Training expenses	23469.6	30680.4	15192.6	69342.6	3.00
Subscription expenses	1564.64	2045.36	1012.84	4622.84	0.20
International relations expenses	4693.92	6136.08	3038.52	13868.52	0.60
Expenses for cleaning and sanitizing materials	3129.28	4090.72	2025.68	9245.68	0.40
Building maintenance and upkeep services	15646.4	20453.6	10128.4	46228.4	2.00
Guard and security services	15646.4	20453.6	10128.4	46228.4	2.00
Telephone and internet expenses	782.32	1022.68	506.42	2311.42	0.10
Expenses with inventory items	23469.6	30680.4	15192.6	69342.6	3.00
Depreciation of buildings and fixed assets	60238.64	78746.36	38994.34	177979.34	7.70
General Administration and Management Expenses	7823.2	10226.8	5064.2	23114.2	1.00

Source: Created by authors.

Total costs allocated to processes and activities on the three faculties are presented as follows (Table 5).

Table 5. The status of cost allocation from the process level to the activities

Explanations	Faculty of Finance (Eur)	Faculty of Accounting (Eur)	Faculty of Marketing (Eur)
The educational quality assurance process	436000	570000	282000
<i>Didactic education activities</i>	390000	510000	252000
<i>Research and publication activities</i>	46000	60000	30000
The process of ensuring the infrastructure of the faculty	300699.44	408673.56	201751.14
<i>Financial activities</i>	83708.24	109426.76	54186.94
<i>Maintenance and auxiliary activities</i>	208470	288000	142000
<i>Communication and marketing activities</i>	698	1020	500
<i>Administrative and secretarial activities</i>	7823.2	10226.8	5064.2
The process of providing support for students and teachers	29150	38300	19000
<i>Professional development activities</i>	29150	38300	19000

Source: Created by authors.

4.3. Determining Activity Expenditures and Activity Cost Drivers

The actual expenses of the activities registered on the three faculties are presented as follows (Table 6):

Table 6. The situation of the actual expenses of the institution of higher education

Expenses	Total cost (Eur)			
	Faculty of Finance (Eur)	Faculty of Accounting (Eur)	Faculty of Marketing (Eur)	University (Eur)
Teaching and auxiliary staff expenses	390000	510000	252000	1152000
Utility expenses, of which:	175600	244000	120000	539600
<i>Electricity</i>	158040	219600	108000	485640
<i>Water</i>	17560	24400	12000	53960
Scientific research expenses, of which:	46000	60000	30000	136000
<i>Teachers</i>	39500	50000	20000	109500
<i>Students</i>	6500	10000	10000	26500
Training expenses	23000	30000	15000	68000
Subscription expenses, of which:	1500	2000	1000	4500
<i>Teachers</i>	1200	1500	800	3500
<i>Students</i>	300	500	200	1000
International relations expenses, of which:	4650	6300	3000	13950
<i>Teachers</i>	997.5	1800	500	3297.5
<i>Students</i>	3652.5	4500	2500	10652.5
Expenses for cleaning and sanitizing materials	2850	4000	2000	8850
Building maintenance and upkeep services	15020	20000	10000	45020
Guard and security services	15000	20000	10000	45000
Telephone and internet expenses, of which:	698	1020	500	2218
<i>Teachers, secretariat</i>	500	700	350	1550
<i>Students</i>	198	320	150	668
Expenses with inventory items	23469.6	30680.4	15192.6	69342.6
Depreciation of buildings and fixed assets	60238.64	78746.36	38994.34	177979.34
General Administration and Management Expenses	7823.2	10226.8	5064.2	23114.2
Total effective expenses	765849.44	1016973.56	502751.14	2285574.14

Source: Created by authors.

Establishing the cost drivers and their quantities to achieve the distribution of the costs of the activities on the cost bearers is carried out:

a) for teachers (Table 7):

Table 7. *The situation of cost drivers of activities for teaching staff*

Activities	Activity cost drivers	Amount of cost drivers		
		Faculty of Finance	Faculty of Accounting	Faculty of Marketing
Teaching activities	No. course teaching hours	280	336	280
	No. seminar teaching hours	280	336	280
	No. examination hours	8	8	8
	No. student consultation hours	56	84	56
	No. tutoring hours	56	84	56
Research and publication activities	No. research project hours	280	280	280
	No. articles published by teachers	150	162	130
Professional development activities	No. Erasmus participations for teachers	35	50	50
	No. training hours	192	192	192
	No. hours of internet exploration for documentation	360	360	360
Financial activities	No. inventory items	1820	2250	1124
	Monthly depreciation rate	780	820	520
Maintenance and auxiliary activities	Consumption kwh	12000	14000	14000
	Consumption m ³	1080	1100	1100
	Quantity used annually	140	142	102
	No. of hours worked	640	640	640
	No. of hours worked	320	320	320
Communication and marketing activities	No. telephone and internet subscriptions	4	4	4
Administrative and secretarial activities	No. of hours (administration)	288	288	288
	No. hours attendance meetings	112	112	112
	No. teaching staff committees	64	64	64

Source: Created by authors.

b) for students (Table 8):

Table 8. *Status of cost drivers of student activities*

Activities	Activity cost drivers	Amount of cost drivers		
		Faculty of Finance	Faculty of Accounting	Faculty of Marketing
Teaching activities	No. course teaching hours	280	336	280
	No. seminar teaching hours	280	336	280
	No. examination hours	8	8	8
	No. student consultation hours	56	84	56
	No. tutoring hours	56	84	56
Research and publication activities	No. research project hours	280	280	112
Professional development activities	No. Erasmus participations for students	125	175	85
	No. hours of internet exploration for documentation	720	720	500
Financial activities	No. inventory items	1820	2250	1124
	Monthly depreciation rate	780	820	520
Maintenance and auxiliary activities	Consumption kwh	12000	14000	14000
	Consumption m ³	1080	1100	1100
	Quantity used annually	140	142	102
	No. of hours worked	640	640	640
	No. of hours worked	320	320	320
Communication and marketing activities	No. telephone and internet subscriptions	6	6	4
Administrative and secretarial activities	No. of hours (administration)	288	288	288
	No. hours attendance meetings	112	112	112

Source: Created by authors.

Table 9. Allocation of activity costs to cost bearers (teaching staff)

Activities/Cost Drivers	Faculty of Finance			Faculty of Accounting			Faculty of Marketing		
	38 teaching staff + 15 auxiliary staff			50 teaching staff + 16 auxiliary staff			30 teaching staff + 8 auxiliary staff		
	Costs (Eur)	Amount of cost drivers	Unit cost per teacher (Eur)	Costs (Eur)	Amount of cost drivers	Unit cost per teacher (Eur)	Costs (Eur)	Amount of cost drivers	Unit cost per teacher (Eur)
Didactic education activities (Included in the basic norm)	390000		573.5294118	510000		601.4150943	252000		370.5882353
No. allocated teaching/learning hours, of which		680			848			680	
No. course teaching hours		280			336			280	
No. seminar teaching hours		280			336			280	
No. examination hours		8			8			8	
No. student consultation hours		56			84			56	
No. tutoring hours		56			84			56	
Research and publication activities	46000		210.7142857	60000		261.1111111	30000		144.2307692
No. research project hours	31000	280	110.7142857	42000	280	150	21000	280	75
No. articles published by teachers	15000	150	100	18000	162	111.1111111	9000	130	69.23076923
Professional development activities	25197.5		151.625	33300		196.4166667	16300		90.34722222
No. Erasmus participations for teachers	997.5	35	28.5	1800	50	36	500	50	10
No. training hours	23000	192	119.7916667	30000	192	156.25	15000	192	78.125
No. hours of internet exploration for documentation	1200	360	3.333333333	1500	360	4.166666667	800	360	2.222222222
Financial activities	83708.24		90.12441026	109426.76		109.6678797	54186.94		88.50566343
No. inventory items	23469.6	1820	12.89538462	30680.4	2250	13.63573333	15192.6	1124	13.51654804
Monthly depreciation rate	60238.64	780	77.22902564	78746.36	820	96.03214634	38994.34	520	74.98911538
Maintenance and auxiliary activities	208470		120.1301521	288000		159.7865466	142000		85.10621976
Consumption kwh	158040	12000	13.17	219600	14000	15.68571429	108000	14000	7.714285714
Consumption m³	17560	1080	16.25925926	24400	1100	22.18181818	12000	1100	10.90909091
Quantity used annually	2850	140	20.35714286	4000	142	28.16901408	2000	102	19.60784314
No. of hours worked	15020	640	23.46875	20000	640	31.25	10000	640	15.625
No. of hours worked	15000	320	46.875	20000	320	62.5	10000	320	31.25
Communication and marketing activities	500		125	700		175	350		87.5
No. telephone and internet subscriptions	500	4	125	700	4	175	350	4	87.5
Administrative and secretarial activities	7823.2		219.2513889	10226.8		286.6141865	5064.2		141.9282242
No. of hours (administration)		288	27.16388889		288	35.50972222		288	17.58402778
No. hours attendance meetings		112	69.85		112	91.31071429		112	45.21607143
No. teaching staff committees		64	122.2375		64	159.79375		64	79.128125
Total cost per teacher			1490.374649			1790.011485			1008.206334

Source: Created by authors.

Table 10. Allocation of activity costs to cost bearers (students)

Activities/Cost Drivers	Faculty of Finance Number of students:650			Faculty of Accounting Number of students:850			Faculty of Marketing Number of students:420		
	Costs (Eur)	Amount of cost drivers	Unit cost per student (Eur)	Costs (Eur)	Amount of cost drivers	Unit cost per student (Eur)	Costs (Eur)	Amount of cost drivers	Unit cost per student (Eur)
Didactic education activities									
No. allocated teaching/learning hours from which	390000	680	573.5294118	510000	848	601.4150943	252000	680	370.5882353
No. course teaching hours		280	1392.857143		336			280	
No. seminar teaching hours		280	1392.857143		336			280	
No. examination hours		8	48750		8			8	
No. student consultation hours		56	6964.285714		84			56	
No. tutoring hours		56	6964.285714		84			56	
Research and publication activities	6500		23.21428571	10000		35.71428571	10000		89.28571429
No. research project hours		280	23.21428571		280	35.71428571		112	89.28571429
Professional development activities	3952.5		29.63666667	5000		26.40873016	2700		29.81176471
No. Erasmus participations for students	3652.5	125	29.22	4500	175	25.71428571	2500	85	29.41176471
No. hours of internet exploration for documentation	300	720	0.416666667	500	720	0.694444444	200	500	0.4
Financial activities	83708.24		90.12441026	109426.76		122.5627873	54186.94		87.40137029
No. inventory items	23469.6	1820	12.89538462	30680.4	1420	21.60591549	15192.6	1224	12.4122549
Monthly depreciation rate	60238.64	780	77.22902564	78746.36	780	100.9568718	38994.34	520	74.98911538
Maintenance and auxiliary activities	208470		120.1301521	288000		159.7865466	142000		85.10621976
Consumption kwh	158040	12000	13.17	219600	14000	15.68571429	108000	14000	7.714285714
Consumption m3	17560	1080	16.25925926	24400	1100	22.18181818	12000	1100	10.90909091
Quantity used annually	2850	140	20.35714286	4000	142	28.16901408	2000	102	19.60784314
No. of hours worked	15020	640	23.46875	20000	640	31.25	10000	640	15.625
No. of hours worked	15000	320	46.875	20000	320	62.5	10000	320	31.25
Communication and marketing activities	198		33	320		53.33333333	150		37.5
No. telephone and internet subscriptions	198	6	33	320	6	53.33333333	150	4	37.5
Administrative and secretarial activities	7823.2		97.01388889	10226.8		126.8204365	5064.2		62.80009921
No. of hours (administration)		288	27.16388889		288	35.50972222		288	17.58402778
No. hours attendance meetings		112	69.85		112	91.31071429		112	45.21607143
<i>Total cost per student</i>			966.6488154			1120.420512			762.4934035

Source: Created by authors.

4.4. Allocation of Activity Costs to Cost Bearers

The allocation of activity costs to cost bearers (Teachers, auxiliary staff, students) is shown in Tables 9 and 10. A summary of the two tables is presented in Table 11.

Table 11. *Synthesis of unit costs of teaching staff and students by activities and faculties*

Activities	Faculty of Finance	Faculty of Accounting	Faculty of Marketing
Teaching activities	573.5294118	601.4150943	370.5882353
Research and publication activities	210.7142857	261.1111111	144.2307692
Professional development activities	151.625	196.4166667	90.34722222
Financial activities	90.12441026	109.6678797	88.50566343
Maintenance and auxiliary activities	120.1301521	159.7865466	85.10621976
Communication and marketing activities	125	175	87.5
Administrative and secretarial activities	219.2513889	286.6141865	141.9282242
Total cost per teacher	1490.374649	1790.011485	1008.206334
Teaching activities	573.5294118	601.4150943	370.5882353
Research and publication activities	23.21428571	35.71428571	89.28571429
Professional development activities	29.63666667	26.40873016	29.81176471
Financial activities	90.12441026	122.5627873	87.40137029
Maintenance and auxiliary activities	120.1301521	159.7865466	85.10621976
Communication and marketing activities	33	53.33333333	37.5
Administrative and secretarial activities	97.01388889	126.8204365	62.80009921
Total cost per student	966.6488154	1120.420512	762.4934035

Source: Created by authors.

4.5. Determination of unit costs

The total unit costs of the cost bearers (teaching staff and auxiliary staff, students) were determined by adding up all direct and indirect costs (by activity). Following the centralization of information after distribution, the following costs resulted (Table 12):

Table 12. *Unit cost situation according to ABC*

Faculty	Total costs (Eur)	Number of students	Cost per student (Eur)	Number of teaching staff and auxiliary staff	Cost per teacher and auxiliary staff (Eur)
Finance	765849.44	650	966.6488154	53	1490.374649
Accounting	1016973.56	850	1120.420512	66	1790.011485
Marketing	502751.14	420	762.4934035	38	1008.206334

Source: Created by authors.

5. Discussions

By following the principles of ABC and following the specific stages of ABC, we can find a series of positive aspects that entitle us to conclude that the model proposed for testing can be successfully implemented within a higher education institution due to the multiple advantages it confers.

Table 13. *The situation of unit costs according to traditional methods*

Faculty	Total costs (Eur)	Number of students	Cost per student (Eur)	Number of teaching staff and auxiliary staff	Cost per teacher and auxiliary staff (Eur)
Finance	765849.44	650	1178.229908	53	14449.98943
Accounting	1016973.56	850	1196.439482	66	15408.6903
Marketing	502751.14	420	1197.026524	38	13230.29316

Source: Created by authors.

Compared to the traditional methods of determining unit costs (most of them through an average of expenses) which take into account only arbitrary cost drivers (Table no. 13), the ABC model takes into account in the distribution of indirect costs (of activities) drivers of specific costs that are based on the cause-effect relationship between the expenditure and the chosen cost inducer (Lelkes, 2020; Cokins and Căpușneanu, 2010), as can also be seen from Table 12. The costs per student from the three faculties calculated by ABC are much smaller than those calculated by traditional methods, the deviations between the two models (traditional and ABC) being presented in Table 14.

Table 14. *Situation of cost differences between ABC and traditional methods*

Faculty	Cost per student (Eur)		Difference	Cost per teacher and auxiliary staff (Eur)		Difference
	Traditional method	ABC		Traditional method	ABC	
Finance	1178.229908	966.6488154	-211.5810923	1089.401764	1490.374649	400.9728849
Accounting	1196.439482	1120.420512	-76.01897028	1110.233144	1790.011485	679.7783407
Marketing	1197.026524	762.4934035	-434.5331203	1097.709913	1008.206334	-89.50357852

Source: Created by authors.

Concerning personnel costs (teaching and auxiliary), ABC makes an evident differentiation compared to the traditional method that considers absolutely all persons (teaching staff, auxiliary staff, students) when determining the unit costs. The calculated differences indicate that although the costs calculated by the traditional method are lower compared to ABC (at the Faculty of Finance and the Faculty of Accounting), they do not correctly reflect the allocation of costs separated by teaching staff and auxiliary staff from those with students. The traditional method resorted to dividing the total costs among all the staff within the faculty, needing a clear record demarcated between teaching staff and students, as respected by ABC principles. Through the presented, hypothesis H1, according to which traditional cost calculation methods have a negative impact on the reliability of cost information, and hypothesis H2, according to which ABC has a positive impact on the reliability of cost information, have been demonstrated.

Table 15. *The status of calculated results for students according to traditional and ABC methods*

Faculty	Traditional method		Result	ABC		Result
	Revenue per student (Eur)	Cost per student (Eur)		Revenue per student (Eur)	Cost per student (Eur)	
Finance	1203.569231	1178.229908	25.33932308	1203.569231	966.6488154	236.9204154
Accounting	1203.152941	1196.439482	6.713458824	1203.152941	1120.420512	82.7324291
Marketing	1205.761905	1197.026524	8.735380952	1205.761905	762.4934035	443.2685012

Source: Created by authors.

In other words, ABC provides reliable cost management due to the determination of the real cost of a product (Amir et al., 2012; Hashim, 2013), contributing to the elimination of non-value-adding activities and increasing the performance of higher education institutions (Cox et al., 2007). The ABC system is flexible, with specific characteristics that allow the management of the higher institution to focus on a specific faculty (Ismail, 2006) or certain support services (Khrisnan, 2006). Through what was presented and argued, hypothesis H3

was also demonstrated, according to which ABC implementation positively impacts the higher education institution's performance.

Attaching the cost to an activity increases user awareness of the price and value of that activity (Cropeer and Cook, 2000). This can be used to better design activities and change behavioral patterns by minimizing costs. Managers deliberately opt for the behavioral orientation of less precise costing systems over more complex costing techniques to induce desired behavioral responses (Merchant and Shields, 1993). ABC helps managers in higher education institutions understand the factors that influence the costs of teaching, and the costs of individual courses are an essential aspect of the decision-making process (Port and Burke, 1989).

As observed, the testing and implementation of the proposed ABC model in a higher education institution to determine the unit costs of teaching staff and students were successful, and the research team also found other aspects related to

1. ABC Design and the costing system must be selected and designed by specialists according to the context and characteristics of a private university.
2. The implementation team must establish the final cost drivers around which the ABC design will be carried out.
3. There is a need for a clear definition of the processes and activities as well as their composition, a fact that helps to correctly allocate or apportion indirect costs to the final cost bearers.
4. There is a need to establish cost drivers that express the causal link between the type of expenditure to be allocated and the specifically chosen driver.

6. Conclusions

In the last decade, higher education institutions have engaged in a series of reforms aimed at their structure and management system, considering their specificity, objectives, and strategies. Moving towards an entrepreneurial model, higher education institutions must adopt new cost management models and approach new markets, customers, and products. For this reason, private universities must have a clear record of costs and efficient management that can be achieved using advanced costing methods providing information that helps management make effective decisions in the long or medium term. This was also the purpose of our research, to identify and test an ABC model to help with cost management, namely the determination of unit costs for teachers and students in three faculties.

As is well known, each higher education institution has a distinct history and culture, its local environment, and its ethos in dealing with external market/funding pressures. In principle, ABC applies to all higher education institutions, although there are some reservations about changing the variables considering the cost allocation method. According to ABC, these implications can be explained through engagement, training, communication, data collection, processing, and interpretation. The model proposed and

tested for ABC implementation within a private higher education institution comes with several advantages, such as:

1. Determination of real costs.
2. The determination, selection, and use of cost drivers according to the specifics of the private higher education institution.
3. The accuracy of the information provided increases the qualitative decision-making level on the part of the institution's management.
4. Flexibility or adaptability of the model according to future requirements or demands from customers.
5. It is improving competitiveness.

The own contributions to the realization of this research are highlighted by the above-mentioned advantages and by the proposed model that comes to cover an existing and little-explored lack in specialized literature. The general conclusion of this research is that the ABC model can be of value in an institution of higher education, respecting its principles and especially by supporting its implementation by all employees, not only management.

This research focused on private sector universities in Romania, where the purpose that led to the testing and implementation of ABC within these institutions was determined due to the current context. Our research is limited only to the private higher education sector. However, the obtained results justify extending our research to the public sector since the latter is also characterized by public funding. This would be one of the future research directions. However, there may be others, such as: testing and implementing ABC within public higher education institutions by determining the costs of academic courses, research projects, departmental costs, studies (bachelor's, master's, doctorate, post doctorate), development of the concept of opportunity cost for academic staff, etc.

References

- Acton, D.D. and Cotton, W.D.J. (1997). Activity-based costing in a university setting. *Journal of Cost Management*, 11(2), 32-38.
- Aldukhil, Y. (2012). *Developing and Testing a Model of Successful Adoption of Activity-Based Costing*. PhD thesis, Victoria University.
- Al-Omiri, M. (2003). *The diffusion of management accounting innovations: a study of the factors influencing the adoption, implementation levels and success of ABC*. PhD thesis, University of Huddersfield.
- Amir, A.M., Auzair, S.M., Maelah, R. and Ahmad, A. (2012). Determination of Educational Cost in Public University – A Modified Activity Based Approach. *World Journal of Social Sciences*, 2(2), 34-48.
- Anguiano, M., D'Anieri, P., Hull, M., Kasturiraman, A. and Rodriguez, J. (2017). Optimizing resource allocation for teaching: An experiment in activity-based costing. Retrieved from <https://www.ucr.edu/sites/g/files/rcwecm986/files/2018-03/ucr_abc_whitepaper.pdf>

- Anthony, R.N. and Young, D.W. (1999). *Management control in nonprofit organizations*. Boston, MA: Irwin/McGraw-Hill.
- Baird, K., Harrison, G. and Reeve, R. (2004). Adoption of activity management practices: A note on the extent of adoption and the influence of organizational and cultural factors. *Management Accounting Research*, 15, 383-399.
- Barr, M.J. and McClellan, G.S. (2018). *Budgets and financial management in higher education*. John Wiley and Sons.
- Berry, R.H. (1994). *Management Accounting in Universities*. London: CIMA.
- Birch, D. (1988). *Managing Resources in Further Education*. Blagdon: The Further Education Staff College.
- Bottomley, J.A. (1972). *Costs and potential economies*. Paris: Organisation for Economic Cooperation and Development (OECD).
- Bottomley, J.A. (1976). Unit cost studies in French universities. *Socio-economic Planning Sciences*, 10(1), 27-30.
- Bourn, M. (1994a), Meeting the Indirect Costs of Support Services in Universities: Top-Slicing, Charging-Out, Taxes, Trading, and Devolution. *Financial Accountability and Management*, 10, 323-38.
- Bourn, M. (1994b). "A Long and Winding Road: The Evolution of Devolution in Universities". In: R.H. Berry, ed. *Management Accounting in Universities*. London: CIMA, 5-24.
- Brès, L., Raufflet, E. and Boghossian, J. (2018). Pluralism in organizations: Learning from unconventional forms of organizations. *International Journal of Management Reviews*, 20(2), 364-386.
- Briciu, S. and Căpușneanu, S. (2011). Aspects of the normalization of managerial accounting in Romania on a microeconomic level, *Theoretical and Applied Economics*, 3, 95-106.s
- Brierley, J.A. (2009). Toward an understanding of the sophistication of product costing systems. *Journal of Management Accounting Research*, 20, 61-78.
- Brusca, I., Labrador, M. and Condor, V. (2019). Management Accounting Innovations in Universities: A Tool for Decision Making or for Negotiation? *Public Performance and Management Review*, 42(5), 1138-1163.
- Burnett, C., Smith, R. and Silberstein, M. (1994a). "The First Phase in the Development of an Alternative Course Costing System". In: R.H. Berry, ed. *Management Accounting in Universities*. London: CIMA, 85-91.
- Burnett, C., Smith, R. and Silberstein, M. (1994b). "The development of an alternative course costing model". In Berry, R.H. (Ed), *Management Accounting in Universities* (CIMA, London).
- Buttross, T. and Schmelzle, G. (2020). "Finance: Activity-Based Costing (ABC)". In *Encyclopedia of Public Administration and Public Policy*, Third Edition (pp. 1-6). Routledge.
- Căpușneanu, S., Stolojescu, B.I.-N., Solomon, A.-G. and Rakoș, I.-S. (2024). Activity-Based Costing (ABC) Model for Romanian Public Higher Education Institutions, *Annales Universitatis Apulensis, Series Oeconomica*, 26(1): 167-181.
- Carr, J.G. (1994). *Effective Financial Management in Further and Higher Education*, London: Certified Accountants Educational Trust.

- Chan, S.Y. and Lee, D.S. (2003). An empirical investigation of symptoms of obsolete costing systems and overhead cost structure. *Managerial Auditing Journal*, 18(2), 81-89.
- Cheng, L., Lu, Q., Wu, B., Yin, C., Bao, Y. and Gong, L. (2018). Estimation of the costs of desertification in China: a critical review. *Land Degradation and Development*, 29(4), 975-983.
- Clarke, P., Hill, N. and Stevens, K. (1999). Activity based costing in Ireland: barriers to, and opportunities for change. *Critical Perspectives on Accounting*, 10(4), 443-68.
- Cokins, G. (1996). *Activity-based cost management: Making it work: A manager's guide to implementing and sustaining an effective ABC system*. Chicago: Irwin Professional Publishing.
- Cokins, G. (2002). *Activity-based cost management: an executive's guide*. John Wiley and Sons.
- Cokins, G. and Căpușneanu, S. (2010). Cost drivers. Evolution and benefits. *Theoretical and Applied Economics*, 8, 7-16.
- Cokins, G. Stratton, A. and Helbling, J. (1993). *An ABC manager's primer: Straight talk on activity-based costing*. Montvale, NJ: Institute of Management Accountants.
- Cooper, R. and Kaplan, S. (1988). *Measure Costs Right: Make the Right Decisions*, Harvard Business Review, September-October, 96-103.
- Cox, K.S., Downey, R.G. and Smith, L.G. (2007). Activity Based Costing and Higher Education – Can it Work.
- Cropper, P. and Cook, R. (2000). Activity-Based Costing in Universities – Five Years On. *Public Money and Management*, 20, 61-68.
- Del Río Sánchez, R., Rodríguez Cornejo, V., García Valderrama, T. and Sánchez Ortiz, J., (2019). Design of the activities map with the ABC cost model for the university departments. *Cuadernos de Gestión*, 19(2), 159-184.
- Devlin, M., Zhang, L.C., Edwards, D., Withers, G., McMillan, J., Vernon, L. and Trinidad, S. (2022). The costs of and economies of scale in supporting students from low socioeconomic status backgrounds in Australian higher education. *Higher Education Research and Development*, 1-16.
- Doyle, K. (1991). Study of Student Costs using Activity Based Costing Methodology. Proceedings of the Conference of the Australasian Association for Institutional Research (AAIR) (2nd Melbourne, Victoria, Australia, October 1-3).
- Du, G., Yuan, J., Miao, F. and Wei, P. (2017). Effectiveness of design process of education quality assurance system based on EFQM model. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(12), 8205-8211.
- Du, M. (2021). Balanced Scorecard in University Financial Management. In The Sixth International Conference on Information Management and Technology (ICIMTECH 21). Association for Computing Machinery, New York, NY, USA, Article 64, 1–5.
- Elagili, G. (2015). *Adoption factors for the implementation of activity based costing systems: A case study of the Libyan cement industry*. Doctoral dissertation, University of Salford.
- Figlewicz, R. (2002). Comprehensive management of the quality of education in higher education on the example of the University of Humanities and Economics in Łódź. OW WSHE, 26-43.
- García Valderrama T. and Del Río Sánchez, R. (2006) Development and Implementation of a University Costing Model. *Public Money and Management*, 26(4), 251-255.

- Garrison, R.H. and Noreen, E.W. (2000), *Managerial Accounting*, 9th ed., McGraw-Hill, New York, NY.
- Goddard, A. and Ooi, K. (1998). Activity-based costing and central overhead cost allocation in universities: A case study. *Public Money and Management*, 18(3), 31-38.
- Gordon, G. and Fischer, M. (2011). Accounting strategy to improve public higher education management. *Journal of Accounting and Finance*, 11(3), 11-25.
- Gosselin, M. and Journeault, M. (2022). The implementation of activity-based costing by a local government: an actor-network theory and trial of strength perspective. *Qualitative Research in Accounting and Management*, 19(1), 18-44.
- Gosselin, M. (1997). The effect of strategy and organizational structure on the adoption and implementation of activity-based costing. *Accounting, Organizations and Society*, 22(2), 105-122.
- Granof, M.H., Platt, D.E. and Vaysman, I. (2000). Using activity-based costing to manage more effectively. The PricewaterhouseCoopers Endowment for the Business of Government Grant Report.
- Groves, R., Pendlebury, M. and Newton, J. (1994). "Management Accounting Information in Universities: A Cardiff Experiential Perspective". In: R.H. Berry, ed. *Management Accounting in Universities*. London: CIMA, 69-83.
- Hansen, D.R., Mowen, M.M. and Heitger, D.L. (2021). *Cost management*. Cengage Learning.
- Hardy, C. (1991). Pluralism, power, and collegiality in universities. *Financial Accountability and Management*, 7(3), 127-42.
- Hashim, J.H. (2013). Activity-based costing (ABC) Model for Public Higher Education Institutions (PHEI): A guide for a model development. *International Journal of Management and Information Technology*, 7(3), 1089-1100.
- Hentschke, G.C. (2021). "Monetizing and Growing the Assets of Higher Education Institutions". In: Al-Youbi, A.O., Zahed, A.H.M., Atalar, A. (eds) *International Experience in Developing the Financial Resources of Universities*. Springer, Cham.
- Heskin, K. and Sharma, R. (2001). Activity based costing in an Australian university: A pilot of social and behavioural sciences. *Journal of Institutional Research*, 10(1), 56-62.
- Hicks, D.T. (1992). *Activity-Based Costing for small and mid-sized businesses: An implementation guide*. New York: John Wiley and Sons, Inc.
- Hoang, T.B.N., Pham, D.H., Nguyen, T.M.G. and Nguyen, T.T.P. (2020). Factors Affecting Activity-Based Costing Adoption in Autonomous Public Universities in Vietnam. *The Journal of Asian Finance, Economics and Business*, 7(12), 877-884.
- Horngren, C.T., Foster, G. and Datar, S. M. (1997). *Cost accounting: A managerial emphasis* (9th ed). Annotated Instructor's Edition. Upper Saddle River, NJ: Prentice-Hall.
- Islam, S.S., Pulungan, A.H. and Rochim, A. (2019, December). Inventory management efficiency analysis: A case study of an SME company. In *Journal of Physics: Conference Series* (Vol. 1402, No. 2, p. 022040). IOP Publishing.
- Ismail, N.A. (2006). Activity-Based Management for Higher Education Institutions. *Accountants Today*.
- Ismail, N.A. (2010). Activity-based management system implementation in higher education institutions. *Campus Wide Information Systems*, 27(1), 40-52.

- Jarrar, N.S., Smith, M. and Dolley, C. (2007), Perceptions of Preparers and Users to Accounting Change: A Case Study in an Australian University. *Managerial Auditing Journal*, 22(1), 80-94.
- Jenkins, A. and Gibbs, G. (1995). Scandal of postgraduate army. THES (15 Sep) p. 13.
- Jones, D. (1986). Accountability and Budgets in Colleges: A Practical Unit Cost Approach. *Coombe Lodge Report*, 19, 1.
- Jourdaine, M., Loubet, P., Sonnemann, G. and Trébucq, S. (2021). The ABC-LCA method for the integration of activity-based costing and life cycle assessment. *Business Strategy and the Environment*, 30(4), 1735-1750.
- Kaplan, S. and Cooper, R. (1998). *Cost and Effect: Using Integrated Cost Systems to Drive Profitability and Performance*. Harvard Business School Press, Boston.
- Khalid, K. and Ismail, R. (2019). Spending profiles of sultan idris education university undergraduates: a CHAID-based segmentation. *International Business Education Journal*, 12, 39-52.
- Kissa, B., Stavropoulos, A., Karagiorgou, D. and Tsanaksidou, E. (2019). Using time-driven activity-based costing to improve the managerial activities of academic libraries. *The Journal of Academic Librarianship*, 45(5), 102055.
- König, H., König, H. and Konnopka, A. (2020). The excess costs of depression: A systematic review and meta-analysis. *Epidemiology and Psychiatric Sciences*, 29, E30.
- Krishnan, A. (2006). An application of activity based costing in higher learning institution: A local case study. *Contemporary Management Research*, 2(2), 75-90.
- Lelkes, A.-M.T. (2020). Weighted average consumption of cost drivers. *Journal of Applied Accounting Research*, 21(1), 77-89.
- Lima, C.M.F. (2011), The Applicability of the Principles of Activity Based Costing System in a Higher Education Institution. *Economics and Management Research Projects: An International Journal*, 1(1), 57:65.
- Luther, R. and Robson, N. (2001). Overhead allocation: a cautionary tale! *Accounting Education*, 10(4), 413-419.
- Mahesha, V. (2022). A comparative study of activity based costing and traditional costing as a fragment of pricing. *SAARJ Journal on Banking and Insurance Research*, 11(2), 1-9.
- Mazbayeva, K., Barysheva, S. and Saparbayeva, S.S. (2022). The influence of the importance of cost information, product diversity and accountants' participation on the activity-based costing adoption. *Journal of Accounting and Organizational Change*, 18(2), 346-366.
- McChlery, S., McKendrick, J. and Rolfe, T. (2007). Activity-based management systems in higher education. *Public Money and Management*, 27(5), 315-322.
- Merchant, K. A. and Shields, M. D. (1993), When and why to measure costs less accurately to improve decision-making. *Accounting Horizons*, 7(2), 76-81.
- Mijoč, J., Pekanov Starčević, D. and Mijoč, I. (2014). Investigation of the relationship between contemporary cost management methods and improvement in financial performance. *Economic Research-Ekonomska Istraživanja*, 27(1), 393-413.
- National Commission on the Cost of Higher Education. (1998). Straight talk about college costs and prices: Report of the National Commission on the Cost of Higher Education. Retrieved from <<https://files.eric.ed.gov/fulltext/ED416762.pdf>>

- Niñerola, A., Hernández-Lara, A.B. and Sánchez-Rebull, M.V. (2021). Improving healthcare performance through Activity-Based Costing and Time-Driven Activity-Based Costing. *The International Journal of Health Planning and Management*, 36(6), 2079-2093.
- Novak, D. D., Paulos, A. and St. Clair, G. (2011). Data-driven budget reductions: A case study. *The Bottom Line*, 24(1), 24-34.
- O'Guin, M.C. (1991). *The complete guide to activity-based costing*. Englewood Cliffs, NJ: Prentice Hall.
- Ostadi, B. and Zare, R. (2022). Activity-based costing in the public sector and non-profit organisations: towards risk-based approach. *International Journal of Productivity and Quality Management*, 35(1), 1-16.
- Pham, D.H., Dao, T.H. and Bui, T.D. (2020). The Impact of Contingency Factors on Management Accounting Practices in Vietnam. *Journal of Asian Finance, Economics and Business*, 7(8), 77-85.
- Port, J. and Burke, J. (1989). Why Higher Education must learn its ABC. *Public Finance and Accountancy*, 15, 12-13.
- Rankin, R. (2016). *Exploring the relationship among contextual factor on activity- based costing adoption*. Doctoral dissertation, North central University.
- Rezapour, A., Souresafil, A., Peighambari, M.M., Heidarali, M. and Tashakori-Miyanroudi, M. (2021). Economic evaluation of programs against COVID-19: A systematic review. *International journal of surgery*, 85, 10-18.
- Scapens, R.W., Ormston A.L. and Arnold, J. (1994). "The Development of Overhead Recovery Models at the University of Manchester". In: R.H. Berry, ed. *Management Accounting in Universities*. London: CIMA, 55-68.
- Schoute, M. (2011). The relationship between product diversity, usage of advanced manufacturing technologies and activity-based costing adoption. *The British Accounting Review*, 43(2), 120-134.
- Sergeeva, M.G., Latipova, L.N., Rekhtina, I.V., Sannikova, N.I., Zemliakov, D.N. and Shvedov, L.A. (2019). Organization of monitoring in the quality management system of the educational process when training of specialists. *Humanities and Social Sciences Reviews*, 7(6), 227-232.
- Sims, M.A. (1973). Accounting Information in Universities. *Higher Education Review* 5(3), 3-23.
- Sorros, J., Lois, P., Charitou, M., Karagiorgos, A.T. and Belesis, N. (2022). Improving competitiveness in education institutes – ABC's neglected potential. *Competitiveness Review*, 32(3), 302-325.
- Stouthuysen, K., Swiggers, M., Reheul, A.M. and Roodhooft, F. (2010). Time-driven activity-based costing for a library acquisition process: A case study in a Belgian University. *Library Collections, Acquisitions, and Technical Services*, 34(2-3), 83-91.
- Sumrall, V.E. (2019). *Diffusion of Activity Based Costing (ABC) in Australian Universities: An Exploration of Drivers and Barriers of ABC Adoption*. Doctoral dissertation, Charles Darwin University.
- Turk, F.J. (1992). The ABCs of Activity-Based Costing: A Cost Containment and Reallocation Tool. *Business Officer*, 26(1), 36-43.
- Turney, P.B.B. (1991). Common cents: The ABC performance breakthrough. Beaverton, OR* Cost Technologies, Inc.

- Weaver-Meyers, P., Aldrich, D. and Seal, R.A. (1985). Circulation Service Desk Operations: Costing and Management Data. *College and Research Libraries*, 46(5), 418-431.
- Yakhou, M. and Ushafer, K. (2012). Adapting the balanced scorecard and activity-based costing to higher education institutions. *International Journal of Management in Education*, 6(3), 258-272.
- Young, M.E. and Geason, R.W. (1982). Cost Analysis and Overhead Charges at a Major Research University Proceedings of the Annual Forum of the Association for Institutional Research (22nd, Denver, CO, May 16-19).

Capital, coal, and change: modelling India's energy substitutability with a translog production framework

Tanzeem HASNAT

Lal Bahadur Shastri Institute of Management, India
tanzeem.hasnat91@gmail.com

Umer Jeelanie BANDAY

Indian Institute of Technology Delhi, India
ubanday@gmail.com

Abstract. *This study employs a Transcendental Logarithmic Production Function to analyze the substitutability among capital, labour, coal, and oil in India's economy from 1991 to 2023. Utilizing ridge regression to address multicollinearity, it reveals that all inputs positively contribute to output, with significant substitution possibilities among them—especially capital-coal, labour-oil, and coal-oil. The findings highlight the potential of technology-driven capital investment and skill development in enhancing energy sustainability. Policy implications emphasize the need for targeted energy pricing, investment in energy-efficient technologies, and strategic energy diversification to align economic growth with environmental sustainability.*

Keywords: energy consumption, economic growth, fossil fuels, production function, India.

JEL Classification: Q43, O13, C51.

1. Introduction

Energy consumption is a critical component of the global economy, accounting for 10% to 15% of total GDP. This significant contribution emphasizes the importance of both renewable and non-renewable energy resources in promoting economic growth and progress across a wide range of sectors. In India, energy plays an important role in enabling economic growth, backing the country's increasing industrialization and urbanization during the last several decades. As the world's third largest energy user, India's energy demands are crucial not only for economic development, but also for shifting to more sustainable energy use by improving capital efficiency.

Energy plays a crucial role in the survival and expansion of the global economy, as the production of goods and services is largely dependent on energy resources. This is especially true for developing nations, where sustainable energy is essential for both social and economic progress. However, increasing energy demand inevitably leads to a larger ecological footprint (Wang & Yang, 2020). The challenge of balancing energy needs with environmental stewardship is a persistent and critical issue for emerging economies (Lin & Raza, 2020). For a rapidly growing economy like India, fossil fuels remain a dominant source for meeting its energy demands (Wang et al., 2020). According to the International Energy Agency, nearly half (49%) of global CO₂ emissions from energy consumption come from emerging economies, largely driven by urbanization and industrialization (Paul & Bhattacharya, 2004). These patterns suggest a continued rise in energy-related CO₂ emissions in developing countries.

India is currently the third-largest energy consumer and CO₂ emitter globally, with emissions reaching 2,279 million tons in 2022. As shown in Table 1, there is a clear positive correlation between gross domestic product (GDP), CO₂ emissions, and energy consumption over the years (Alam et al., 2011; IEA, 2022; Citaristi, 2022; Banday and Kocoglu, 2023). This makes India a key case for examining inter-factor and inter-fuel substitution, the impact of energy use on economic growth, and the role of technological advancements in addressing these challenges (Stern, 2011; Apergis & Payne, 2010).

Table 1. *India's GDP, energy consumption and CO₂ emissions*

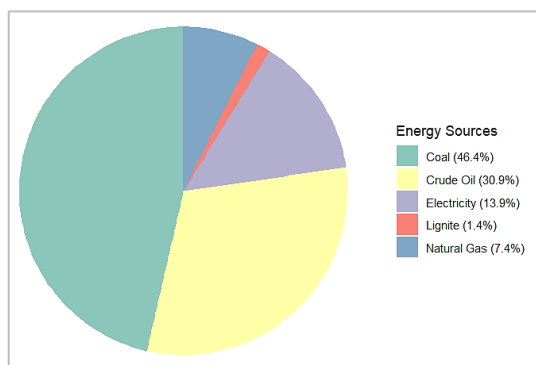
Year	GDP	Energy consumption	CO ₂ emissions
2013	9213017	26822	1804.585
2014	9801370	28453	1860.187
2015	10527674	29063	2026.904
2016	11369493	29713	2035.741
2017	12308193	30966	2067.426
2018	13144582	32712	2184.437
2019	13992914	32548	2316.24
2020	14534641	29807	2277.776
2021	13687118	33018	2074.646
2022	14925840	35159	2279.007

Source: Compiled by author based on data from Energy Statistics India.

This study aims to develop a translog production function that incorporates both energy and non-energy inputs, focusing on evaluating factor and interfuel substitution. Understanding India's current energy mix is essential, with coal remaining dominant (nearly 50%), followed by crude oil (31%), natural gas (7%), and electricity from hydro,

nuclear, and renewables (see Fig. 1). However, interfuel substitution must carefully balance the trade-offs between reducing emissions and minimizing import dependence.

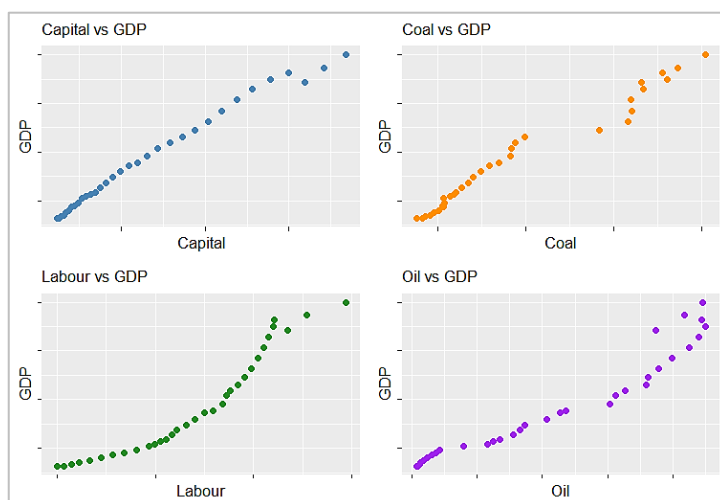
Figure 1. *Source wise split of energy consumption in India*



Source: Compiled by author based on data from Energy Statistics India.

The Indian Energy Statistics report for 2019 highlights the substantial availability of key energy resources such as coal, gas, oil, and electricity, as well as a significant rise in their demand. This increasing demand has contributed to CO₂ emissions, underscoring the importance of these resources in India's energy mix (IEA, 2019). In this context, the present study aims to estimate a production function for India's developing economy using a transcendental logarithmic (translog) form. The study investigates the potential for both inter-factor and inter-fuel substitution, focusing on energy and non-energy inputs from 1991 to 2023. The positive association between the gross domestic product (GDP) and key variables including capital, oil, coal, and labor, as shown in Fig. 2, highlights the relationship between economic growth and adverse environmental effects. Comprehending these correlations is vital in evaluating forthcoming energy requirements and molding policies for sustainable growth.

Figure 2. *Relationships Between GDP and Key Economic Variables*



Given India's growing population and energy demands, understanding future energy consumption depends heavily on estimating inter-factor production elasticities and inter-fuel substitution elasticities (Alam et al., 2011; Stern, 2011). Additionally, the study assesses the relative technical progress among production factors, which, when combined with elasticity estimates, can inform state policies on resource allocation for energy conservation and emission reduction (Apergis & Payne, 2010; Aneja et al., 2017). To achieve these objectives, the study constructs and estimates a translog production function, which offers flexibility in measuring elasticities, interaction effects, and the technical progress of production factors. The translog model is well-suited for analyzing these complex relationships, making it an efficient tool for understanding energy consumption patterns, interfuel substitution, and technological advancements in the Indian economy (Christensen et al., 1973; Berndt & Wood, 1975)

2. Literature Review

2.1. Substitutability among factors of production

An extensive examination of the foundational literature reveals two primary strands related to the substitutability of production factors. The first strand encompasses both conceptual and empirical studies aimed at understanding the substitutability among factors of production. This understanding is crucial for developing strategies to reduce reliance on certain inputs, particularly energy sources, by substituting them with labour or capital (Berndt & Wood, 1975; Magnus, 1979; Pindyck, 1979; Prywes, 1986). Such substitution can only be implemented when empirical evidence supports the notion of substitutability without any loss of output.

The implications of resource substitution extend to fuel prices, demand dynamics, and ultimately, output growth. A significant aspect that emerges from research conducted in both developing and developed countries is the ongoing debate surrounding the substitutability and complementarity of energy and non-energy inputs. For instance, Berndt and Wood (1975) identified a complementary relationship between capital and energy. In contrast, Pindyck (1979) found evidence supporting the idea that these factors serve as substitutes across ten nations. A subsequent body of literature has further explored this theme. Studies by Christopoulos (2000), Thompson and Taylor (1995), and Truong (1985) uphold the capital-energy substitutability hypothesis. Conversely, Anderson (1981), Fuss (1977), and Prywes (1986) provided evidence in favour of the capital-energy complementarity hypothesis. More recent analyses, such as those by Lin and Xie (2014), appear to shift the debate towards capital-energy substitution, primarily focusing on developed nations. Nevertheless, these findings contribute to a broader understanding of sustainable growth pathways that are less energy intensive.

The second strand addresses the substitution possibilities among four predominant traditional fuels: coal, natural gas, oil, and electricity. This analysis offers policymakers the flexibility to adjust the fuel energy profile of the economy, considering both production

efficiency and emission concerns (Halvorsen, 1977; Griffin, 1977; Vlachou & Samouilidis, 1986; Andrikopoulos et al., 1989; Taheri, 1994). Energy sources that are locally sourced or exhibit lower emission profiles could feasibly replace imported or environmentally detrimental energy alternatives without sacrificing output.

2.2. Importance of energy in key sectors

The critical role of energy in specific sectors such as construction, industrial heating, and heavy manufacturing cannot be overstated. Consequently, numerous studies investigate energy-non-energy substitutability and inter-energy substitution within sectors of various countries. Recent studies warrant attention in this context. For instance, Rehfeldt et al. (2018) examined industrial heat demand in Europe. Ma et al. (2018) focused on the commercial building sector in China. Huh et al. (2018) studied the cement industry in Korea. Wesseh Jr and Lin (2018) investigated energy dynamics in Egypt, while Liu et al. (2018) analyzed heavy industry in China. Additionally, Khalid and Jalil (2019), Wei et al. (2019), Lin and Xu (2019), Lin and Raza (2020), and Bello and Solarin (2022) have also contributed to this topic.

In the context of India, several studies have explored the energy mix's responsiveness to price changes. Uri (1979) analyzed the sensitivity of the energy mix from the 1960s to the 1970s across five sectors: transportation, manufacturing and mining, agriculture, government and commercial activities, and household consumption. This study employed a trans log cost function model incorporating capital, labor, and various energy sources, including oil, coal, and electricity. The findings indicated that energy consumption is price sensitive in the commercial sector. Shankar and Pachauri (1983) investigated the complementarity between energy and capital within India's manufacturing industries, providing evidence supporting the energy-capital complementarity hypothesis. Vashist (1984) and Sarkar and Roy (1995) also contributed to the discourse on inter fuel substitution. Recent research has expanded the focus on inter fuel substitution and energy elasticity in India. For example, Tiwari and Menegaki (2019) utilized a time-varying Kalman filter approach to assess electricity price elasticity in India from 1975 to 2013, revealing that electricity demand is influenced by foreign direct investment, trade, and supply-side factors.

While Adebayo et al. (2020), Usman et al. (2021), Apergis and Payne (2010), and Ouedraogo (2013) have studied renewable energy, economic growth, and energy efficiency, they have largely ignored the critical role of total energy consumption and its relationship with real capital (K) in achieving sustainability. Furthermore, past research has focused on certain sectors within various nations, but none has examined this interaction in the context of growing economies such as India. This is a scientific topic because understanding these processes is critical for policymakers looking to optimize energy consumption and promote sustainable development. Thus, the current study aims to address the literature gap by investigating the interfuel substantiation in Indian economy.

3. Data and Methodology

3.1. Variables and data sources

The dataset considered for this study spans yearly data on GDP, labour employment, capital stock, and the consumption of coal and petroleum (henceforth, referred to as Oil) in India from 1990 to 2023. These variables are chosen based on a production function where GDP depends on capital, labour, and energy, as underscored by coal and oil due to their predominance in India's energy supply. A difficult call is about the inclusion of electricity in the model. Logically, energy aspect of electricity is masked because other energy sources go as inputs in it and hence its inclusion could lead to double counting of energy sources and requires estimating additional parameters. To understand the importance of various sources of energy in India, electricity generated by hydro, nuclear and other renewable sources (ORS) is considered but not incorporated in the model of the production function. The amount of capital employed is assessed using capital stock. This, by definition, is a stock variable. The commonly disseminated data in this regard is that of capital formation, which is essentially 'investment', a flow variable (which accumulates to make a stock). The prevailing approach for gauging capital stock is the perpetual inventory method as given in equation (1):

$$K_t = K_{t-1} \cdot (1 - \delta) + I_t \quad (1)$$

Where K_t and K_{t-1} are the capital stock in year t and $t-1$ respectively, and δ and I_t are notations to denote depreciation rate of capital stock and the investments in year t respectively. Nevertheless, this approach has its own set of challenges, the most common being the determination of the initial capital stock, K_0 . Moreover, one must be cautious in choosing the rate of depreciation of the capital stock, δ . The present study adopts the approach of Berlemann and Wesselhoft (2014) and Lin and Ahmed (2016) for estimation of capital stock. They provide a working model for the estimation incorporating the insights from earlier studies by Nehru and Dhareshwar (1993), De la Fuente and Domenech (2000), and Kamps (2006). This unified approach leverages the strengths and addresses the weaknesses of the studies. While these earlier approaches share commonalities, they diverge notably in estimating the initial capital stock, K_{t-1} . For this, we follow Lin and Ahmed (2016) and Raza et al. (2021) by approximating the initial capital stock to be:

$$K_0 = \frac{I_0}{g + \delta} \quad (2)$$

where K_0 is the initial capital stock, I_0 represents the initial capital investment, 'g' is the computed growth rate of capital investment over the period of study, and 'δ' is depreciation. For the choice of δ , we follow the World Bank convention of a standard 5% depreciation rate. We apply the methodology proposed by Berlemann and Wesselhoft (2014) to estimate India's capital stock series. This estimation uses initial capital stock, depreciation rates, and investment rates from 1990-91 to 2022-23. A detailed overview of the variables is provided in Table 2.

Table 2. *Description of variables*

Variables	Units	Source
GDP (Y_t)	Rupees crore	RBI Handbook of Statistics
Capital Stock (K_t)	Rupees crore	RBI Handbook of Statistics
Labour (L_t)	Millions	Labour and Employment Statistics, MOSPI
Coal (C_t)	Petajoules	Energy Statistics
Oil (O_t)	Petajoules	Energy Statistics

Source: Computed by author.

3.2. Methods

The techniques employed to gauge the substitutability of factor inputs primarily rely on production functions. Research indicates the usage of CES (Constant Elasticity of Substitution) production functions as well as flexible production functions for empirical examination of the capital – energy substitution hypothesis (Koetse et al. (2008)). Flexible production functions yield flexibility to estimates of substitution parameters. Among the class of flexible production functions, the trans-log production function primarily introduced by Christensen et al. (1973) is widely favoured. Numerous studies in the field utilize this function due to its advantages over the CES production function (Considine (1989), Jones (1995), Bataille (1999)).

In accordance with the principles of duality theory, research in the field has utilized either the trans log cost function or the trans-log production function. In microeconomic theory, the dual for a trans-log production function is the trans-log cost function. This duality implies that all the essential information captured in a trans-log cost function is obtainable from the trans-log production function (Debertin and Pagoulatos, 1985). The choice between the two then comes down to the availability of requisite parameters underlying the two models. For the trans-log cost function, this set is input prices and the resulting output produced. Adeyemo et al. (2007), Penphanussak and Wongsapai (2008) and Ma et al. (2008) opted for the trans-log cost function to estimate the elasticities of substitution or complementarity between input factors. They favoured it perhaps because it incorporates information on input prices, which leads to a straightforward computation of own-price and cross-price elasticities. However, in many cases, aggregated data on factor prices such as wages, rents, and energy costs are not available for large datasets. Consequently, some studies relied on its dual counterpart, namely the trans-log production function (Smyth et al. (2011), Lin and Wesseh (2013), Wesseh et al. (2013)). Following suit, we adopt the trans-log production function in our study due to the unavailability of input price data for the sample.

A production function takes the following general form:

$$Y_t = f(K_t, L_t, C_t, O_t) \quad (3)$$

Where Y_t , K_t , L_t , C_t , and O_t represent output produced, capital stock, labour employed, coal consumption and oil consumption in India, respectively. As suggested by the literature, the trans-log production function is given in equation (4):

$$\begin{aligned} \ln Y_t = & \varepsilon + \beta_K \ln K_t + \beta_L \ln L_t + \beta_C \ln C_t + \beta_O \ln O_t + \beta_{KL} \ln K L_t + \beta_{KC} \ln K C_t \\ & + \beta_{KO} \ln K O_t + \beta_{LO} \ln L O_t + \beta_{LC} \ln L C_t + \beta_{OC} \ln O C_t \\ & + \beta_{KK} (\ln K_t)^2 + \beta_{LL} (\ln L_t)^2 + \beta_{CC} (\ln C_t)^2 + \beta_{OO} (\ln O_t)^2 \end{aligned} \quad (4)$$

We differentiate equation (4) with respect to the natural log of K_t , L_t , C_t , and O_t to obtain the output elasticity with respect to capital, labour, coal, and oil. The partial differentials are presented in equation, (5), (6), (7) and (8) respectively.

$$\theta K = \frac{dY/Y}{dK/K} = \frac{d\ln Y_t}{d\ln K_t} = \beta_K + \beta_{KL}\ln L_t + \beta_{KC}\ln C_t + \beta_{KO}\ln O_t + 2\beta_{KK}\ln K_t \quad (5)$$

$$\theta L = \frac{dY/Y}{dL/L} = \frac{d\ln Y_t}{d\ln L_t} = \beta_L + \beta_{KL}\ln K_t + \beta_{LC}\ln C_t + \beta_{LO}\ln O_t + 2\beta_{LL}\ln L_t \quad (6)$$

$$\theta C = \frac{dY/Y}{dC/C} = \frac{d\ln Y_t}{d\ln C_t} = \beta_C + \beta_{CK}\ln K_t + \beta_{LC}\ln L_t + \beta_{CO}\ln O_t + 2\beta_{CC}\ln C_t \quad (7)$$

$$\theta O = \frac{dY/Y}{dO/O} = \frac{d\ln Y_t}{d\ln O_t} = \beta_O + \beta_{KO}\ln K_t + \beta_{LO}\ln L_t + \beta_{CO}\ln C_t + 2\beta_{OO}\ln O_t \quad (8)$$

The estimates of the elasticity of substitution between various pairs of factor inputs, which would indicate the level of substitutability/complementarity can be obtained using the above partial differential expressions. The resultant elasticity estimates give the change in the input factors mix relative to a unit change in the marginal rate of technical substitution. In theory, it captures how the substitution between input factors changes contingent upon the price change of one input. The elasticity of substitution assumes a value ranging from zero to infinity, where a zero shows no possible substitutability between factors (often the case with fixed input proportions) while infinity or practically large value indicates perfect substitutability. For the specific case of capital and labour, the elasticity of substitution can be expressed as:

$$\sigma_{KL} = \frac{d\left(\frac{K}{L}\right)}{\frac{K}{L}} \left[\frac{d\left(\frac{MPP_L}{MPP_K}\right)}{\left(\frac{MPP_L}{MPP_K}\right)} \right]^{-1} = \frac{d\left(\frac{K}{L}\right)}{d\left(\frac{MPP_K}{MPP_L}\right)} \cdot \frac{\left(\frac{MPP_L}{MPP_K}\right)}{\left(\frac{K}{L}\right)} \quad (9)$$

Where MPP_K and MPP_L depict marginal productivity of capital and labour respectively.

Furthermore, it is known that

$$\frac{MPP_L}{MPP_K} = \frac{\partial Y / \partial L}{\partial Y / \partial K} = \frac{\theta L}{\theta K} \cdot \frac{K}{L} \quad (10)$$

Combining (9) and (10), we get the equation (11) as:

$$\sigma_{KL} = \frac{d\left(\frac{K}{L}\right)}{d\left(\frac{MPP_L}{MPP_K}\right)} \cdot \frac{\theta L}{\theta K} = \frac{\theta L}{\theta K} \cdot \left[\frac{d\left(\frac{MPP_L}{MPP_K}\right)}{d\left(\frac{K}{L}\right)} \right]^{-1} = \frac{\theta L}{\theta K} \cdot \left[\frac{d\left(\frac{\theta L}{\theta K} \frac{K}{L}\right)}{d\left(\frac{K}{L}\right)} \right]^{-1} \quad (11)$$

We also know that

$$\left[\frac{d\left(\frac{\theta L}{\theta K} \frac{K}{L}\right)}{d\left(\frac{K}{L}\right)} \right] = \frac{\theta L}{\theta K} + \frac{K}{L} \cdot \frac{d\left(\frac{\theta L}{\theta K}\right)}{d\left(\frac{K}{L}\right)} \quad (12)$$

$$d\left(\frac{\theta L}{\theta K}\right) = -\frac{\theta L}{\theta K} \cdot d\theta K + \frac{1}{\theta K} \cdot d\theta L \quad (13)$$

$$d\left(\frac{K}{L}\right) = -\frac{K}{L^2} \cdot dL + \frac{1}{L} \cdot dK \quad (14)$$

Combining (12), (13) and (14), we get the formal expressions for elasticity of substitution between capital and labour as:

$$\sigma_{KL} = \left[1 + \left[-\beta_{KL} + \left(\frac{\theta K}{\theta L}\right) \cdot \beta_{LL} \right] \cdot (-\theta K + \theta L)^{-1} \right]^{-1} \quad (15)$$

Similarly, the expression for elasticity of substitution between other pair of factor inputs, viz. capital-coal, capital-oil, labour-coal, labour-oil and coal-oil, can be worked out as under:

$$\sigma_{KC} = \left[1 + \left[-\beta_{KC} + \left(\frac{\theta K}{\theta C}\right) \cdot \beta_{CC} \right] \cdot (-\theta K + \theta C)^{-1} \right]^{-1} \quad (16)$$

$$\sigma_{KO} = \left[1 + \left[-\beta_{KO} + \left(\frac{\theta K}{\theta O}\right) \cdot \beta_{OO} \right] \cdot (-\theta K + \theta O)^{-1} \right]^{-1} \quad (17)$$

$$\sigma_{LC} = \left[1 + \left[-\beta_{LC} + \left(\frac{\theta L}{\theta C}\right) \cdot \beta_{CC} \right] \cdot (-\theta L + \theta C)^{-1} \right]^{-1} \quad (18)$$

$$\sigma_{LO} = \left[1 + \left[-\beta_{LO} + \left(\frac{\theta L}{\theta O}\right) \cdot \beta_{OO} \right] \cdot (-\theta L + \theta O)^{-1} \right]^{-1} \quad (19)$$

$$\sigma_{CO} = \left[1 + \left[-\beta_{CO} + \left(\frac{\theta C}{\theta O}\right) \cdot \beta_{OO} \right] \cdot (-\theta C + \theta O)^{-1} \right]^{-1} \quad (20)$$

The possibility of Inter-factor and inter-fuel substitution necessitates the elasticity of substitution to be a positive number.

Usually, the model is estimated using the ordinary least squares (OLS) technique. However, due to the presence of numerous explanatory variables in the trans-log production function, there is a heightened risk of significant multicollinearity, as noted by Pavelescu (2011). Multicollinearity poses challenges in estimation by increasing the variance of the obtained OLS estimates, thereby compromising the efficiency of the parameters. To address this issue, we opt for a slight modification of the OLS method by applying L2 transformation to the OLS.

The L2 transformation, also known as the Ridge transformation, pioneered by Hoerl and Kennard (1970), is a technique used in regression analysis to handle multicollinearity and reduce the variance of parameter estimates. In the context of ridge regression, the L2 transformation adds a penalty term to the ordinary least squares (OLS) objective function. This penalty term is proportional to the square of the magnitude of the coefficients, hence the term L2, and it is scaled by a parameter λ , which controls the amount of shrinkage applied to the coefficients.

Now, the objective function of L2 transformed OLS, or the ridge regression can be expressed as:

$$\text{minimise } \left\{ \sum_{i=1}^n (y_i - \beta_0 - \beta_1 x_{i1} - \beta_2 x_{i2} - \dots - \beta_p x_{ip})^2 + \lambda \sum_{j=1}^p \beta_j^2 \right\} \quad (21)$$

Here, the first term is the ordinary least squares (OLS) residual sum of squares, and the second term is the penalty term added to it. The λ parameter is a tuning parameter that determines the trade-off between fitting the data well and keeping the coefficients small. As is evidenced from the above objective function, increasing λ increases the amount of shrinkage applied to the coefficients, which can help mitigate multicollinearity but may also lead to bias in the parameter estimates.

In practice, several methods are employed to arrive at the optimal value of λ . The most common one is the Ridge Trace Plot, which has been used in this paper. This method involves iteratively estimating the coefficients of the model for various values of λ and observing how they change with increasing regularization. The goal is to find the level of regularization (λ) that strikes a balance between reducing model complexity and preserving predictive accuracy. By examining the plot of coefficients against λ values, one can identify the point at which the coefficients stabilize, indicating that further regularization may not be necessary. Additionally, if any coefficients exhibit incorrect signs according to theoretical expectations, adjustments can be made to ensure their correctness.

Moreover, the study performs Cross Validation exercise to yield the optimal value of λ . Cross Validation is a method commonly used for selecting the optimal value of the tuning parameter in ridge regression. Here, the data is divided into k subsets, or folds, of approximately equal size. For each fold, a ridge regression model is trained on the remaining $k-1$ folds. The model is then validated on the fold that was left out. The process is repeated k times, each time using a different fold as a validation set. The performance of the model is evaluated using the relevant metric, here, the mean squared error (MSE), on each validation set. The average performance across all folds is calculated for each candidate value of λ . The value of λ that minimizes the average error is selected as the optimal tuning parameter. Cross-validation helps to ensure that the model's performance is robust and not dependent on the specific partitioning of the data. By systematically rotating through different subsets of the data for training and validation, cross-validation provides a more reliable estimate of how the model will perform on unseen data.

4. Results

A considerable number of parameters need to be estimated in equation (4) and this raises a potential existence of high multicollinearity. Hence, we follow the standard procedure suggested by Kmenta (1986) to diagnose the possible existence of multicollinearity in the model. Primarily, it suggests running auxiliary regressions, those are regressions of each independent variable (capital, labour, coal, and oil) on the remaining independent variables. The set of obtained coefficients of determination (R^2) for these auxiliary regressions would indicate the extent of multicollinearity. High R^2 values for many auxiliary regressions indicate multicollinearity. We run four auxiliary regressions which yield the four R^2 values as: 0.976, 0.943, 0.978, and 0.997. Also, we estimate the variance inflation factor (VIF) for each variable in these models and all values are greater than 10. This further confirms the presence of significant multicollinearity.

Furthermore, employing the ordinary least squares (OLS) estimation technique to estimate equation (4) reveals that while all parameter estimates collectively exhibit a significant effect on output, only 65% of the individual estimates turn out to be statistically insignificant. Additionally, half of the estimates display incorrect signs, contradicting economic theory. These findings confirm the presence and severity of multicollinearity and necessitate a remedy, namely ridge regression.

4.1. Results of ridge regression model

The most pertinent question at the onset is the optimal value of the ridge penalty parameter, λ . For this we resort to the Figure 3 which depicts Cross Validated Mean Squared Errors across various folds of iterations. We supplant it with the standard practice of a Ridge Trace Plot as given in Figure 4. The optimal λ value turns out 0.025. This is the value that minimises the Mean Squared Error and the coefficients are stabilised as shown by the Ridge Trace Plot.

Figure 3. Plot of Mean Squared Error against penalty parameter

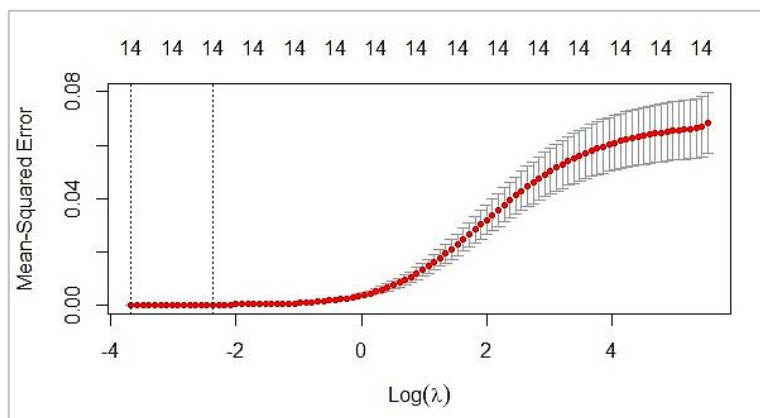
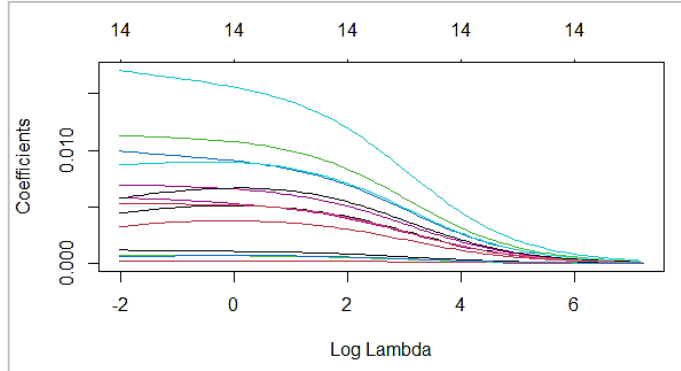


Figure 4. Ridge Trace Plot

Source: Generated by author.

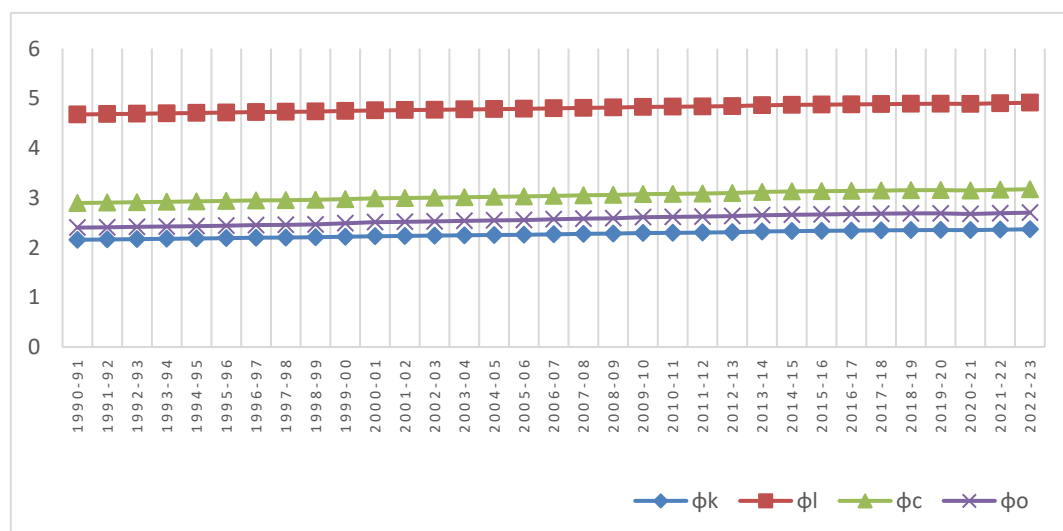
In this study, we do not present the standard errors or significance values of the coefficients obtained from our ridge regression analysis. This decision is based on the understanding that standard errors in ridge regression are often less reliable. Instead, we focus on robust techniques and align our findings with economic theory to validate the generated coefficients. To ensure the reliability of our estimates, we conducted a cross-validation exercise, which confirmed that the coefficients displayed their expected economic signs. The model effectively addresses the issue of multicollinearity, and the regression coefficients are consistently positive, in line with economic theory, indicating increasing returns to scale for all input factors. Additionally, both the cross-influence and square-influence estimates are positive, reinforcing the reasonableness of our ridge regression parameters. These results are summarized in Table 3.

Table 3. Results of Ridge regression model

Ridge regression with $\lambda = 0.025$														
R square= 0.8501														
SS=32.841														
MS=2.127														
F value = 15.31														
Sig F = 0.00														
Var	lnK	lnL	lnC	lnO	lnKlnK	lnLlnL	lnClnC	lnOlnO	lnKlnL	lnKlnC	lnKlnO	lnLlnC	lnLlnO	lnClnO
Coeff	0.06	0.20	0.08	0.04	0.004	0.01	0.006	0.01	0.005	0.007	0.005	0.009	0.006	0.01

4.2. Output elasticities and elasticities of substitution

Equations (5) to (8) are utilized to estimate output elasticities concerning input factors. These elasticities are depicted in Figure 5 and summarized in Table 4.

Figure 5. Output elasticity of factor inputs

Source: Computed by author.

Table 4. Output elasticities of capita, labour, coal, and oil

Year	ϕ_k	ϕ_l	ϕ_c	ϕ_o
1990-91	2.155572	4.674932	2.894997	2.400433
1991-92	2.162403	4.682752	2.903565	2.406467
1992-93	2.169015	4.690007	2.911651	2.414845
1993-94	2.175189	4.697121	2.919382	2.42152
1994-95	2.181831	4.70529	2.927983	2.430256
1995-96	2.188648	4.713643	2.936827	2.43905
1996-97	2.19596	4.722523	2.946661	2.450253
1997-98	2.20046	4.727991	2.951435	2.456026
1998-99	2.20641	4.735203	2.958787	2.464314
1999-00	2.216457	4.746346	2.973019	2.48805
2000-01	2.226854	4.757429	2.988448	2.510037
2001-02	2.232524	4.763151	2.995185	2.517272
2002-03	2.237956	4.768669	3.001805	2.525072
2003-04	2.244809	4.77585	3.011063	2.536535
2004-05	2.251347	4.782776	3.019748	2.545454
2005-06	2.256907	4.788949	3.026422	2.551859
2006-07	2.265854	4.798746	3.038948	2.567976
2007-08	2.273515	4.8071	3.049044	2.579151
2008-09	2.280256	4.814617	3.057774	2.587379
2009-10	2.291071	4.826418	3.073688	2.609513
2010-11	2.295463	4.830279	3.07824	2.614354
2011-12	2.300709	4.835078	3.084251	2.621043
2012-13	2.307952	4.842777	3.093942	2.632347
2013-14	2.322519	4.860378	3.11736	2.649637
2014-15	2.329847	4.868581	3.127711	2.659105
2015-16	2.334535	4.873288	3.13328	2.665793
2016-17	2.338896	4.877452	3.138228	2.672633
2017-18	2.344061	4.882744	3.144711	2.679044
2018-19	2.35017	4.889183	3.152848	2.6863
2019-20	2.352198	4.890203	3.153856	2.68667

Year	ϕ_k	ϕ_l	ϕ_c	ϕ_o
2020-21	2.349565	4.88783	3.146864	2.673973
2021-22	2.358697	4.899428	3.160645	2.688935
2022-23	2.366956	4.911966	3.172609	2.700746
Mean	2.265594	4.797839	3.039121	2.561577
Standard Deviation	0.066477	0.072779	0.088236	0.099545

Source: Computed by authors.

All obtained output elasticities are positive with the highest value obtained for labour, followed by coal and then oil. The input consumption shows a rising trend as is evident from the positive values of the elasticities. Simply put, it underscores heavily reliance of India's output growth on greater labour utilization and increased energy consumption. These estimated output elasticities are then employed to obtain the elasticities of substitution for all pairs of inputs following equations (15) to (20). The estimated values for the same can be found in Table 5.

Table 5. Elasticities of substitution between factor inputs

Year	σ_{kl}	σ_{ko}	σ_{kc}	σ_{lc}	σ_{lo}	σ_{co}
1990-91	1.003907	0.878761	1.031582	1.007537	1.065832	1.045895
1991-92	1.003878	0.878222	1.031491	1.007537	1.065692	1.045772
1992-93	1.003878	0.879114	1.031408	1.007537	1.065534	1.04561
1993-94	1.003822	0.879306	1.031327	1.00733	1.065395	1.045479
1994-95	1.003795	0.880362	1.031235	1.00733	1.065226	1.045311
1995-96	1.003795	0.881336	1.031141	1.00733	1.065057	1.045144
1996-97	1.003738	0.883294	1.031033	1.007107	1.064858	1.044934
1997-98	1.00372	0.883894	1.030993	1.007107	1.064749	1.044828
1998-99	1.00372	0.885014	1.030919	1.007107	1.064598	1.044675
1999-00	1.003653	0.891533	1.03076	1.00689	1.064263	1.044255
2000-01	1.003607	0.896582	1.030583	1.00689	1.063954	1.043871
2001-02	1.003607	0.897179	1.03052	1.00689	1.063834	1.043743
2002-03	1.003558	0.898112	1.030456	1.006625	1.063713	1.043607
2003-04	1.003528	0.899934	1.030359	1.006625	1.063544	1.043409
2004-05	1.003528	0.900816	1.03027	1.006625	1.063402	1.043254
2005-06	1.003476	0.901084	1.030208	1.006412	1.063289	1.043143
2006-07	1.003439	0.903781	1.030075	1.006412	1.063062	1.042873
2007-08	1.003439	0.905018	1.029974	1.006412	1.062892	1.042685
2008-09	1.003379	0.905489	1.029888	1.006142	1.062755	1.042546
2009-10	1.003334	0.909435	1.029718	1.006142	1.062473	1.04219
2010-11	1.003334	0.909537	1.029683	1.006142	1.062399	1.04211
2011-12	1.003289	0.909971	1.029632	1.005908	1.062304	1.042002
2012-13	1.003259	0.911267	1.029536	1.005908	1.062148	1.041822
2013-14	1.003259	0.912	1.029278	1.005908	1.061856	1.041531
2014-15	1.003174	0.912617	1.029174	1.005529	1.061712	1.041379
2015-16	1.003154	0.913213	1.029126	1.005529	1.061621	1.041275
2016-17	1.003154	0.91396	1.029086	1.005529	1.061535	1.041171
2017-18	1.003113	0.914296	1.029028	1.005391	1.061442	1.041071
2018-19	1.003088	0.914586	1.028951	1.005391	1.061333	1.040956
2019-20	1.003088	0.914035	1.028954	1.005391	1.06132	1.040949
2020-21	1.003089	0.910764	1.029047	1.005403	1.061425	1.041136
2021-22	1.003056	0.912591	1.028905	1.005403	1.061215	1.040905
2022-23	1.003056	0.913641	1.028786	1.005403	1.061019	1.040723
Mean	1.003452	0.900023	1.030095	1.006389	1.063195	1.043038
Standard Deviation	0.000279	0.013237	0.000895	0.000752	0.001533	0.001702

Source: Computed by authors.

The computations illustrate that all pairs of substitution elasticities exhibit positive signs and are close to unity, indicating substitutability among all inputs. Particularly high substitutability is observed between capital and coal, labour and oil, as well as coal and oil. These substitution dynamics are crucial for augmenting power generation capacities, fostering conservation, ensuring environmental sustainability, and enhancing energy security. Conversely, the substitution between labour and energy is pivotal for any meaningful exercise geared towards conserving energy and generating employment.

5. Discussions

In the literature, various studies like Berndt and Wood (1975), Fuss (1977), and others suggest capital and energy to be complementary inputs. On the other hand, there are studies that recognise them as substitutes, like the ones by Griffin and Gregory (1976) and Pindyck (1979). The present study finds a positive and close-to-unity substitution elasticity between capital and energy throughout the entire sample period. This finding aligns with similar results obtained by Medina and Vega-Cervera (2001) in their study on Portugal, Italy, and Spain, Smyth et al. (2011) studying Chinese iron and steel sector, and Wesseh et al. (2013) for Liberia. This observed substitutability between energy and capital hints at the fruitful results of increasing investment, particularly when this investment is made in energy-saving technology, complemented by curbing of energy subsidies and energy price ceilings (Wesseh et al., 2013). The adoption of true energy prices is expected to stimulate technological innovation and encourage the implementation of capital-intensive methods geared towards conserving energy.

The inter fuel substitutability, that is coal-oil substitutability, has environmental and Balance of Payment ramifications for India. On the one hand, oil swells import bill whereas coal doesn't, as it is mostly domestically sources. On the other, the environmental emissions are higher for coal as compared to oil. So, even though the study finds evidence for inter fuel substitutability, a rational call on practical substitution would require weighing in all the angles well.

The trend indicating a slightly increasing substitutability between energy and labour over time suggests that the substitution is efficient. Therefore, it becomes crucial for the government to prioritize investment in the labour market, particularly by improving the education and skills of the workforce, with a focus on efficient energy use. Enhancing the knowledge and skills of workers not only increases labour productivity but also promotes better energy efficiency and conservation (Mukherjee (2008)). This relationship is further supported by the following points:

1. Higher labour productivity contributes directly to increased overall output (Schurr (1983)).
2. Improvements in technical and managerial skills among workers and entrepreneurs help in minimizing energy waste.
3. Skilled labourers understand energy usage better and can effectively employ energy-efficient technologies (Mandal and Madheswaran (2011)).

Lin and Ouyang (2014) and Lin and Zhang (2013) noted similar findings in their studies, highlighting the significance of investing in the labour market to achieve energy conservation objectives.

5.1. Scenario analysis

The elasticity of substitution between capital and energy holds practical significance, particularly in scenario analyses aimed at estimating potential energy conservation and reducing CO₂ emissions. We conduct scenario analyses by considering increased investments in energy-saving technologies by 5% and 10%. The results, presented in Table 6, outline the potential for energy conservation and CO₂ emission reduction under various investment scenarios for the year 2021.

While the differences in potential energy conservation and CO₂ emission reduction between coal and oil are not substantial, the findings underscore the critical importance of investing in energy-saving technologies in both sectors. Coal is noted for its high pollution intensity, while India faces heavy import reliance in case of oil. This highlights the necessity of directing efforts towards improving energy efficiency across these sectors.

Table 6. Energy conservation and the CO₂ emission reduction in 2021 under different scenarios

Scenarios	Increase of energy saving technology by	Coal		Oil	
		Conservation (in petajoules)	CO ₂ emission reduction (Mt)	Conservation (in petajoules)	CO ₂ emission reduction (Mt)
1	5%	932.4	74.12	517.1	24.44
2	10%	1864.8	148.25	1034.2	48.87

Source: Computed by author.

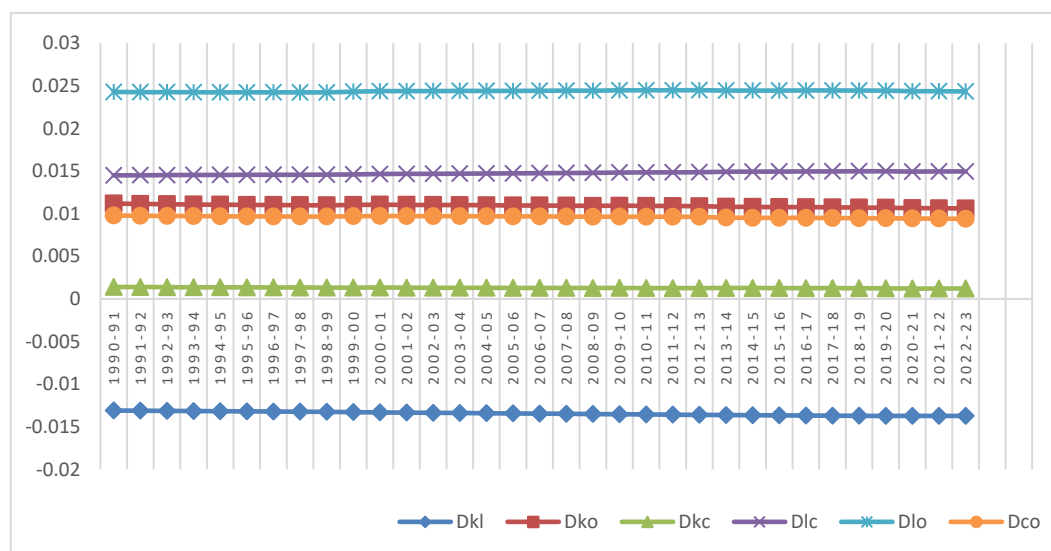
5.2. Relative difference in input technical progress

In this study, we also investigate the varying rates of technical advancement between pairs of energy and non-energy input factors. To do so, we make use of the trans-log production function of the Indian economy, which combines the output elasticities and estimated coefficients of equation (4). Following the methodologies outlined by Smyth et al. (2012), Lin and Wesseh (2013), and Raza et al. (2021) the function employed for this analysis is expressed as:

$$D_{ij} = \frac{B_i}{\phi_i} - \frac{B_j}{\phi_j} \quad (22)$$

Where D_{ij} quantifies the difference in technical progress between input i and input j , and B_i and B_j are the estimated coefficients derived from equation (4). ϕ_i and ϕ_j denote the current state of technical knowledge of inputs ' i ' and ' j '. A positive D_{ij} indicates that the rate of technical progress for input ' i ' surpasses that of input ' j ', while a negative D_{ij} suggests the opposite. If D_{ij} equals zero, it signifies that technical progress for both inputs' advances at an identical pace.

We plot the outcomes of equation (22) in Figure 6. The analysis reveals slight discrepancies in the relative technical progress among the four inputs.

Figure 6. *Difference in technical progress between pairs of factor inputs*

As seen in the time plot, the differences are minimal, and the convergence pattern indicates efficient progression of inputs over time. The figure shows that advancements in technology for capital and coal occur at a similar pace, as their technical progress disparity remains negligible. On the other hand, the capital-labour pair consistently shows a slight negative value across the sample period, suggesting that the technical progress in capital slightly outpaces that of labour. In contrast, labour demonstrates greater technical progress than the two energy sources. The convergence trend in technical progress differences across all pairs of input factors is indicative of potential opportunities for substitution in the future. This implies that adjustments in input combinations could be considered to enhance efficiency and productivity.

6. Conclusions and policy recommendations

The study employs a transcendental logarithmic production function to examine technological changes and potential substitutions among capital, labour, coal, and oil in India from 1991 to 2023. Detecting multicollinearity, the study applies ridge regression, employing the L2 transformation to estimate the production function. The study uncovers four main findings.

Firstly, positive output elasticities for all inputs indicate increasing consumption over time, highlighting their role in fostering economic growth. Secondly, all four inputs exhibit substitutability, particularly noticeable between specific pairs like capital-coal, labour-coal, and oil-coal. Capital-energy substitution, the first pair, suggests that investing in energy-saving technologies and phasing out energy subsidies could encourage capital-intensive production methods. The second pair, labour-energy substitution, indicates that enhancing worker knowledge and skills may promote energy conservation. Thirdly, inter-fuel

substitution potential exists between oil and coal but requires consideration of balance of payments and environmental implications associated with each energy source.

Lastly, the study identifies convergence in technical progress differences among factor input pairs, indicating significant substitutability between capital and labour for energy. Technological advancements in any input could potentially elevate its dominance over time. This convergence suggests a focus on enhancing capital in other factor inputs to support alternative energy sources and diversify the energy supply mix.

In summary, these findings provide insights for policymakers to design effective price-based policies, rationalize tariffs and subsidies, formulate growth strategies focused on physical and human capital, and develop environmental policies focused on energy efficiency and conservation. They underscore the importance of advancing technology, fostering a skilled labour force, and promoting a diversified energy supply mix. However, limitations include the specificity of the trans-log production function, potential efficiency losses from numerous parameters despite a small ridge penalty (0.025), and the exclusion of variables like electricity consumption, suggesting opportunities for future research and model refinement.

Author Contributions: This paper is a collaborative effort between both authors. T.H. contributed to the conceptualization, data analysis, methodology, and estimations, while U.J.B. was responsible for the methodology, discussion, literature review, introduction, and editing. Both authors have reviewed and approved the final version of the manuscript for publication.

Funding: No funding was received for this research.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

- Apergis, N., and Payne, J.E. (2010). The emissions, energy consumption, and growth nexus: evidence from the commonwealth of independent states. *Energy policy*, 38(1), 650-655.
- Adeyemo, O.O., Mabugu, R., and Hassan, R.H. (2007). Interfuel substitution: the case of the Nigerian industrial sector. *Journal of Energy in Southern Africa*, 18(1), 39-50.
- Aneja, R., Banday, U.J., Hasnat, T., and Koçoglu, M. (2017). Renewable and non-renewable energy consumption and economic growth: empirical evidence from panel error correction model. *Jindal Journal of Business Research*, 6(1), 76-85.
- Alam, M.J., Begum, I.A., Buysse, J., Rahman, S., and Van Huylenbroeck, G. (2011). Dynamic modeling of causal relationship between energy consumption, CO2 emissions and economic growth in India. *Renewable and Sustainable Energy Reviews*, 15(6), 3243-3251.

- Andrikopoulos, A.A., Brox, J.A., and Paraskevopoulos, C.C. (1989). Interfuel and interfactor substitution in Ontario manufacturing, 1962-82. *Applied Economics*, 21(12), 1667-1681.
- Bataille, C. (1999). Capital for energy and inter-fuel elasticities of substitution from a technology simulation model: estimating the cost of greenhouse gas reduction. *Master of Natural Resources Management Research Project, Report*, (226).
- Banday, U.J., and Kocoglu, M. (2023). Modelling simultaneous relationships between human development, energy, and environment: Fresh evidence from panel quantile regression. *Journal of the Knowledge Economy*, 14(2), 1559-1581.
- Bello, M.O., and Solarin, S.A. (2022). Searching for sustainable electricity generation: The possibility of substituting coal and natural gas with clean energy. *Energy & Environment*, 33(1), 64-84.
- Berlemaun, M., and Wesselhöft, J.E. (2014). Estimating aggregate capital stocks using the perpetual inventory method: A survey of previous implementations and new empirical evidence for 103 countries. *Review of Economics*, 65(1), 1-34.
- Berndt, E.R., and Wood, D.O. (1975). Technology, prices, and the derived demand for energy. *The review of Economics and Statistics*, 259-268.
- Citaristi, I. (2022). International energy agency—iea. In *The Europa directory of international organizations 2022* (pp. 701-702). Routledge.
- Christensen, L.R., Jorgenson, D.W., and Lau, L.J. (1973). Transcendental logarithmic production frontiers. *The review of economics and statistics*, 28-45.
- Considine, T.J. (1989). Separability, functional form and regulatory policy in models of interfuel substitution. *Energy Economics*, 11(2), 82-94.
- de La Fuente, A., and Donénech, R. (2000). Human Capital in Growth Regressions: How Much Difference Does Data Quality Make? Economics Department Working Papers No. 262. *Working Papers-Organisation for Economic Cooperation and Development Economics Department*.
- Debertin, D.L., and Pagoulatos, A. (1985). Contemporary production theory, duality, elasticities of substitution, the translog production function and agricultural research.
- Fuss, M.A. (1977). The demand for energy in Canadian manufacturing: An example of the estimation of production structures with many inputs. *Journal of econometrics*, 5(1), 89-116.
- Griffin, J.M. (1977). Inter-fuel substitution possibilities: a translog application to intercountry data. *International Economic Review*, 755-770.
- Griffin, J.M. (1993). Methodological advances in energy modelling: 1970-1990. *The Energy Journal*, 14(1), 111-124.
- Griffin, J.M., and Gregory, P.R. (1976). An intercountry translog model of energy substitution responses. *The American economic review*, 66(5), 845-857.
- Halvorsen, R. (1977). Energy substitution in US manufacturing. *The Review of Economics and Statistics*, 381-388.
- Hoerl, A.E., and Kennard, R.W. (1970). Ridge regression: applications to nonorthogonal problems. *Technometrics*, 12(1), 69-82.
- Huh, S.Y., Lee, H., Shin, J., Lee, D., and Jang, J. (2018). Inter-fuel substitution path analysis of the Korea cement industry. *Renewable and Sustainable Energy Reviews*, 82, 4091-4099.
- International Energy Agency (IEA), 2022. *India Energy Outlook 2022*. IEA Publications, Paris.

- IEA, I. (2020). Energy policy review. *International Energy Agency*.
- Jones, C.T. (1995). A dynamic analysis of interfuel substitution in US industrial energy demand. *Journal of Business & Economic Statistics*, 459-465.
- Kamps, C. (2006). New estimates of government net capital stocks for 22 OECD countries, 1960–2001. *IMF staff papers*, 53, 120-150.
- Khalid, W., and Jalil, A. (2019). An econometric analysis of inter-fuel substitution in energy sector of Pakistan. *Environmental Science and Pollution Research*, 26, 17021-17031.
- Kmenta, J. (1986). Elements of Econometrics Macmillan Publishing Co. *New York*.
- Koetse, M.J., De Groot, H.L., and Florax, R.J. (2008). Capital-energy substitution and shifts in factor demand: A meta-analysis. *Energy economics*, 30(5), 2236-2251.
- Lin, B., and Ahmad, I. (2016). Technical change, inter-factor and inter-fuel substitution possibilities in Pakistan: a trans-log production function approach. *Journal of cleaner production*, 126, 537-549.
- Lin, B., and Ouyang, X. (2014). Electricity demand and conservation potential in the Chinese nonmetallic mineral products industry. *Energy Policy*, 68, 243-253.
- Lin, B., and Raza, M.Y. (2020). Analysis of energy security indicators and CO2 emissions. A case from a developing economy. *Energy*, 200, 117575.
- Lin, B., and Raza, M.Y. (2020). Energy substitution effect on transport sector of Pakistan: A trans-log production function approach. *Journal of Cleaner Production*, 251, 119606.
- Lin, B., and Wesseh Jr, P.K. (2013). Estimates of inter-fuel substitution possibilities in Chinese chemical industry. *Energy economics*, 40, 560-568.
- Liu, K., Bai, H., Wang, J., and Lin, B. (2018). How to reduce energy intensity in China's heavy industry—Evidence from a seemingly uncorrelated regression. *Journal of cleaner production*, 180, 708-715.
- Ma, H., Oxley, L., Gibson, J., and Kim, B. (2008). China's energy economy: Technical change, factor demand and interfactor/interfuel substitution. *Energy economics*, 30(5), 2167-2183.
- Ma, T., Wu, J., Hao, L., Lee, W. J., Yan, H., and Li, D. (2018). The optimal structure planning and energy management strategies of smart multi energy systems. *Energy*, 160, 122-141.
- Magnus, J.R. (1979). Substitution between energy and non-energy inputs in the Netherlands 1950-1976. *International Economic Review*, 465-484.
- Mandal, S.K., and Madheswaran, S. (2011). Energy use efficiency of Indian cement companies: a data envelopment analysis. *Energy Efficiency*, 4, 57-73.
- Medina, J., and Vega-Cervera, J.A. (2001). Energy and the non-energy inputs substitution: evidence for Italy, Portugal and Spain. *Applied Energy*, 68(2), 203-214.
- Mukherjee, K. (2008). Energy use efficiency in the Indian manufacturing sector: An interstate analysis. *Energy policy*, 36(2), 662-672.
- Nehru, V., and Dhareshwar, A. (1993). Sources, methodology and results. *Revista de análisis económico*, 8(1), 37-59.
- Paul, S., and Bhattacharya, R.N. (2004). Causality between energy consumption and economic growth in India: a note on conflicting results. *Energy economics*, 26(6), 977-983.
- Pavelescu, F.M. (2011). Some aspects of the translog production function estimation. *Romanian Journal of Economics*, 32(1), 41.

- Penphanussak, S., and Wongsapai, W. (2008, January). The demand for energy in the manufacturing sector of Thailand. In *Paper presentation at the technology and innovation for sustainable development conference, Faculty of Engineering, Khon Kaen University Thailand* (pp. 1-3).
- Pindyck, R.S. (1979). Interfuel substitution and the industrial demand for energy: an international comparison. *The Review of Economics and Statistics*, 169-179.
- Prywes, M. (1986). A nested CES approach to capital-energy substitution. *Energy Economics*, 8(1), 22-28.
- Raza, M. Y., Wang, X., and Lin, B. (2021). Economic progress with better technology, energy security, and ecological sustainability in Pakistan. *Sustainable Energy Technologies and Assessments*, 44, 100966.
- Rehfeldt, M., Fleiter, T., and Toro, F. (2018). A bottom-up estimation of the heating and cooling demand in European industry. *Energy Efficiency*, 11, 1057-1082.
- Stern, D.I. (2011). The role of energy in economic growth. *Annals of the New York Academy of Sciences*, 1219(1), 26-51.
- Sarkar, S., and Roy, J. (1995). Inter-fuel substitution during post oil embargo period-case study of two energy intensive manufacturing industries in India. *Indian Economic Journal*, 43(2), 33.
- Schurr, S.H. (1983). Energy efficiency and economic efficiency: an historical perspective. *Energy, Productivity and Economic Growth*, Schurr, Sonebulum and Wood, eds. Oelgeschlager, Gunn and Hain Publishers.
- Shankar, K.R., and Pachauri, R.K. (1983). A study of energy use in India's manufacturing industries. *Agency for International Development, Washington, DC*.
- Smyth, R., Narayan, P.K., and Shi, H. (2011). Substitution between energy and classical factor inputs in the Chinese steel sector. *Applied energy*, 88(1), 361-367.
- Smyth, R., Narayan, P.K., and Shi, H. (2012). Inter-fuel substitution in the Chinese iron and steel sector. *International Journal of Production Economics*, 139(2), 525-532.
- Taheri, A.A. (1994). Oil shocks and the dynamics of substitution adjustments of industrial fuels in the US. *Applied Economics*, 26(8), 751-756.
- Tang, C.F., and Tan, E.C. (2013). Exploring the nexus of electricity consumption, economic growth, energy prices and technology innovation in Malaysia. *Applied Energy*, 104, 297-305.
- Tiwari, A. K., and Menegaki, A. N. (2019). A time varying approach on the price elasticity of electricity in India during 1975–2013. *Energy*, 183, 385-397.
- Uri, N. D. (1979). Energy demand and interfuel substitution in India. *European Economic Review*, 12(2), 181-190.
- Vashist, D.C. (1984). Substitution possibilities and price sensitivity of energy demand in Indian manufacturing. *Indian Economic Journal*, 32(2), 84.
- Vlachou, A.S., and Samouilidis, E.J. (1986). Interfuel substitution: Results from several sectors of the Greek economy. *Energy Economics*, 8(1), 39-45.
- Wang, Q., and Yang, X. (2020). Imbalance of carbon embodied in South-South trade: Evidence from China-India trade. *Science of the Total Environment*, 707, 134473.
- Wang, Q., Jiang, X.T., Yang, X., and Ge, S. (2020). Comparative analysis of drivers of energy consumption in China, the USA and India—a perspective from stratified heterogeneity. *Science of the total environment*, 698, 134117.

- Wesseh Jr, P.K., and Lin, B. (2018). Energy consumption, fuel substitution, technical change, and economic growth: Implications for CO₂ mitigation in Egypt. *Energy Policy*, 117, 340-347.
- Wesseh Jr, P.K., Lin, B., and Appiah, M.O. (2013). Delving into Liberia's energy economy: technical change, inter-factor and inter-fuel substitution. *Renewable and Sustainable Energy Reviews*, 24, 122-130.
- Wesseh Jr, P.K., Lin, B., and Appiah, M.O. (2013). Delving into Liberia's energy economy: technical change, inter-factor and inter-fuel substitution. *Renewable and Sustainable Energy Reviews*, 24, 122-130.
- Xu, B., and Lin, B. (2019). Can expanding natural gas consumption reduce China's CO₂ emissions? *Energy Economics*, 81, 393-407.

Unemployment in Ghana: analyzing the asymmetric effects of export processing zones in dealing with the problem

Alexander QUAICOE

University of Ghana Business School, Legon
alexanderquaicoe@gmail.com

Abstract. *Across the developing world, many countries are championing the establishment of export processing zones (EPZs) due to the perceived economic benefits associated with them. The reduction in the issue of unemployment is one main reason for the full embrace of the EPZ policy but as to whether this dream is being achieved is unclear. Relying on aggregated data for the period 1998Q1-2024Q4 from Ghana's free zones, this study quantitatively analyses the impact of EPZs measured by their investment and export activities on the country's unemployment rate by considering the issue of asymmetries through the use of the nonlinear autoregressive distributed lag technique. The empirical results point to the crucial role of the zones in Ghana in reducing unemployment in both the short and long-terms. Aside the selected variables being cointegrated, there is also the presence of long-run asymmetric effects of both EPZ investment and export on the unemployment rate. It is therefore suggested that government should streamline and enhance the EPZ subsidies to attract more firms that particularly engage in higher grade production to employ more people while helping them to acquire more skills.*

Keywords: export processing zones, investment, export, unemployment, asymmetric effects, Ghana.

JEL Classification: E23, E24, F23, F31, H25.

1. Introduction

Emerging countries around the world have become accustomed to the idea that the concept of export processing zones (EPZs) has the ability to spur them on in terms of their economic development. This accounts for its proliferation in that part of the world where in return for the perceived benefits, countries with actually limited financial resources continue to compete among themselves fiercely for the global supply of foreign direct investment through the provision of generous trade subsidies (Cirera & Lakshman, 2017). The incentives are provided to make the potential host countries look more attractive in terms of the business environment.

Prior to the onset of export processing zones, most of these third world countries were engaged in restrictive trade to produce goods and services domestically for the citizens with the aim of attaining economic self-reliance. The import-substitution policy for example which encouraged nations to apply import quotas and other trade tariffs with the aim of promoting local production was one such popular policy championed by such governments (Elbeydi et al., 2010). Sadly however, most implementing countries of this policy were soon faced with a myriad of economic challenges including high rate of inflation, unemployment, uncompetitive export sector and a deterioration in their balance of payments (Irwin, 2021). Hence, EPZs came in to cure the ills associated with the closed economies, and this can be attested to in the examples of several countries in Asia and South America, two of the world's developing regions that have fully embraced EPZs, although for Africa, regarded as the most impoverished continent in the world, it only accounts for 4% of the number of zones around the globe (Rodríguez-Pose et al., 2022).

Ghana could be described as one important country on the African continent with keen interest in the EPZ policy. The country is a chief producer of primary commodities with the vast majority of its working population engaged in farming. The country operationalised its flagship Tema Export Processing Zone (TEPZ) under the Ghana Free Zones Authority in 1996, although it has since added three more zones in Boankra in the Ashanti Region and Sekondi and Shama, both in the Western Region (GFZA, 2022). The Ghanaian zones directly employ 24,203 workers annually on average (or 0.22% of the labour force), who are responsible for more than 14% of all exports from Ghana (GFZA, 2022). By nature, firms do not necessarily have to be sited in any particular zone before they are able to enjoy the incentives on offer aside the fact that an export processing zone firm could be 100% owned by expatriates or could have a joint ownership.

The generous subsidies offered investors in the form of fiscal incentives, superior infrastructure and lax regulation are hoped to attract more export-oriented firms to promote economic development especially in respect of employment generation, seen as a crucial measure of zone success (Cirera & Lakshman, 2017). The resources pumped into the provision of the incentives could however have been used elsewhere to help the citizens and hence there is the need to see if overall, the zones on the other hand are contributing to the development of the host nation.

Ascertaining the efficacy of the policy is however very difficult as it has only limited amount of literature available in comparison to other areas of economics. This situation

could be attributed to the lack of success with zone implementation or the lack of data, with the few available studies skewed in favour of the very successful Latin American and Asian countries such as Mexico, Panama, Costa Rica, Dominican Republic, China, South Korea, Hong Kong, Taiwan, Singapore, Bangladesh and Sri Lanka, (Islam & Mukhtar, 2011; Sargent & Matthews, 2009; Sigler, 2014; Wang et al., 2013). What about Africa? The situation is totally different since most countries have not been very successful with zone implementation.

Also, in terms of the data issue, there is no internationally available data on export processing zones across the globe with differences in the definition and types of zones as well as opaque incentive regime most of which are actually in breach of World Trade Organisation (WTO) rules accounting for this (Siroën & Yucer, 2014). In fact, to date, the only available statistics on EPZs is the 2007 ILO statistics compiled by Boyenge which only gives information on the total number of countries with zones, number of zones across the world and total number of employment (Boyenge, 2007). The vast majority of EPZ host countries do not provide any time series data and even where they do the data are mere estimates which diverge from reality (Gibbon et al., 2008). The total effect of all this is that it does not allow for proper cross-country study of the concept involving the use of robust econometric models.

Thus, having been able to obtain data on Ghana's free zones programme, this paper seeks to find out how the country's free zones activities measured by all investments in the zones and exports from the zones are helping in the fight against unemployment. Although some qualitative studies have looked at the employment activities in the zones elsewhere (Cizkiewicz et al., 2017; Leong, 2013), this is a first-of-its-kind paper that uses aggregate free zones data to determine their impact on national unemployment. In doing so, we employ the nonlinear autoregressive distributed lag (NARDL) methodology to examine the asymmetric effects of EPZ investments and exports on Ghana's unemployment.

In all, many international organisations have different opinions on the concept of EPZs. Some express a bit of cynicism about it whilst others still think it is capable of facilitating the economic development of nations. Such a study will therefore make it possible for such world bodies and other development partners including advanced nations some of which are still major donors to the poor countries like Ghana to know the contribution of the policy in terms of its developmental impacts especially regarding the reduction of unemployment. This will help them to know which areas or sectors to direct their assistance to in relation to the EPZ policy.

There are five chapters to this paper. In chapter one, there is the introduction, comprising of the study's background, problem statement, purpose of study and its significance. Chapter two highlights the theoretical and empirical foundations of the study in the literature review whilst chapter three describes the research methodology. The penultimate chapter presents the results of the study and discusses same and in the final chapter, the study is concluded.

2. Literature review

Different opinions exist the world over about the impact of export processing zones in the developing world. Governments, economists, researchers and international organisations proffer differing views on the operations of EPZs. In the case of governments in emerging countries that actually struggle constantly to balance their national budgets, they predictably see the EPZ policy as a good and timely tool to employ to help them develop their countries due to the perceived benefits associated with EPZs such as the expansion of the export sector to rake in more foreign exchange, creation of employment for the teeming youth, attraction of badly needed foreign capital, technology transfer among others (Waters, 2013).

On the other hand, most economists display a lot of pessimism about EPZs (Engman et al., 2007). Although they actually struggle to obtain any up-to-date data to conduct meaningful studies and especially do cross-country comparisons, the cursory assessments from the operation of most zones have not given the world's economists any room to be hopeful about EPZs. The source of the pessimism for the economists is simply the way the zones are treated. That is, the zones are usually offered the generous trade incentives in the name of trade liberalisation while in actual fact the larger economy is left unattended to. In other words, the zones are almost treated as an economy within an economy in which the conditions that pertain in the zones usually differ from what exist in the wider economy. While infrastructure for example in the zones is superior and entities in the zones enjoy huge tax exemptions, similar producers elsewhere in the economy have to grapple with difficulties regarding issues like electricity, water, roads among others aside having to pay exorbitant taxes in most EPZ countries. Such an arrangement is what does not make the policy more impactful, thus the need for a broader and a more comprehensive opening up of the whole economy to benefit all producers in all sectors.

Connected to this is the idea of sub-optimality attached to export processing zones. This is similar to the pessimistic view of economists in which it is argued that EPZs are a sub-optimal policy in the sense that it only confers advantages on a few while at the same time distorting the allocation of limited resources (Engman et al., 2007). The advantages here are the popular incentives to attract firms into the zones which make operators enjoy better services compared to the rest of the economy. There is also a distortion in zone operation since resources are directed to places where they may not be put to an optimal use. This happens as a result of the belief held by governments that EPZ firms perform better than non-EPZ firms. The argument here therefore is the need for a better policy for developing countries that offers all producers equal opportunities through a proper agenda of a more systematic and robust economy-wide liberalisation.

Again, there is also a negative view of export processing zones in relation to labour issues (Cirera & Lakshman, 2017). This stems from the fact that in most EPZ countries, labour codes in the zones differ from what exist in the rest of the domestic economy. This is why a lot of national and international bodies especially the International Labour Organisation fault EPZs because of poor treatment of workers. Some of these labour issues concern working conditions, wages, health and safety of workers, unionisation, etc. With the different labour laws in the zones which are mostly more flexible in most cases, employers

usually engage the services of young women for their very dexterous nature which is more suited to the generally repetitive work in the zones, and who also tend to be more disciplined relative to their male counterparts and are often prepared to accept lower wages without bothering about union issues (Cirera & Lakshman, 2017). These factors lead to abuses in some zones where even basic conditions to promote the welfare of workers are usually non-existent. It therefore comes as no surprise that most EPZs have a very high labour turnover ranging from 5% to 10% per month (Cirera & Lakshman, 2017).

Theoretically, the existing literature on export processing zones has broadly been based on three principal theories namely the neoclassical, new growth and cost-benefit theories. Whereas the neoclassical theory by Hamada (1974) argues that the policy is a welfare-reducing one when it comes to its effects on national development because it distorts production from its factor-based comparative advantage, the new growth theory (Johansson, 1994) on the other hand contends that the policy is actually welfare-increasing due to the huge positive externalities associated with the foreign inflows attracted into the zones. For its part, Warr's (1987) cost-benefit theory which rather calls for a painstaking calculation of all costs and benefits associated with the EPZ policy to arrive at a bottom line net present value for workers, government and society as a whole has rather produced contrasting conclusions based on its empirical evaluations.

On the specific issue of unemployment too, the classical theory, the Keynesian theory and structural theory have been used to underpin most studies. The classical theory of unemployment which is also referred to as the natural or real-wage unemployment postulates that unemployment occurs primarily as a result of employee real wage increment since the labour market just like any proper economic market is influenced by the forces of demand and supply (Solow, 1980). The Keynesian theory of unemployment which is also sometimes called cyclical or deficient-demand unemployment argues that unemployment occurs when people are not hired to produce goods and services because there is a lack of effective demand for those goods and services. Finally, the structural theory of unemployment says that unemployment occurs when there is a complete mismatch in terms of the jobs available and the skills those who seek employment have.

On the empirical front, few studies have been conducted in various contexts to look at some employment-related activities in the zones. These largely descriptive studies such as Hancock (2006), Islam and Mukhtar (2011), Sawkut et al. (2009), Thuita and Oiyee (2018) and Vinod and Meerabai (2016) have however been conducted using firm-level data or at best data from the level of the zones instead of overall data at the aggregate level for all firms in all zones. They have also produced no unanimous conclusions on the potency of the zones to deal with the issue of unemployment at the national level.

3. Methodology

The current study employs the nonlinear autoregressive distributed lag technique (Shin et al., 2014) to analyse the effect of Ghana's free zones in helping to reduce the menace of unemployment. As an enhanced version of the symmetric autoregressive distributed lag (ARDL) methodology, the NARDL is equally applicable on variables with different levels

of integration (i.e. I(0) and I(1) series), or variables that are only stationary after first differencing (i.e. I(1)). The key difference however is rooted in NARDL's ability to incorporate asymmetries or nonlinearities in the dynamic relationship of the variables. It does so by decomposing the explanatory variables into positive and negative shocks and adding these shocks as individual input variables in the model (Shin et al., 2014). The linear functional form of our model is thus specified as follows:

$$UNM_t = f(INV_t, EPX_t, RGP_t, POG_t, DMW_t) \quad (1)$$

where UNM is the national unemployment rate, INV and EPX are the free zones investment and export growth rates respectively and RGP , POG and DMW are our included endogenous variables known to impact unemployment, where RGP is the GDP growth rate, POG is the population growth rate and DMW is growth rate in daily minimum wage.

Converting the above linear function into a nonlinear one with the decomposition of our key EPZ variables into their positive and negative shocks gives us the following equation:

$$UNM_t = f(INV_t^+, INV_t^-, EPX_t^+, EPX_t^-, RGP_t, POG_t, DMW_t) \quad (2)$$

Therefore, in line with Saleem et al. (2023), and following the original work of Shin et al. (2014), we specify the functional form of the NARDL model as follows:

$$\begin{aligned} \Delta UNM_t = & \beta_1 + \sum_{i=1}^p \alpha_{1i} \Delta UNM_{t-i} + \sum_{i=0}^{q11} \sigma_{1i}^+ \Delta INV_{t-i}^+ + \sum_{i=0}^{q12} \sigma_{1i}^- \Delta INV_{t-i}^- + \\ & \sum_{i=0}^{q13} \delta_{1i}^+ \Delta EPX_{t-i}^+ + \sum_{i=0}^{q14} \delta_{1i}^- \Delta EPX_{t-i}^- + \sum_{i=0}^{q15} \gamma_{1i} \Delta RGP_{t-i} + \sum_{i=0}^{q16} \psi_{1i} \Delta POG_{t-i} + \\ & \sum_{i=0}^{q17} \lambda_{1i} \Delta DMW_{t-i} + \rho UNM_{t-1} + \varphi_{11}^+ INV_{t-1}^+ + \varphi_{12}^- INV_{t-1}^- + \varphi_{13}^+ EPX_{t-1}^+ + \\ & \varphi_{14}^- EPX_{t-1}^- + \varphi_{15} RGP_{t-1} + \varphi_{16} POG_{t-1} + \varphi_{17} DMW_{t-1} + \mu_{t1} \end{aligned} \quad (3)$$

where α_i , σ_i^+ , σ_i^- , δ_i^+ , δ_i^- , γ_i , ψ_i and λ_i are the NARDL short-run coefficients and ρ and the φ 's represent the long-run coefficients. β is the constant term, t stands for the time dimension, μ is the idiosyncratic error term, p and q respectively are the lag lengths for the regressand and the regressors and Δ is the difference operator. It must be made clear that 1 is used across equation (3) to differentiate the NARDL equation from the subsequent error correction model (ECM) which has been given the number 2, thus in equation (3) for instance, $q11$ means the first q in the first equation and $q12$ is the second q in the first equation etc.

In estimating NARDL, both long and short-run equilibrium relationships could be investigated based on Bounds test which is actually a joint test of all lagged one-period levels of positive as well as negative shocks together with all other explanatory variables and the explained variable. The null hypothesis of the NARDL model is an F -test and is indicated below:

$$H_0: \rho = \varphi_1^+ = \varphi_2^- = \varphi_3^+ = \varphi_4^- + \varphi_5 = \varphi_6 = \varphi_7 = 0$$

As per Shin et al. (2014), if the calculated F -statistic is above the upper bound critical value, the null is rejected, meaning that the series are cointegrated in the presence of asymmetry. With this, we move on to estimate asymmetric error correction model as follows:

$$\begin{aligned} \Delta UNM_t = & \beta_2 + \sum_{i=1}^p \alpha_{2i} \Delta UNM_{t-i} + \sum_{i=0}^{q21} \sigma_{2i}^+ \Delta INV_{t-i}^+ + \sum_{i=0}^{q22} \sigma_{2i}^- \Delta INV_{t-i}^- + \\ & \sum_{i=0}^{q23} \delta_{2i}^+ \Delta EPX_{t-i}^+ + \sum_{i=0}^{q24} \delta_{2i}^- \Delta EPX_{t-i}^- + \sum_{i=0}^{q25} \gamma_{2i} \Delta RGP_{t-i} + \sum_{i=0}^{q26} \psi_{2i} \Delta POG_{t-i} + \\ & \sum_{i=0}^{q27} \lambda_{2i} \Delta DMW_{t-i} + \emptyset ECT_{t-1} + \mu_{t2} \end{aligned} \quad (4)$$

where ECT_{t-1} is the error correction term and its coefficient ($\emptyset$) is the speed of adjustment.

The NARDL long-run asymmetric coefficients are calculated by dividing the *negative* of the coefficient value of each positive shock (or increase) by the coefficient of the dependent variable, and also the *negative* of the coefficient value of each negative shock (or decrease) by the coefficient of the dependent variable. Thus, with cointegration based on the Bounds test, Wald test is done to verify whether the difference in the asymmetric coefficients is statistically significant, and this is shown below (Shin et al., 2014):

$$\begin{aligned} H_0: \frac{-\varphi_{11}^+}{\rho} &= \frac{-\varphi_{12}^-}{\rho} \text{ or } \frac{-\varphi_{13}^+}{\rho} = \frac{-\varphi_{14}^-}{\rho} \\ H_A: \frac{-\varphi_{11}^+}{\rho} &\neq \frac{-\varphi_{12}^-}{\rho} \text{ or } \frac{-\varphi_{13}^+}{\rho} \neq \frac{-\varphi_{14}^-}{\rho} \end{aligned}$$

From the above, if the null hypothesis is rejected, it suggests that there is long-run asymmetry. As stated in Shin et al. (2014), the Wald test for short-run asymmetry also follows similar conclusion and its null hypothesis is highlighted below:

$$\begin{aligned} H_0: \sum_{i=1}^q \sigma_i^+ &= \sum_{i=1}^q \sigma_i^- \\ H_0: \sum_{i=1}^q \delta_i^+ &= \sum_{i=1}^q \delta_i^- \end{aligned}$$

As part of the NARDL estimation, there is also the issue of dynamic multiplier graph. This graph reveals how the dependent variable changes to its new long-term equilibrium path as a result of a shock in the independent variable (Shin et al., 2014). This is represented below:

$$DM_h^+ = \sum_{j=0}^h \frac{\partial UNM_{t+j}}{\partial INV_t^+}, DM_h^- = \sum_{j=0}^h \frac{\partial UNM_{t+j}}{\partial INV_t^-}, \text{ for } h = 0, 1, 2, \dots \quad (5)$$

where, if $h \rightarrow \infty$, then $DM_h^+ \rightarrow \frac{-\varphi_{11}^+}{\rho}$ and $DM_h^- \rightarrow \frac{-\varphi_{12}^-}{\rho}$

$$DM_h^+ = \sum_{j=0}^h \frac{\partial UNM_{t+j}}{\partial EPX_t^+}, DM_h^- = \sum_{j=0}^h \frac{\partial UNM_{t+j}}{\partial EPX_t^-}, \text{ for } h = 0, 1, 2, \dots \quad (6)$$

where, if $h \rightarrow \infty$, then $DM_h^+ \rightarrow \frac{-\varphi_{13}^+}{\rho}$ and $DM_h^- \rightarrow \frac{-\varphi_{14}^-}{\rho}$

This study uses quarterly data from 1998Q1 to 2024Q4. The free zones data come from the Ghana Free Zones Authority, with the remaining ones being sourced from the World Bank's World Economic Indicators as well as the International Labour Organisation and Ghana's employment ministry.

4. Findings

The summary statistics for the paper are presented in Table 1 below:

Table 1. *Summary statistics*

	Unemploy. rate (UNM)	Positive shocks in EPZ investment growth rate (INV ⁺)	Negative shocks in EPZ investment growth rate (INV ⁻)	Positive shocks in EPZ export growth rate (EPX ⁺)	Negative shocks in EPZ export growth rate (EPX ⁻)	Real GDP growth rate (RGP)	Pop. growth rate (POG)	Daily min. growth rate (DMW)
Mean	5.40	14.19	-13.72	5.79	-5.98	5.49	2.38	19.78
Maximum	10.53	305.25	0.00	131.55	0.00	14.47	2.76	47.03
Minimum	1.99	0.00	-301.91	0.00	-106.78	0.10	1.88	5.60
Std. dev.	2.37	41.37	40.75	15.82	14.28	2.72	0.26	10.02
Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Observations	108	108	108	108	108	108	108	108

Source: Author's calculation from EViews.

The summary statistics in the above table indicate that our dependent variable which is Ghana's unemployment rate has averagely hovered around 5.40% between 1998 and 2024, reaching a high of 10.53% and a low of 2%. For our export processing zones variables, broken down into their positive and negative changes or shocks, the free zones investment witnessed a mean of 14.20% in its positive shocks with the negative shocks averaging -13.72% in their growth rates. The respective maximum values for the positive and negative shocks or increases and decreases have been 305.25% and 0.00%, and the minimum values for the same period have been 0.00% and -302% respectively. Regarding the free zones export variable, it witnessed an average figure of 5.79% in its positive shocks, with a maximum value of 131.55% and a minimum of 0.00% whilst the negative shocks recorded a mean growth rate of -6%, with 0.00% and -106.78% respectively being the maximum and minimum values.

Turning to the other variables included in the study known to affect the target variable, Ghana's real GDP growth rate for the study period recorded a mean figure of 5.49%, with 14.47% being its highest figure and 0.10% the lowest. Also, the country's population growth rate averaged 2.38%, recording 2.76% as its highest figure, with a minimum of 1.88%. Finally, the national daily minimum wage grew at 19.78% on average and it saw its highest recorded figure being 47% with 5.60% being its minimum value.

Table 2. *Correlation matrix*

	UNM	INV	EPX	RGP	POG	DMW
UNM	1.0000					
INV	0.2262**	1.0000				
EPX	0.1971**	0.7869***	1.0000			
RGP	-0.2610**	0.0851	0.1225	1.0000		
POG	0.6036***	0.2465**	0.2574**	0.1894**	1.0000	
DMW	0.8616***	0.1210	0.1738*	-0.0355	0.5474***	1.0000

***, ** and * respectively show 1%, 5% and 10% levels of significance.

Source: Author's calculation from Eviews 13.

In Table 2 above, the correlation coefficients for the study variables are displayed. Apart from the real GDP growth rate which relates negatively with the unemployment rate, all the other variables are noted to have positive relationship with the target variable. In all however, only population growth rate and growth rate in the daily minimum wage are observed to have fairly strong association with the dependent variable.

Table 3. *ADF unit root test*

Variable	Levels	1 st difference
UNM	-2.6964	-4.1729***
INV	-7.3953***	
EPX	-6.3380***	
RGP	-4.0332***	
POG	-0.8445	-2.1631**
DMW	-2.0586	-3.1077**

***, ** and * indicate significance level at the 1%, 5% and 10% respectively.

Source: Author's calculation from EViews 13.

Table 4. *PP unit root test*

Variable	Levels	1 st difference
UNM	-1.3103	-4.1163***
INV	-2.5176	-9.7420***
EPX	-2.8356*	-8.8582***
RGP	-2.6762*	-6.0716***
POG	-2.6861	-3.5113**
DMW	-1.5236	-3.9301***

***, ** and * indicate significance level at the 1%, 5% and 10% respectively.

Source: Author's calculation from EViews 13.

Table 5. *ZA breakpoint unit root test*

Variable	Levels	Break date	1 st difference	Break date
UNM	-5.8551***	2013Q1		
INV	-8.7625***	2000Q4		
EPX	-7.2562***	2012Q2		
RGP	-5.4089***	2013Q3		
POG	-5.4469***	2016Q1		
DMW	-3.6253	2023Q2	-5.26764**	2023Q1

***, ** and * indicate significance level at the 1%, 5% and 10% respectively.

Source: Author's calculation from EViews 13.

Tables 3-5 above all report the results of the various unit root tests conducted to ascertain the stationarity properties of the variables of study. All three tests are conducted to neutralise the weaknesses in each other by the strength of the others, with the ADF regarded as a good one due to the stability of its critical values (Dickey & Fuller, 1979) while the Phillips-Perron unit root test is viewed to be robust in terms of its treatment of both the autocorrelation and heteroscedasticity in the disturbance process of the test equation (Phillips & Perron, 1986). The Zivot-Andrews unit root test on its part considers the issue of structural breaks in which such breaks which are ignored by the other two tests are treated endogenously (Zivot & Andrews, 1990).

From the test statistics in the tables, whereas all the variables are stationary only after first differencing (i.e. $I(1)$) under the PP unit root test, in terms of the ADF one, the free zones variables and real GDP are stationary at levels (i.e. $I(0)$) with the remaining series

integrated of the first order. Also, regarding the ZA stationarity test results, only the minimum wage variable is $I(1)$ with all the others being $I(0)$. From the foregoing, the selected NARDL technique is thus appropriate as it is able to accommodate variables of different levels of integration or pure $I(1)$ series, if only none of them is $I(2)$.

Table 6. Lag selection results

Ghana						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1841.6445	NA	1.09e+08	35.53162	35.68419	35.59343
1	-950.5722	1662.193	7.860787	19.08793	20.15585	19.52057
2	-770.8720	314.4752*	0.499118*	16.32446*	18.30776*	17.12795*
3	-743.2178	45.20403	0.596060	16.48496	19.38362	17.65929
4	-727.9084	23.25849	0.916827	16.88285	20.69688	18.42803

* indicates the lag length selected by a particular criterion

Source: Author's calculation from EViews 13.

Results from the lag selection based on the various selection criteria are captured in Table 6 with lag 2 being chosen as the maximum lag. Thus, to obtain more robust results that are diagnostically meaningful, lag 2 was assigned to the dependent variable whilst lag 1 was given to the explanatory variables.

Table 7. NARDL Bounds cointegration test

F-statistic: 4.1441		
Significance level	Critical values	
	I(0)	I(1)
1%	2.96	4.26
5%	2.32	3.50
10%	2.03	3.13

Source: Author's calculation from EViews 13.

As part of the NARDL estimation, it is crucial to verify if there is long-run equilibrium relationship among the variables. This is done by the use of the Bounds test for cointegration whose null hypothesis states that there is no cointegration. This is an *F-statistic* test in which the null is rejected when the test statistic is greater than the $I(1)$ critical value at the appropriate level of significance. From the table, based on the conventional 5% significance level, the calculated *F-statistic* is more than the $I(1)$ critical value, thus the null hypothesis is rejected, an indication of the fact that there is asymmetric cointegration.

Table 8. Model diagnostic checks

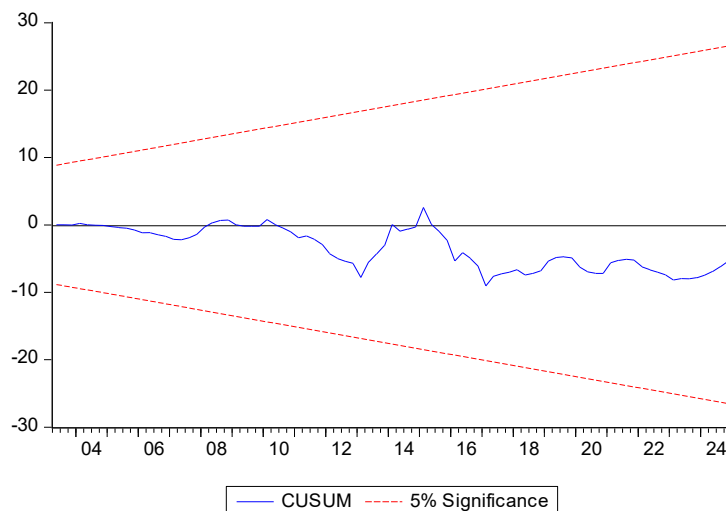
Test	Statistic	Probability
Serial correlation	0.587560	0.5578
Heteroscedasticity	2.443378	0.0580
Functional form	1.370409	0.2593

Source: Author's calculation from EViews 13.

Table 8 shows the results for the various diagnostic tests conducted as part of the study's analysis, namely the Breusch-Godfrey Serial Correlation LM test, the Breusch-Pagan-Godfrey heteroscedasticity test and the Ramsey functional form test. The null for both the serial correlation and heteroscedasticity tests is that there is the absence of serial correlation and heteroscedasticity in the model. From the above table, the reported test statistics have *p-values* of more than 5%, and hence we reject the null hypotheses and conclude that there

is no problem of serial correlation and also that the model is homoscedastic. Similarly, for the Ramsey functional form also, based on the p -value of the test statistic, the conclusion is that the selected model is well-specified.

Figure 1. Model stability test



Source: Author's construction from EViews 13.

The cumulative sum (CUSUM) graph in Figure 1 above demonstrates the dynamic stability of the model of study, and with the blue line falling strictly within the 5% red boundary, the model is said to be very much stable dynamically.

Table 9. Asymmetric error correction model estimates

Variable	Coefficient	Std. error	t-stat
Long-run estimates			
$UNM(-1)$	-0.0967***	0.0219	-4.4213
INV^+	-0.0010**	0.0004	-2.3526
$INV^-(-1)$	-0.0001	0.0004	-0.3255
EPX^+	-0.0025**	0.0010	-2.4128
$EPX^-(-1)$	0.0021*	0.0012	1.7586
$RGP(-1)$	-0.0331***	0.0093	-3.5563
$POG(-1)$	-0.4427**	0.1863	-2.3767
$DMW(-1)$	-0.0012	0.0055	-0.2226
Short-run estimates			
$D(UNM(-1))$	0.4999***	0.0600	8.3360
$D(INV^-)$	0.0019**	0.0009	2.1751
$D(EPX^-)$	-0.0039	0.0025	-1.5945
$D(RGP)$	-0.0642***	0.0143	-4.4878
$D(POG)$	-5.8181***	1.2344	-4.7135
$D(DMW)$	0.0214**	0.0105	2.0353
C	2.4482***	0.4151	5.8983
ECT_{t-1}	-0.0967***	0.0162	-5.9752
R-squared: 0.7534			
F-statistic: 42.7698			
Prob. (F-statistic): 0.0000			

***, ** and * indicate significance level at the 1%, 5% and 10% respectively.

Source: Author's calculation from EViews 13.

In Table 7, it was proven that there is cointegration for the selected variables and thus Table 9 reports the estimates from the asymmetric error correction model. In the table, aside the results for both the long and short-run dynamics of the model, there is also the error correction term with its coefficient being the speed of adjustment which carries the right negative sign and is also statistically significant. The negative and statistically significant ECT indicates that there is long-run convergence in the model even after a short-run shock has occurred. Specifically 9.67% of departures from equilibrium are corrected each period. It also means that in the long-run, all the included independent variables Granger-cause the dependent variable.

Turning to the long-run estimates and to the key explanatory variables of the study, both free zones investment and export are observed to have some effect on the unemployment rate in Ghana. In specific terms, increases or positive shocks in EPZ investment have negative impact on the unemployment rate and positive changes in the export variable also affect the rate of unemployment negatively. By way of magnitude, a unit increase in free zones investment reduces the unemployment rate by 0.0010 units and a unit increase in export reduces unemployment by 0.0025 units in Ghana.

Both results turn out to be good and are largely in line with the general empirical literature. First, these studies agree to the significant impact of investment on unemployment at the aggregate level with more investment said to bring about a reduction in the rate of unemployment (Ali & Zulfiqar, 2018; Karimov, 2024; Okoli & Okeke, 2024). So for Ghana's free zones, more investment in the zones means that more capital is being attracted into the zones with more hands needed to work on the capital. Secondly, most zone operators actually rely on the domestic market to source their inputs, with more investments calling for the production of more of such inputs, and hence the need for more people to be employed. This buttresses the new growth theory of export processing zones which argues in favour of the establishment of EPZs due to the positive externalities associated particularly with the investments into the zones especially the creation of employment (Johansson, 1994).

On the other hand, in terms of the EPZ export, more of it leading to less unemployment means that as the firms in the zones undertake more exports, the unemployment rate comes down. This also finds support in aggregate studies such as Hendrasto et al. (2023) and Ugarte and Olarreaga (2021) which have called for the enhancement of the export sector of countries since an upsurge in exports reduces unemployment. For the EPZ sector, the main goal is actually to increase the volume of exports of the implementing nation (Fatemah & Qayyuma, 2018). Thus, with exports going up in both quality and quantity to meet international standards, more people get employed and hence there is a reduction in the rate of unemployment in the domestic economy.

Still on the long-run results, both real GDP growth rate and population growth rate are observed to have negative effect on the unemployment rate, in which a unit increase in GDP growth rate reduces the unemployment rate by 0.0331 units, with a unit increase in the population growth rate causing a 0.4427 units decrease in the unemployment rate. For the GDP variable, this aligns with the existing literature including Amor (2023), Haider et al. (2023) and Şit (2024), with more economic growth noted to cause a reduction in the

general levels of unemployment – buttressing the well-established Okun’s law (Okun, 1962). This is because an expansion in the economy means more goods and services being produced, of which in the case of a developing country like Ghana, such production activities are mostly undertaken by the cheap labour force by way of labour-intensive production. Relative to the population growth variable, although it runs counter to the conventional economic studies such as Anam and Amin (2024) and Umoh (2025) which say an increase in the rate of population growth leads to more unemployment, it however finds support in papers such as Bloom and McKenna (2015) and Vilakati et al. (2024) which have contended otherwise. This could be attributed to the fact that inasmuch as more labourers become available, most of them find employment albeit in menial and not too lucrative jobs, with also, increasing population widening demand for goods and services, thus creating fresh job opportunities.

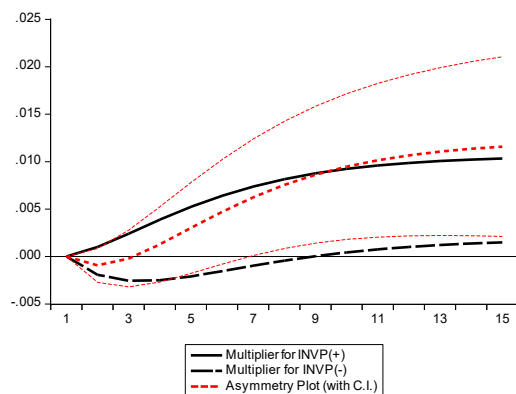
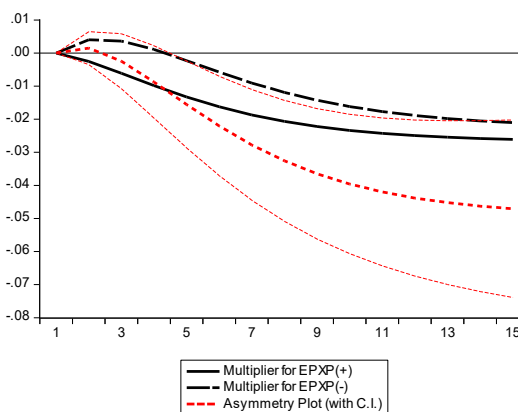
Regarding the short-run estimates, free zones investment is the only EPZ variable seen to impact unemployment through its negative shocks. Specifically, a unit decrease (negative shock) in EPZ investment increases the unemployment rate by 0.0019 units. This result is very much in line with the earlier one observed under the long-run estimates, whereby when investment in the zones go down, people become unemployed, and this brings to light the critical role of export processing zones in dealing with the problem of unemployment. Similarly, both short-run real GDP growth rate and population growth rate affect unemployment negatively, with a unit increase in both bringing about a 0.0642 and 5.8181 units decrease in unemployment respectively, in line with the observation under the long-run estimates. Finally, the growth rate in the daily minimum wage also leads to an increase in the unemployment rate, with a unit increase in the minimum wage variable causing a 0.0214 units increase in the unemployment rate. This is supported by Abraham and Kearney (2020), Doh et al. (2024) and Ramos-Herrera (2023). This may be explained in line with the classical theory of unemployment where an enhancement in the minimum wage increases the cost of production leading more businesses to hire less people.

Table 10: Results of test of asymmetry

Long-run asymmetry	INV	4.3022**
	EPX	7.1733**
Short-run asymmetry	INV	-
	EPX	-

Source: Author’s calculation from EViews 13.

Table 10 presents results of both long and short-run tests of asymmetry. Whereas the long-run test is based on *Chi-square* distribution, the short-run test is an *F-statistic*. In both cases, the null hypothesis is that there is no asymmetry, whether long or short. From the table, in terms of the long-run results, both free zones investment and export are observed to have asymmetric effects on the unemployment rate as their respective *p-values* are less than 5%. This means that in the long-term, the magnitude of the impact of the two free zones variables regarding their positive and negative shocks on the target variable is dissimilar. However, similar conclusions cannot be drawn in respect of the short-run asymmetry which did not produce meaningful results based on its additive sum approach from stepwise regression.

Figure 2. *Dynamic multiplier graphs***EPZ investment****EPZ export****Source:** Author's construction from EViews 13.

In line with Shin et al. (2014), the dynamic multiplier graphs are presented for the two free zones variables in Figure 2 above. The graph shows how the explained variable adjusts to its new long-run equilibrium position following a change in the explanatory variable. On the horizontal axis of this graph is the dimension of time while the vertical axis highlights the various shocks experienced by the various variables. The deep broken red line is the asymmetry plot reflecting the change in the dynamic multipliers of positive and negative shocks and is in the 95% confidence interval represented by the upper and lower bands of the light broken red lines. Again, the continuous black line is the positive shocks whilst the broken black line is the negative shocks in the independent variable.

From the EPZ investment graph, both positive and negative shocks in that variable are observed to impact unemployment positively, although in the short-run, the effect of the negative shocks is rather negative. Overall however, the effect of the positive shocks outweighs that of the negative shocks. In the export graph also, both positive and negative changes in free zones export are seen to be having negative impact on the dependent variable although in the initial stages, the negative shocks' effect is positive.

5. Conclusion

Unemployment is a major socio-economic issue confronting many nations especially those in the global south. This is because as both a local and national issue, it does not promote progress, with the unemployed usually unable to contribute meaningfully to the development agenda. To this end, most developing countries have embraced the concept of export processing zones with the aim of attracting export-oriented firms to produce goods and services, in the hope that by so doing, people may be employed. But the question is whether this dream is being realised.

This paper has thus looked at the effect of the free zones concept in dealing with the issue of unemployment by focusing on Ghana. EPZ investment and export are the two key

measures of zone activities focused on in this study with quarterly data spanning the period 1998Q1-2024Q4 being used. The nonlinear autoregressive distributed lag methodology was employed which showed clearly based on its Bounds test that there is cointegration among the study variables, aside the presence of long-run asymmetry between the EPZ variables and unemployment. The asymmetric error correction term also indicates that there is a 9.67% convergence rate towards long-run equilibrium after a temporary shock in the short-term, and this also shows that all the independent variables Granger-cause the dependent variable.

On the empirical results, positive shocks in both free zones investment and export are observed to have significant negative impact on the unemployment rate in Ghana in the long-run. In the short-term also, reductions or negative shocks in the investment variable have positive effect on the dependent variable. These results are very much in sync with the general literature that contends that both investment and export help to reduce the incidence of unemployment, thus highlighting the critical role of Ghana's free zones in combating unemployment.

For the included endogenous variables, both real GDP growth rate and population growth rate also have both short and long-term negative effects on unemployment. Although the GDP result resonates with the literature generally, the population one contradicts the majority of the existing literature. This however could be attributed to the fact that an expanding population may be getting employed but largely in menial and not-too-lucrative jobs, with more labourers becoming available meaning cheaper labour. Also, the growth rate in the daily minimum wage variable has a positive effect on unemployment in the short-term and this is in agreement with the classical unemployment theory in which higher wages likely lead to less people being hired by businesses.

From the findings of the study, it can safely be concluded that the free zones in Ghana are helping both in the short and long-runs to reduce the incidence of unemployment through their investment and export activities. More effort should therefore be made by government through the enhancement of the existing incentive regime to ensure the expansion of the free zones programme especially in more deprived but resource-rich areas for firms to produce more so as to employ more people. Businesses operating in the zones should also transition into the production of higher quality goods requiring higher level skills and through the process help more zone workers to become more skillful and technically adept. Further studies should therefore consider the nature of the employment in the zones as part of their analyses.

References

- Abraham, K.G., and Kearney, M.S. (2020). Explaining the decline in the US employment-to-population ratio: A review of the evidence. *Journal of Economic Literature*, 58(3), 585–643.
- Ali, A., and Zulfiqar, K. (2018). An Assessment of Association between Natural Resources Agglomeration and Unemployment in Pakistan. *Pakistan Vision*, 19(1), 110–126.

- Amor, M.B. (2023). Economic growth and unemployment relationship in Tunisia: An empirical evidence from ARDL Bound test approach. *Montenegrin Journal of Economics*, 19(2), 73–84. <<https://doi.org/10.14254/1800-5845/2023.19-2.14>>
- Anam, S., and Amin, M.A. (2024). The impact of population growth and unemployment on Pakistan economy. *Review of Economic Trends*, 1(1), 26–33. <<https://doi.org/10.20448/journal.518.2020.5.48.54>>
- Bloom, D.E., and McKenna, M.J. (2015). *Population, labour force and unemployment: Implications for the creation of (decent) jobs, 1990–2030*. UNDP Human Development Report Office, New York.
- Boyenge, J.-P.S. (2007). *ILO database on export processing zones*. (ILO Working Paper, 251, 2754).
- Cirera, X., and Lakshman, R.W.D. (2017). The impact of export processing zones on employment, wages and labour conditions in developing countries: Systematic review. *Journal of Development Effectiveness*, 9(3), 344–360. <<https://doi.org/https://doi.org/10.1080/19439342.2017.1309448>>
- Cizkowicz, P., Cizkowicz-Pękala, M., Pękaia, P., and Rzońca, A. (2017). The effects of special economic zones on employment and investment: A spatial panel modeling perspective. *Journal of Economic Geography*, 17(3), 571–605.
- Dickey, D.A., and Fuller, W.A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74(366), 427–431. <<https://doi.org/https://doi.org/10.2307/2286348>>
- Doh, T., Kim, S., Lee, H., and Song, K. (2024). *The economic effects of a rapid increase in the minimum wage: Evidence from South Korea experiments*. Federal Reserve Bank of Kansas City Working Paper, (22-13).
- Elbeydi, K.R.M., Hamuda, A.M., and Gazda, V. (2010). The relationship between export and economic growth in Libya Arab Jamahiriya Khaled. *Theoretical and Applied Economics*, 1(1), 69–76.
- Engman, M., Onodera, O., and Pinali, E. (2007). Export processing zones: Past and future role in trade and development. In *OECD Trade Policy Working Paper No. 53*.
- Fatemah, A., and Qayyuma, A. (2018). Modeling the impact of exports on the economic growth of Pakistan. *Turkish Economic Review*, 5(1), 56–64.
- GFZA. (2022). *Free zones statistical publications*. Ghana Free Zones Authority.
- Gibbon, P., Jones, S., and Thomsen, L. (2008). *An assessment of the impact of export processing zones and an identification of appropriate measures to support their development*. Danish Institute for International Studies.
- Haider, A., Jabeen, S., Rankaduwa, W., and Shaheen, F. (2023). The nexus between employment and economic growth: A cross-country analysis. *Sustainability*, 15(15), 1–18. <<https://doi.org/10.3390/su151511955>>
- Hamada, K. (1974). An economic analysis of the duty-free zone. *Journal of International Economics*, 4(3), 225–241. <[https://doi.org/https://doi.org/10.1016/0022-1996\(74\)90044-0](https://doi.org/https://doi.org/10.1016/0022-1996(74)90044-0)>
- Hancock, P. (2006). Women, work and empowerment: A portrait of women workers in two of Sri Lanka's export processing zones. *Norwegian Journal of Geography*, 60(3), 227–239. <<https://doi.org/https://doi.org/10.1080/00291950600891836>>

- Hendrasto, N., Ibrahim, M.Y., and Novianti, T. (2023). The roles of export of coffee commodity and macroeconomics factors on unemployment in Indonesia. *Jurnal Social Economic of Agriculture*, 12(2), 94–104. <<https://doi.org/10.26418/j.sea.v12i2.66113>>
- Irwin, D.A. (2021). The rise and fall of import substitution. *World Development*, 139, 105306. <<https://doi.org/https://doi.org/10.1016/j.worlddev.2020.105306>>
- Islam, Z., and Mukhtar, U. (2011). EPZ history in Bangladesh and its administration and legislation for economic enclave. *Business and Management Review*, 1(7), 86–107.
- Johansson, H. (1994). The economics of export processing zones revisited. *Development Policy Review*, 12(4), 387–402. <<https://doi.org/https://doi.org/10.1111/j.1467-7679.1994.tb00075.x>>
- Karimov, M. (2024). An empirical investigation of the relationship between foreign direct investment and unemployment rate in Azerbaijan: an ARDL approach. *Asian Journal of Applied Economics*, 31(2), 98–114.
- Leong, C.K. (2013). Special economic zones and growth in China and India: An empirical investigation. *International Economics and Economic Policy*, 10(4), 549–567. <<https://doi.org/https://doi.org/10.1007/s10368-012-0223-6>>
- Okoli, C.K., and Okeke, C.T. (2024). Assessing the impact of foreign direct investment on unemployment rate in Nigeria. *Asian Journal of Economics, Business and Accounting*, 24(4), 260–277. <<https://doi.org/10.9734/ajeba/2024/v24i41278>>
- Okun, A.M. (1962). *Potential GNP: Its measurement and significance*. In *Proceedings of the Business and Economic Statistics Section of the American Statistical Association*. Alexandria, VA. 7, 89–104.
- Phillips, C.B.P., and Perron, P. (1986). Testing for a unit root in time series regression. *Biometrika*, 75(2), 347–353. <<https://doi.org/https://doi.org/10.2307/2336182>>
- Ramos-Herrera, M. del C. (2023). The effects of minimum wage on unemployment for OECD countries: A dynamic fixed effects panel threshold model perspective. *Economic Research-Ekonomska Istrazivanja*, 36(3). <<https://doi.org/10.1080/1331677X.2023.2217880>>
- Rodríguez-Pose, A., Bartalucci, F., Frick, S. A., Santos-Paulino, A. U., and Bolwijn, R. (2022). The challenge of developing special economic zones in Africa: Evidence and lessons learnt. *Regional Science Policy and Practice*, 14(2), 456–481. <<https://doi.org/https://doi.org/10.1111/rsp3.12535>>
- Saleem, A., Sial, M.H., and Cheema, A.R. (2023). Does an asymmetric nexus exist between exports and economic growth in Pakistan? Recent evidence from a nonlinear ARDL approach. *Economic Change and Restructuring*, 56(1), 297–326. <<https://doi.org/https://doi.org/10.1007/s10644-022-09426-z>>
- Sargent, J., and Matthews, L. (2009). China versus Mexico in the global EPZ industry: Maquiladoras, FDI quality, and plant mortality. *World Development*, 37(6), 1069–1082. <<https://doi.org/https://doi.org/10.1016/j.worlddev.2008.10.002>>
- Sawkut, R., Vinesh, S., and Sooraj, F. (2009). The net contribution of the Mauritian export processing zone using benefit–cost analysis. *Journal of International Development*, 21(3), 379–392. <<https://doi.org/https://doi.org/10.1002/jid.1489>>
- Shin, Y., Yu, B., and Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. *Econometric Methods and Applications*, 281–314. <https://doi.org/https://doi.org/10.1007/978-1-4899-8008-3_9>

- Sigler, T.J. (2014). Panama's special economic zones: Balancing growth and development. *Bulletin of Latin American Research*, 33(1), 1–15. <<https://doi.org/10.1111/blar.12035>>
- Siroën, J.-M., and Yucer, A. (2014). Trade performance of free trade zones. *Document De Travail*, 1–28.
- Şit, M. (2024). The relationship between unemployment and economic growth in selected large emerging countries: A revisit using threshold regression analysis. *Journal of Economic Policy Researches / İktisat Politikası Araştırmaları Dergisi*, 11(1), 76–85. <<https://doi.org/10.26650/jep1232910>>
- Solow, R.M. (1980). On theories of unemployment. *The American Economic Review*, 70(1), 1–11.
- Thuita, G., and Oiyie, Y. (2018). Compensation, working conditions and employee satisfaction in Kilifi Export Processing Zones, Kenya. *International Journal of Economics, Business and Management Research*, 2(2), 2456–7760.
- Ugarte, C., and Olarreaga, M. (2021). Can export promotion reduce unemployment? In *Robert Schuman Centre for Advanced Studies Research Paper No. RSC*, 65. <<https://doi.org/10.2139/ssrn.3914009>>
- Umoh, E. (2025). Unemployment and economic development in Nigeria: An analysis of trends and implications (2013-2022). Available at SSRN 5073675. <<https://doi.org/10.2139/ssrn.5073675>>
- Vilakati, W., Semosa, P., and Ogujiuba, K. (2024). Effect of socio-economic variables on unemployment in South Africa: A vector error correction model. *Journal of Infrastructure, Policy and Development*, 8(8), 1–19. <<https://doi.org/10.24294/jipd.v8i8.5130>>
- Vinod, K.U., and Meerabai, M. (2016). Significance of free economic zones: A study from an international perspective. *International Journal of Trade & Global Business Perspectives*, 5(4), 3111–3120.
- Wang, D.T., Gu, F.F., Tse, D.K., and Yim, C.K.B. (2013). When does FDI matter? The roles of local institutions and ethnic origins of FDI. *International Business Review*, 22(2), 450–465.
- Warr, P.G. (1987). Export promotion via industrial enclaves: The Philippines' Bataan export processing zone. *The Journal of Development Studies*, 23(2), 220–241. <<https://doi.org/10.1080/00220388708422028>>
- Waters, J.J. (2013). Achieving world trade organization compliance for export processing zones while maintaining economic competitiveness for developing countries. *Duke Law Journal*, 63(2), 481–524.
- Zivot, E., and Andrews, D.W.K. (1990). Further evidence on the great crash, the oil price shock, and the unit root hypothesis. *Journal of Business & Economic Statistics*, 20(1), 25–44. <<https://doi.org/10.1198/073500102753410372>>

A PRISMA-based systematic literature review on the mismatches between the Romanian higher education system and the labor market needs

Daria Elisa VUC

Bucharest University of Economic Studies, Romania
daria.vuc@economie.ase.ro

Abstract. *As labor markets are dynamic and change rapidly, it is crucial for universities to catch up and align curricula with the required needs so as to produce graduates that can easily enter the workforce and find a suitable job for their qualifications. In Romania, there are some mismatches between the higher education system and the labor market and they are reflected in the number of overeducated or undereducated employees, for one instance, or in graduates' success in transitioning from university to work. The objective of this systematic literature review is, firstly, to develop one search criteria in order to sort out the most relevant papers on the topic for the database, and, secondly, to conduct qualitative analysis on what has been researched in the last ten years on the given topic of mismatches between the Romanian higher education system and the labor market, what contributes to these mismatches and what possible and feasible solutions there are. Although there is still need for further research concerning Romania's case, results show that the higher education system is still not funded sufficiently and, in order to align curricula with labor market demands, universities must partner up with the business sector and exchange feedback on a constant basis so as to develop internships and traineeships and programs for lifelong learning, reskilling and career re-orientation.*

Keywords: higher education, labor market, systematic literature review, employment, university curricula.

JEL Classification: A1, A2.

1. Introduction

Besides offering superior level of studies, higher education systems must ensure they produce well-prepared professionals for the labor market. At the same time, graduates must be satisfied with their work in order to lead fulfilling lives, and, for that to happen, the competences gained throughout the learning process must align with the fast-changing work environments. The issue of integrating graduates into the labor market is a worldwide concern for many countries and it still represents one of the academic areas that needs ongoing research. This matter is also called ‘graduate employability’ and it drives higher education institutions to be strongly innovative and to collaborate with employers and organizations in order to develop the proper competences for an effective labor market insertion (Abelha, et al., 2020). However, the same study suggests that even though employers repeatedly let administrative institutions know about this problem, academics remain in charge of the competences’ development process, without following ‘an integrative institutional approach’ (Abelha, et al., 2020).

There are two sustainable development goals (SDGs) that aim for quality education (SDG4) and decent work and economic growth (SDG8). SDG4 proposes lifelong learning for all the people in the world and calls for actions to reduce dropout rates, illiteracy and enhance secondary school completion, while SDG8 promotes sustainable economic growth through full employment, productivity and decent work (United Nations, 2025). In 2022, reports showed that one in four young people were NEET (not in education, employment or training), with young women being twice more affected by this situation than young men, and around 2 billion workers around the world were working in ‘precarious informal jobs’ without benefitting from social protection (United Nations, 2025). In Romania, the unemployment rate recorded in December 2024 was 5.4%, only 0.1 percentage point lower than it was in November 2024, and it has stayed quite the same from 2021 (5.4%), with slight changes in 2022 and 2023 (5.6%) (Statista, 2025). However, the unemployment rate is higher among the 15-24 years old segment, with a value of 23.2%, as registered during April to June 2024 (INS, 2025). By 2030, there will be a need of more than 600000 employees for highly qualified jobs in IT, health or legal, according to the National Institute for Scientific Research in the Field of Work and Social Protection (CES Bucharest, 2025). Thus, the importance of higher education in shaping future professionals for the needs of the labor market can easily be drawn to attention. At the same time, statistics on the Romanian labor point to the fact that the sectors facing the highest vacancy rates are social work and health sectors, education, entertainment and recreation, arts, public administration and defense, compulsory social security, and administrative and support services (EURES, 2025).

Unfortunately, early school dropout is very common in Romania, and more than 15% of young people aged 18-24 have completed only lower secondary education or even less and no longer participate in any type of education or training, this aspect ranking Romania as the EU country with the highest rate of early dropouts (European Commission, 2025). Workers who have not completed an upper secondary stage of education face difficult labor

contexts in Romania, and this can be seen in the employment rates for 25-34 year-olds: only 48% of such people without upper secondary education have a job, while 79% of people with 'upper secondary or post-secondary non-tertiary qualifications' are employed (OECD, 2024). The OECD averages in this case are 61% and 79%. When it comes to tertiary education, the gap is wider between women and men: 54% women aged 25-34 in all OECD member states graduate a tertiary qualification, while 41% men do so, and, in Romania, there is a 26% rate of tertiary educational attainment for women and 19% rate for men (OECD, 2024). However, the situation is reversed in the labor market. Women may outperform men in education, but they struggle more in the labor market, especially if they have only completed below upper secondary educational levels: 30% of young women are employed and 65% of young men are employed in this case (OECD, 2024). On the other hand, by looking at the numbers for tertiary education attainment in Romania, 86% of young women and 93% of young men have a job, but the wage gap is not compensated by the tertiary qualifications, as women earn approximately 88% of the salary their fellow men do, 83% being the average proportion at the OECD level (OECD, 2024). The same report from OECD (2024) highlights that Romania has seen a massive increase in tertiary attainment 'over just one generation', and that educational attainment in young people is considerably impacted by the parents' education: 90% of 25-64 year-olds have graduated from a tertiary education level when at least one of their parents attained tertiary education (OECD, 2024).

The intersection of educational attainment and labor market is prone to result in mismatches due to major differences between what is taught and gained in school in terms of skills and competences and what is actually useful for the work-force of a country in terms of available jobs. Romania is managing the issue of mismatches a bit better than the OECD average, as in 22% employees work in jobs not matching their educational skill level, in comparison with 35%, respectively (OECD, 2024). In Romania, the division between low skills and high skills is traced down among activity sectors, as follows: people who have low skills work in 'sales and services', people who have medium skills work as 'clerks, craft workers, plant and machine operators and assemblers' and people who are highly-skilled work in 'managerial, professional, technical and associated professional occupations' (OECD, 2024). This distribution is spread across regions in the country and, while the West, South West Oltenia, South East, South-Muntenia, North East average around 24% share of jobs for the highly-skilled, the region of Bucharest-Ilfov stands out with a 49% share (OECD, 2024). The share of under-skilled workers in Romania is 18%, compared to 19% in OECD regions, and the share of over-skilled workers in Romania is 4%, compared to 16% in OECD regions (OECD, 2024). As described in this report, 'over-skilled' refers to having a higher educational skill level than your job, while 'under-skilled' is related to working in a job for which you have less skills than necessary. These are just some examples of mismatches between the Romanian education systems and the job market and more of them will be explored in this systematic review using PRISMA methodology, with focus on higher education institutions.

This paper has the sole purpose of digging deeper into the topic of labor market insertion for higher education graduates, as it is of great importance to find out the exact situation there is in Romania. With the means of a systematic literature review, patterns and trends in the academic research can be traced and recommendations for future research and solution implementation methods are more likely to be found. In doing so, through constant research and cooperation with eligible institutions and the business sector, the Romanian higher education system will become better at creating suitable curricula for labor market requirements, and, in this way, Romania may also become better at achieving SDG4 and SDG8 until 2030. This topic will certainly need to be researched constantly, due to the fact that the labor market changes in the span of a few years, and the education systems must adapt accordingly at the same pace. Therefore, the objectives of my research are to find out how often the labor market has changed in the last years, what higher education institutions did to adapt to those changes, what the collaborations between universities and businesses look like, what the main mismatches are and how they can be overcome, what methodologies were used in research by other authors concerning the Romanian context of education and labor, and what future recommendations for potential research there are.

In other words, the scope of this systematic literature review is to explore the following research questions:

- 1) What kinds of mismatches between the Romanian higher education system and the labor market needs are identified in the current literature?
- 2) What contributes to the existence of gaps between the university curricula and employers' demands in Romania?
- 3) How can the higher education system in Romania respond to the changes and requirements of the dynamic labor market?

A well-detailed set of the research steps for collecting the data and analyzing it will be described and explained in the Methodology section.

2. Methodology

This systematic literature review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology. The PRISMA method is based on a set of items included in a checklist which contains objectives, information sources, eligibility criteria, search strategy, selection process, data collection process, the flow diagram, results and discussions. The standard PRISMA method has its roots in healthcare research and adopts a very rigorous research approach for reporting studies by following a specific checklist of items in order to reduce the frequency of publication biases (Moher, et al., 2010). Such analyses use a strict protocol for data selection, with inclusion and exclusion criteria, for a better bigger picture of the current state of research, and for easy replicability of studies (University of Leicester, 2025). This study is a qualitative one, focusing only on drafting the systematic literature review. For this paper, the review protocol will further explain the criteria for paper selection, the

strategy for searching the papers, how the data was extracted, and the procedures of data analysis.

2.1. Data Sourcing Strategies

The database of articles chosen for this research was derived from three well-known and reliable academic databases: Web of Science (WoS), Scopus and ProQuest. Before deciding on the proper mix of keywords to search by, several combinations were tried, and it turned out that the mix of “Romanian higher education system” and “Romanian labor market”, using the Boolean “AND”, returned the largest number of published papers, an aspect which helped at screening a variety of works. When opting only for Romanian and English languages and filtering the last ten years, from 2015 to 2024, the database Web of Science returned, in the first phase, 54 results, Scopus returned 14 results, and even though ProQuest was richer in results, with a number of 1886 sources, after a scan of them was performed, only 4 were accurate for the topic. There were no available publications for the current year 2025. The span of ten years was chosen on the idea that, with the beginning of the former President’s project called “Educated Romania” in 2016, the education systems in Romania started to change, while the labor market has certainly faced major transformations since then. Even though it turned out to be poor literature on exactly the topic of mismatches between the Romanian higher education system and the labor market dynamics, I decided to stick to that mix of search keywords so as to be able to have a broader look on what has been researched so far and to identify gaps for potential future research. Data extraction took place in April 2025.

2.2. Eligibility Criteria

Regarding the inclusion and exclusion criteria, besides the preferred languages Romanian and English, and the years 2015-2024, both qualitative and quantitative studies were included, written by both domestic and foreign authors, and only studies concerning Romania, or comparative studies including our country, were considered fit for this research. Nonetheless, the academic databases contained only papers written in the English language.

2.3. Selecting the Papers

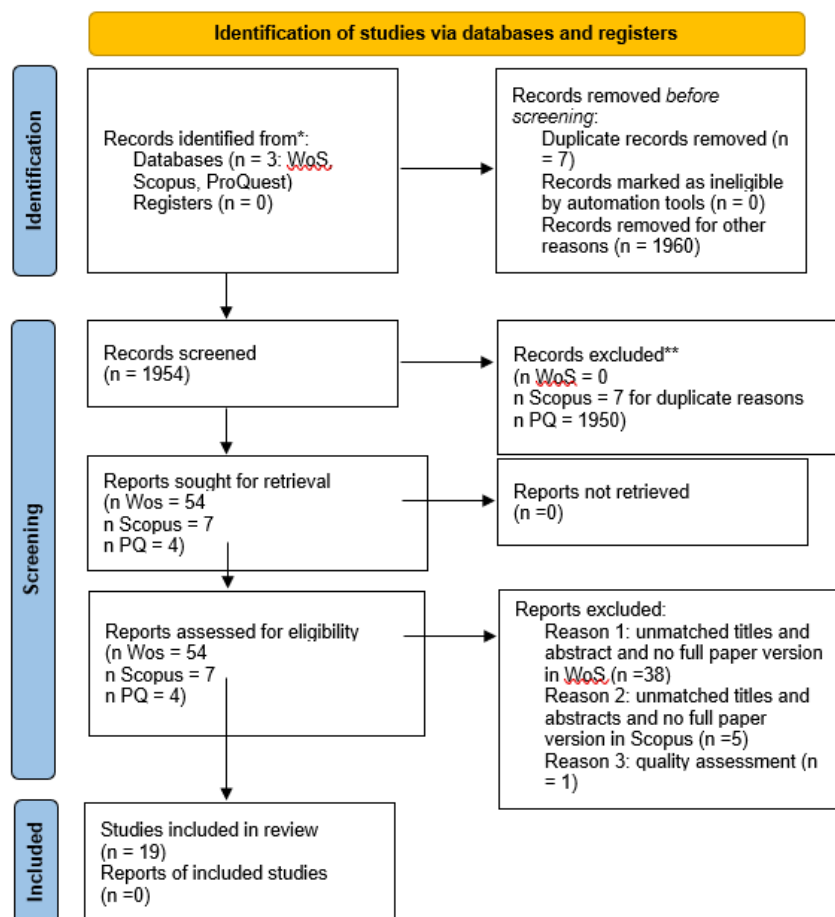
In the first phase, the selected papers were checked by their titles and abstracts, by making sure they are related to the topic. There were 26 papers removed from Web of Science, in the first instance, as the titles and abstracts did not match the topic, and 7 papers removed from Scopus, after checking the double articles, as well. The second phase consisted in finding the full text versions of the papers, which led to other 12 papers removed from Web of Science, and 5 removed from Scopus, because there was no free access available for them, resulting in 14 eligible papers from Web of Science, and 2 articles from Scopus. As for the ProQuest database, because the initial results did not really correspond to this study’s requirements, only 4 papers were chosen. After reading all of the papers entirely for the quality assessment phase, one source from Scopus was removed due to its mismatch from the topic. Thus, the database for this research consists of 19 papers which are

displayed in **Table 1 from Annexes**. A legend for the chosen database was developed, as follows: the papers from Web of Science are named from W1 to W14, the paper from Scopus is codified as S1, and the papers from ProQuest are named from P1 to P4, for a more effective correspondence in the Results and Discussions section.

2.4. Flow Diagram

The flow diagram shown by **Figure** depicts the selection process of this paper's database. No automation tools were involved in conducting this research, only the critical analysis of the author had weight in deciding what papers to include and exclude. The process was quite difficult as the current literature on Romania's case does not offer a great number of proper articles or book chapters on mismatches between the higher education system and the changing labor market. The number of returned papers from Web of Science and Scopus was not high either, with the exception of ProQuest database which did not actually offer papers on the topic, although the same combination of words was applied to it too.

Figure 1. Flow Diagram, Source: Author's own research



3. Results

Web of Science database returned 10 proceeding papers and 4 articles, which were chosen for this study, categorized in areas of research such as *Business, Educational Research, Economics, Environmental Sciences, Environmental Studies, Management, Green Sustainable Science Technology, Social Sciences Interdisciplinary, Business Finance and Computer Science Information Systems*. There is an average of 3 papers in 2015, 2017 and 2019, without a growing trend in sight yet. On the other hand, Scopus database returned 3 conference papers, 2 book chapters and 1 article, but only 1 book chapter was chosen for this study. As for ProQuest database, all of the four selected papers are journal articles. Out of the 19 papers in the database, 12 follow a qualitative methodology and 7 follow a quantitative one.

4. Discussions

The limited number of papers on this topic in Romania complicated the research process a bit, as not all of them answer entirely to the proposed research questions. However, where needed, supplementary data was added to support the objectives of this study.

RQ1: What kinds of mismatches between the Romanian higher education system and the labor market needs are identified in the current literature?

W1 outlines some issues the higher education system encountered on its path to digitalization, an issue which spurred with the dawn of the COVID-19 pandemic. This paper (W1) applied qualitative research with the means of a case study and document analysis approach and by constructing a D-VUCAD analysis. It shows how the Romanian higher education system is volatile in terms of a low rate of tertiary education attainment, especially in young people, high numbers for dropouts, migration to foreign countries and limited participation to courses. Moreover, in the case of Vocational Education and Training (VET) students and graduates, mismatches occur because of a “low utilization of work-based learning opportunities”, which leads to unemployment for the ones in this area (Tanasciuc, 2024). Furthermore, in our country, overeducation is a result of the surplus of higher educated labor supply because of the rigidity of the institutional arrangements, as concluded by source **W3**. There are too many tertiary graduates who face unemployment, and institutional arrangements certainly need improvement (Pana & Fanea-Ivanovici, 2019). The long period transitions from school to work are faced by Eastern European youths, as per source **W9**, and solutions to this problem must be found (Serban & Istrate, 2017).

RQ2: What contributes to the existence of gaps between the university curricula and employers' demands in Romania?

W1 follows qualitative analysis, with the means of case studies and documents through a D-VUCAD perspective, and suggests the fact that higher education institutions have to go through “complex regulatory environments, accreditation standards, and compliance requirements amid digital transformations”, and all actors – students, administrators, policymakers contribute to the complex decision-making stage (Tanasciuc, 2024). In spite

of their higher levels of education, persons aged between 15 and 24 years old feel the burden of the school-to work transition, and, unfortunately, most of them end up being not in employment, education, or training (NEET), as the source **W2** (quantitative analysis) suggests. This issue derives mainly from the fact that even though labor markets have become more complex because of the pressure of technology, globalization and digitalization, the education systems tend to stagnate and keep old and outdated school programs. Romania, together with Bulgaria and Italy, share the highest levels of NEETs in the EU countries. Of course, this fact also reflects other aspects such as attitude regarding school and work, motivation and how urbanized the students' macro-regions of residence are. Nonetheless, there is still not enough data regarding the NEETS (Caroleo, et al., 2022). One aspect which may contribute to turbulences in the academic process and is not so obvious in the first instance is the quality of the teaching staff. Paper **W7** tackles this matter, in a quantitative analysis, and emphasizes that the development of the educational process depends a lot on how well prepared the teaching staff of an educational institution is, as the level of preparedness further dictates the quality and efficiency of the system. This study also states that Romania assigns a low percentage out of its GDP to education and, at the same time, the private sector does not contribute financially as much as it could in order to close the gap. Thus, educational investments have an impact on professors as well, and it is of great importance that educational institutions invest in the continuous lifelong learning of their professors (Matei, et al., 2017). The main issues in Romania in 2017 referred to the lack of strong relationships between firms and the academic environment, as per source **W9**. This leads to graduates who do not manage to find a suitable job according to their level of education, resulting in an increase in the "undereducation" phenomenon, and who put pressure on those without a university diploma (Serban & Istrate, 2017). Another aspect that interferes with the alignment of universities' curricula to the labor market is, as study **W10** shows, represented by too many changes in the structure of higher education institutions' management. A way of tackling this could be investing in training both managers and professors through continuous courses where they can acquire knowledge on the latest didactic practices and the use of technology and information for modernizing the education system (Mergeni, 2016). Insufficient financing from the State budget in the higher education system cannot ensure quality in the university system, so reforms are needed all the time, as **W12** highlights (Manta, et al., 2015).

RQ3: How can the higher education system in Romania respond to the changes and requirements of the dynamic labor market?

Before embarking on aligning the education system with the labor market, **W1** highlights the importance of fighting against the inequalities in the higher education access regarding different socio-economic classes and educational quality. Besides that, in response to the mentioned issues, the integration of dual education within universities would be a good step for enhancing academic standards, as in this way partnerships with the business sector will be fostered, and students' academic chances would be improved by short-cycle and double specialization programs. Improving the digital infrastructure in universities is crucial, well-equipped labs are a must, as well as curriculum revision. Among the solutions,

the paper mentions the importance of “adult career guidance systems, implementing the national second chance program for upper secondary school students, and reskilling over 32,000 persons affected by the transition to a climate-neutral economy” (Tanasciuc, 2024). **W1** discusses about the Vocational Education and Training (VET) and mentions the development of a skill forecasting model so as to match the VET provision with the actual economic needs, a mechanism which is being developed with the help of the project called “ESF-funded ReConnect” (Tanasciuc, 2024). The higher education systems should refrain from increasing the number of students – they should rather adapt curricula to the market dynamics instead, and supply all of the graduates with quality education in order to reduce the number of diplomas which cannot help in finding a job, as per **W3** (qualitative analysis). Thus, the labor market, business environment and education systems must “regulate each other” to find the perfect balance, in terms of always being interconnected and working together on finding out what skills are needed, the number of necessary graduates for the market, and the proper wage rate for them (Pana & Fanea-Ivanovici, 2019). **W4**, through quantitative PLS-SEM analysis based on a questionnaire, indicates the importance of equipping higher education institutions with technology in order to improve the daily activities of students and professors and to achieve a good environment for the academic process, which can positively influence the transition to work for graduates. Besides that, the content of the educational process must be revised by analyzing “the relevance of the study disciplines”, and by orienting students towards sustainability matters. This can be done by balancing the knowledge presented in the courses with study materials from the seminars, by introducing more practical activities and by working on developing “critical and interpretational abilities in students” (Gora, et al., 2019).

In a future attempt to overcome the problem of NEETs, paper **W2** suggests that a constant adaptation of school programs to the new skills which appear on the labor market can be the only solution to reduce the time between graduation and finding a job for young people aged 15-24 (Caroleo, et al., 2022). **W4** also mentions how important it is for universities to keep strong ties with the labor market and to redefine their disciplines and contents so as to keep their educational offerings to high quality level (Gora, et al., 2019). Implementing projects helping youth NEETs insert on the labor market is as vital as implementing projects for higher education graduates, as **W5** concludes. A flexible and labor-market oriented curriculum should be based on a program reorganization by professions and occupational groups for students. Moreover, even after graduation, it is important for employees to take part in vocational training programs. And, as it is an issue presented in most of the papers, investing in education and lifelong learning has to be financed through structural funds (Simionescu & Naros, 2019).

Paper **W6** follows a case study strategy and persists in the idea that the Romanian economy has a chance in surviving and returning to normal if higher education is based on a “National Qualifications Framework”. “EHEA Higher Education Area”, established by the Ministers of Education during the Bologna Process, supports the creation of curricula on competences and learning outcomes (Magdoiu & Rada, 2018). Because there is a need for engineers with economic knowledge, technical universities should focus on

multidisciplinary training for transversal skills acquiring. This qualitative research suggests a set of exact competences, skills, and subjects to be taught in engineering classes, and more studies in Romania should be conducted by higher education institutions by taking this approach in order to draw feasible solutions for adapting their curricula to the economic needs of Romania. Although source **W8** does not reflect on the mismatches, it shows through a qualitative secondary data analysis that Romanian professors, teachers and students are successful abroad during mobility programs, so one proposal from here could be that exchanges abroad and mobility chances are a good practice for sharing ideas, build educational strategies and learn from other universities how to adapt the national curricula to the labor market (Radu & Gogu, 2017). In order to mitigate the negative effects of undereducation, more quality traineeships must be introduced, as well as more funded programs developed for the young people's insertion on the labor market, similar to the "Jobs for Youth" initiative (**W9**). The same paper mentions the enhancing of the quality of and an easier access to the vocational and technical education programs and building the academic system on the lifelong learning concept (Serban & Istrate, 2017). Other solutions presented in source **W10** are the following: more professional counselors for guiding students and future graduates in a suitable career path, continuous granting of Erasmus scholarships through study exchanges, signing contracts with large companies for students' career preparation and actual practical training must be present in all universities, alongside volunteering activities (Mergeani, 2016). Direct exchange of feedback between universities and private companies is crucial, as stated by paper **W11**, as it can incentivize students and professors "to co-create value", because they are the principal stakeholders, whilst the beneficiary is the society and the employer (Oltean, et al., 2016). The Romanian government should set as an objective the reconversion and retraining of employers, and Erasmus projects should be based on skills acquiring activities, as per source **W13** (Nen, 2015). The perpetual underfunding in education systems goes back to the post-communist time and the higher education system in Romania has to remain of great importance to the government (**S1**) (Zaharia, et al., 2024).

Paper **W14** illustrates quantitative research based on a questionnaire addressed to students from University of Polytechnics of Timisoara and University of Polytechnics of Bucharest, and the results indicate that students feel more encouraged to learn in "a relaxing and stimulating environment" (Todorescu, et al., 2015). So, maybe aside from the reforms and money spending on higher education, it is essential for universities to create an environment which stimulates creativity and innovation, an environment which partly resembles the work environment, so that future graduates learn early what they signed up for. Paper **P1** comes with several recommendations such as not only building subject-specific expertise but to also cultivate transferable skills like critical thinking, effective communication, and problem-solving. The same study implies that higher education institutions have to prioritize these competencies by integrating active learning methods and supporting extracurricular engagement. Moreover, the key partnerships between universities and employers are the collaborations with the industry, and, in this way, employers can give students firsthand experience in real-world settings and help them develop skills aligned

with market needs. Strong career support services are as well needed and they include counseling, job placement, and networking opportunities, while tracer studies, which monitor graduates' career paths over time, offer valuable insights into the long-term effectiveness of higher education. Employer surveys and labor market indicators are of great importance, as the first option provides direct input on the qualities and competencies that companies expect from new hires, while the latter can help evaluate how well higher education institutions are preparing students for successful careers, by looking at employment rates and average salaries (Drugas & Tiba, 2024). Source **P2** concludes that there is need for further qualitative research in order to entirely grasp the university-to-work transition in Romania, due to the frequent differences across specializations. For instance, corporate social responsibility (CSR) jobs demand more soft skills, like social competencies, motivated and adaptable outlook on work and job-specific competencies, against hard ones (Gonzague, 2024). Ongoing professional development, high-quality education, and the continuous acquisition of new skills by employees are essential for maintaining a competitive workforce, as per source **P3**, and promoting a culture of lifelong learning is key to personal and professional growth. The paper proposes solutions such as increased investment in education and training, enhancing the quality of early childhood education and care, as it lays a strong foundation for future learning and development, expanding access through more tuition-free opportunities or student loan programs, and, finally, implementing a Lifelong Learning Strategy, advancing the National Qualifications Framework, updating the occupations classification, and reforming the adult education legislation (Lut, 2018). As source **P4** indicates, better employment prospects are in strong ties with participation in one or more specialized internships during undergraduate studies. During periods of economic uncertainty or crisis, graduates commonly pursue further education as a way to delay entry into a challenging job market and to strengthen their competitiveness. Thus, youth employment subsidy programs should be introduced and funded to boost employment by offering financial incentives to both young graduates and their employers. At last, developing career readiness should involve both job-specific competencies, which can be gained through internships in collaboration with potential employers (Baciu, 2022).

5. Conclusions

This paper sustains that there is a huge need for further research on the mismatches between the Romanian higher education system and the actual dynamics of the labor market. At the end of the day, education is the one thing that cannot be taken away from us. Human capital contributes to economic growth and each country in this world has the responsibility to invest in its people in order to stay competitive, create better life opportunities and improve the quality of life overall. As important as tertiary education may be, all levels of education need improvement, right from the early stages, as most of the learning patterns start from there. In this way, students can better choose their university degrees according to their preferences and what is sought after in the labor market. However, choosing a career path

can be a difficult and, at times, a discouraging road for many graduates due to many reasons. First of all, university-to-work transition can last longer than expected or it can result in an unsatisfactory and improper job for many candidates. Mismatches like overeducation or undereducation are some of the examples that can interfere with the process of working in a suitable job. Second of all, frequent dissatisfactions with the chosen domain of work make graduates question their tertiary education degrees. It was shown throughout this systematic literature review where Romania stands when it comes to tertiary education and skills mismatch and I can conclude that there is still need for educational reforms that can redirect the higher education system on the path of labor market alignment. Changing university curricula cannot happen overnight – this is a much more complex process that universities should embark on if they want to provide the labor market with qualified professionals. Universities must co-operate with the business sector when developing educational programs and the business sector should create internship facilities for future graduates to have a more practical approach to the theoretical knowledge they gain during their studies.

References

- Abelha, M. et al. (2020). Graduate Employability and Competence Development in Higher Education – A Systematic Literature Review Using PRISMA. *Sustainability*, 12(15).
- Baciu, E.-L. (2022). Employment Outcomes of Higher Education Graduates from during and after the 2007-2008 Financial Crisis: Evidence from a Romanian University. *Sustainability*, 14(18).
- Caroleo, F.E., Rocca, A., Neagu, G. and Keranova, D. (2022). NEETs and the Process of Transition from School to the Labor Market: A Comparative Analysis of Italy, Romania, and Bulgaria. *Youth and Society*, 54(2), 109S-129S.
- CES Bucharest (2025). *Center for Economy & Society Bucharest*. [Online] Available at: <<https://cesbucharest.com/>> [Accessed 15 April 2025].
- Drugas, M. and Tiba, A. (2024). Graduate Employability as a Key Metric for Evaluating Higher Education Efficiency. *Romanian Journal of School Psychology*, 17(33/34), 97-106.
- EURES (2025). *EUropean Employment Services, Labour Market Information: Romania*. [Online] Available at: <https://eures.europa.eu/living-and-working/labour-market-information-europe/labour-market-information-romania_en> [Accessed 15 April 2025].
- European Commission (2025). *Youth Wiki, 6.3. Preventing early leaving from education and training (ELET)*. [Online] Available at: <<https://national-policies.eacea.ec.europa.eu/youthwiki/chapters/romania/63-preventing-early-leaving-from-education-and-training-elet>> [Accessed 15 April 2025].
- Gonzague, I. (2024). Evidencing Uncertain Career Paths Among Overqualified Employees. *Pangeea*, Issue 2, 45-56.
- Gora, A.A., Stefan, S.C., Popa, S.C. and Albu, C.F. (2019). Students' Perspective on Quality Assurance in Higher Education in the Context of Sustainability: A PLS-SEM Approach. *Sustainability*, 11(17).

- INS (2025). *National Institute of Statistics Romania*. [Online] Available at: <<https://insse.ro/cms/>> [Accessed 15 April 2025].
- Lut, D.M. (2018). The Analysis of Romanian Education and Training System in Accordance with European Requirements. *Quaestus, Timisoara*, Issue 13, 173-184.
- Magdoi, L.D. and Rada, I.C. (2018). The necessity of developing the economic engineering specialization in the current context of Romania's economic structure. *International Journal of Advanced and Applied Sciences*, 5(5), 48-60.
- Manta, S.G., Sarlea, M. and Vaidean, V.L. (2015). Comparative analysis of University Education Systems from the Central and Eastern European Countries. *Procedia Economics and Finance, Emerging Markets Queries in Finance and Business*, Volume 32, 1276-1288.
- Matei, A., Cristache, S.E., Marin, E. and Rotaru, F.G. (2017). Stochastic analysis of the main macro-economic indicators characterizing higher education in Romania during 2001-2016. *Proceedings of the International Conference on Business Excellence*, 11(1), 1158-1166.
- Mergeani, N. (2016). Linking Higher Education with the Labour Market, Unemployment, Reduction Target Among Young Graduates of Higher Education. *International Scientific Conference on Economic and Social Development, Economic and Social Development*, 20-27.
- Moher, D. et al. (2010). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *International Journal of Surgery*, 8(5), 336-341.
- Nen, M. (2015). Professional Insertion of Highly Qualified Human Resources. Case Study - Romania. *Procedia Social and Behavioral Science, Proceedings of the 6th World Conference on Educational Sciences*, Volume 191, 1891-1896.
- OECD (2024). *Education at a Glance 2024 - Country notes: Romania*, s.l.: OECD.
- OECD (2024). *Job Creation and Local Economic Development 2024 - Country Notes: Romania*, s.l.: OECD.
- Oltean, V.E., Borangiu, T. and Dragoicea, M. (2016). On a Qualitative Game Theoretic Approach of Teacher-Student Interaction in a Public Higher Education Service System. *7th International Workshop on Exploring Service Science (IESS)*, Volume 247, 15-29.
- Pana, M.-C. and Fanea-Ivanovici, M. (2019). Institutional Arrangements and Overeducation: Challenges for Sustainable Growth. Evidence from the Romanian Labour Market. *Sustainability*, 11(22).
- Radu, C. and Gogu, E. (2017). Issues and Insights Regarding Tertiary Education. A Romanian Perspective. *Proceedings of the 11th International Management Conference: The Role of Management in the Economic Paradigm of the 21st Century (IMC 2017)*, 446-456.
- Serban, R.I.H. and Istrate, M. (2017). High Education, Professional Insertion and Economic Development in Romania. *Springer Proceedings in Business and Economics, Advances in Applied Economic Research*, 487-501.
- Simionescu, M. and Naros, M.-S. (2019). *Unemployment Among Potential Young Romanian Future Leaders, ESAL 2018*. Prague, Springer Proceedings in Business and Economics, 1310139.
- Statista (2025). *Unemployment rate in Romania from 1991 to 2024*. [Online] Available at: <<https://www.statista.com/statistics/1105150/unemployment-rate-romania/>> [Accessed 15 April 2025].

- Tanasciuc, M. (2024). A D-VUCAD Transitioning Analysis on Romanian Higher Education System in the Context of Artificial Intelligence. Challenges, Opportunities and Perspectives. *Proceedings of the International Conference on Business Excellence*, 18(1), 2420-2432.
- Todorescu, L.-L., Greculescu, A. and Popescu-Mitroi, M.-M. (2015). Engineering Students' Career Choice and the English Teacher's Profile in Romanian Higher Education. *Procedia Social and Behavioral Sciences*, 7th World Conference on Educational Sciences, Volume 197, 201-206.
- United Nations (2025). *The 17 Goals*. [Online] Available at: <<https://sdgs.un.org/goals>> [Accessed 15 April 2025].
- University of Leicester (2025). *What is PRISMA, and why do you need a protocol?* [Online] Available at: <<https://le.ac.uk/library/research-support/systematic-reviews/prisma>> [Accessed 16 April 2025].
- Zaharia, R., Zaharia, R.M. and Edu, T. (2024). Change and Continuity in the Higher Education System. In: *Post-Communist Progress and Stagnation at 35: The Case of Romania*. s.l.: Springer Nature, 233-252.

Annexes

Table1. Database of Papers

Legend	Title	Author(s)	Year	Publication Source	Research Methodology
W1	A D-VUCAD Transitioning Analysis on Romanian Higher Education System in the Context of Artificial Intelligence. Challenges, Opportunities and Perspectives	Marcela Tanasciuc	2024	18th International Conference on Business Excellence (ICBE) - Smart Solutions for a Sustainable Future	Qualitative: case studies and documents through a D-VUCAD perspective
W2	NEETs and the Process of Transition from School to the Labor Market: A Comparative Analysis of Italy, Romania, and Bulgaria	Caroleo Floro Ernesto, Rocca Antonella, Neagu Gabriela, Keranova Dilyana	2022	Youth and Society	Quantitative: LFS microdata (use of some surveys)
W3	Institutional Arrangements and Overeducation: Challenges for Sustainable Growth. Evidence from the Romanian Labour Market	Pana Marius Cristian, Fanea-Ivanovici Mina	2019	Sustainability	Qualitative analysis
W4	Students' Perspective on Quality Assurance in Higher Education in the Context of Sustainability: A PLS-SEM Approach	Gora Ana Alexandra, Stefan Simona Catalina, Popa Stefan Catalin, Albu Catalina Florentina	2019	Sustainability	Quantitative: PLS-SEM, questionnaire
W5	Unemployment Among Potential Young Romanian Future Leaders	Simionescu Mihaela, Naros Maria-Simona	2019	Sustainable Leadership for Entrepreneurs and Academics	Quantitative: VAR model
W6	The necessity of developing the economic engineering specialization in the current context of Romania's economic structure	Magdoi Liliانا, Doina, Rada Ioan Constantin	2018	International Journal of Applied Sciences	Qualitative: Case study strategy
W7	Stochastic analysis of the main macro-economic indicators characterizing higher education in Romania during 2001-2016	Matei Ani, Cristache Silvia Elena, Marin Erika, Rotaru Florica Georgeta	2017	Proceedings of the International Conference on Business Excellence	Quantitative: econometric model based on secondary data in Eviews software
W8	Issues and Insights Regarding Tertiary Education. A Romanian Perspective	Radu Catalina, Gogu Emilia	2017	International Management Conference on Role of Management in the Economic Paradigm of the XXIst Century	Qualitative: secondary data
W9	High Education, Professional Insertion and Economic Development in Romania	Serban Raluca Ioana Horea, Istrate Marinela	2017	Advances in Applied Economic Research	Quantitative
W10	Linking Higher Education with the Labour Market, Unemployment, Reduction Target Among Young Graduates of Higher Education	Mergeani Nicea	2016	15th International Scientific Conference on Economic and Social Development - Human Resources Development	Qualitative
W11	On a Qualitative Game Theoretic Approach of Teacher-Student Interaction in a Public Higher Education Service System	Oltean Virginia Ecaterina, Borangiu Theodor, Dragoicea Monica	2016	7th International Workshop on Exploring Service Science	Qualitative: education game model
W12	Comparative analysis of University Education Systems from the Central and Eastern European Countries	Manta Stefan George, Sarlea Mihaela, Vaidean Viorela Ligia	2015	International Conference on Emerging Markets Queries in Finance and Business (EMQFB)	Qualitative

Legend	Title	Author(s)	Year	Publication Source	Research Methodology
W13	Professional Insertion Of Highly Qualified Human Resources. Case Study - Romania	Nen Madlena	2015	Proceedings of the 6th World Conference on Educational Sciences	Qualitative
W14	Engineering Students' Career Choice And The English Teacher's Profile In Romanian Higher Education	Teodorescu Liliana-Luminita, Greculescu Anca, Popescu-Mitroi Maria-Monica	2015	7th World Conference on Educational Sciences	Quantitative: questionnaire
S1	Change and Continuity in the Higher Education System	Razvan Zaharia, Rodica Milena Zaharia, Tudor Edu	2024	Springer Book Chapter	Qualitative
P1	Graduate Employability as a Key Metric for Evaluating Higher Education Efficiency	Marius Drugas, Alexandru Tiba	2024	Romanian Journal of School Psychology	Qualitative
P2	Evidencing Uncertain Career Paths Among Overqualified Employees	Isirabahenda Gonzague	2024	Pangeea	Qualitative: interviews
P3	The Analysis of Romanian Education and Training System in Accordance with European Requirements	Dina Maria Lut	2018	Quaestus Timisoara	Qualitative
P4	Employment Outcomes of Higher Education Graduates from during and after the 2007–2008 Financial Crisis: Evidence from a Romanian University	Elena-Loreni Baci	2022	Sustainability	Quantitative

Transition effect from deposit and policy interest rates to credit interest rates in Türkiye: detecting asymmetry

Kadir KARAGÖZ

Manisa Celal Bayar University, FEAS, Türkiye
kadir.karagoz@cbu.edu.tr

Suzan ERGÜN

İnönü University, FEAS, Türkiye
suzan.ergun@inonu.edu.tr

Abstract. *The effectiveness of the transmission mechanism of interest rates has been subject of numerous empirical studies. Studies using different methods have reached common findings that the transmission in question does not work very well in Türkiye. In this study, the asymmetric relationship between policy and banking interest rates is investigated using the non-linear ARDL method. The findings indicate that there is an asymmetric interaction between policy and deposit interest rates, and loan interest rates in Türkiye in the long term which raises doubts about the effectiveness of monetary policy and provides insight into the weakness of competition among banks.*

Keywords: interest rate, pass-through effect, asymmetry, NARDL, Türkiye.

JEL Classification: C22, E43, E52.

1. Introduction

Central banks strive to achieve various objectives such as price stability, financial stability and economic growth through the monetary policies they implement. Central banks, whose roles in financial markets have increased significantly, especially in the wake of recent economic crises, have been quite effective in many areas, from determining asset prices to investment and consumption decisions, through the policies they implement (Poyraz et al., 2020). The policy decisions implemented by central banks to achieve their objectives affect economic activity through various transmission mechanisms. The monetary transmission channel is one of the most effective of these channels. In order for monetary policies to have the expected effect on the economy and achieve their objectives, authorities must have a complete assessment of the effects of the policies they implement on the economy. In this assessment process, understanding how monetary policies affect the economy through which channel is important in determining the policies to be implemented (Adanur-Akkan and Nargeleçekenler, 2008). The most traditional of the monetary transmission mechanisms, the interest rate channel, is also referred to as the Keynesian standard monetary transmission channel. Through this channel, the monetary authority changes the marginal cost of borrowing, thereby influencing consumers' consumption decisions and cash flows, as well as producers' investment and spending behaviour, and thus affecting aggregate demand in the economy (Poyraz et al., 2020). In contrast, in the monetarist approach, interest rates are assigned a more passive role in the transmission of monetary policy to economic activity (Goodfriend and King, 1997).

Central banks have a dominant influence on money market conditions and thus steer money market interest rates. Changes in money market interest rates affect longer-term market interest rates and, to varying degrees, individual bank interest rates. Bank decisions regarding returns on assets and liabilities affect the spending and investment behaviour of depositors and borrowers and, consequently, real economic activity. In other words, the faster and more complete transmission of official and market interest rates to retail bank interest rates strengthens monetary policy transmission and can therefore affect price stability. Additionally, the prices and margins set by banks affect bank profitability, the soundness of the banking system, and ultimately financial stability (Bondt, 2005).

Understanding how monetary policy channels work is critical for central bankers to calibrate their policy response functions and policy decisions. Ideally, the interest rate pass-through should be fast, symmetric, and complete. However, in practice, this may not be the case, and adjustments may be slow and incomplete due to various market frictions. Furthermore, a common assumption in monetary policy models is that changes in policy interest rates affect retail prices in a linear manner, regardless of whether they are positive or negative. This may not necessarily be the case, and the transmission may be asymmetric; the speed and magnitude of retail price adjustments may vary depending on whether the policy impulse is positive or negative. In such cases, a linear definition may not be appropriate, and the design of monetary policies may need to be based on a non-linear asymmetric approach. These issues must be taken into account when formulating,

implementing, and communicating policies (Galinda and Steiner, 2022). Based on this idea, this study tests the hypothesis that the pass-through effect of the policy interest rate announced by the Central Bank of Türkiye and the interest rate applied by banks to deposits to the interest rate applied to loans may be asymmetric.

2. Theoretical Background

One of the most fundamental dynamics in economics is the impact of monetary policy on financial markets and the real economy. At the heart of this impact lies the relationship between the policy interest rate set by the central bank and the deposit and lending interest rates applied by banks. This relationship operates through a complex mechanism known as interest rate pass-through and is typically far from perfect or symmetrical; asymmetrical interactions are often observed. These asymmetries directly affect the effectiveness of monetary policy and its transmission to the economy.

2.1. Interest Rate Pass-Through: Definition and Mechanism

Interest rate pass-through refers to the extent and speed at which changes in the policy interest rates set by the central bank are reflected in deposit and lending rates as a result of banks' funding and lending activities. Central banks use the policy interest rate as a key tool to achieve objectives such as fighting inflation, promoting economic growth, and ensuring financial stability. The central bank's policy interest rate is typically a reference point for short-term market interest rates, such as the overnight lending/borrowing rate or the weekly repo rate. It directly affects the cost of borrowing from or depositing money with the central bank for banks. This, in turn, shapes the short-term funding costs among banks.

Deposit interest rates are the interest rates banks pay on deposits collected from households and companies. Increases in the policy rate have the potential to increase banks' funding costs, so banks may adjust deposit rates to attract deposits or retain existing deposits. However, factors such as the maturity of deposits, liquidity preferences, and the level of competition affect this impact.

Credit interest rates are the interest rates charged by banks on loans provided to households and companies. Credit interest rates depend on many factors, including banks' funding costs, credit risk premiums, operational costs, the level of competition, and the bank's profit margin targets. Increases in policy interest rates tend to raise credit interest rates by increasing banks' lending costs, while decreases have the opposite effect.

The effectiveness of monetary policy depends on the degree and speed of this pass-through. If changes in the policy interest rate are quickly and fully reflected in bank interest rates, monetary policy has a stronger impact on economic activity and inflation. Full pass-through refers to an ideal situation where banks reflect all changes in their funding costs in their interest rates.

2.2. Asymmetric Interaction

Interest rate pass-through generally exhibits an asymmetric structure. This means that when the central bank raises (tightening) or lowers (easing) its policy interest rate, the manner and speed at which this is reflected in banks' deposit and lending rates differ. Common asymmetric situations observed in the literature are as follows:

1. **Downward Rigidity for Lending Rates:** When the central bank lowers its policy rate, banks are reluctant to lower their lending rates by the same amount or at the same pace. In other words, even if banks' funding costs decrease, they tend not to immediately lower their lending rates in order to maintain or increase their profit margins. This situation can become particularly apparent in periods when market competition is low or banks' risk perception is high.
2. **Upward Rigidity for Deposit Rates:** When the central bank raises its policy interest rate, banks may not immediately raise their deposit interest rates by the same amount or at the same pace. Banks may tend to raise interest rates more slowly and/or by a smaller amount in order to keep their funding costs under control or to avoid the risk of losing existing deposits.
3. **Upward Flexibility for Lending Rates:** When the central bank raises its policy rate, banks tend to raise their lending rates more quickly and/or more fully.
4. **Downward Flexibility for Deposit Rates:** When the central bank lowers its policy rate, banks tend to lower their deposit rates more quickly and/or more fully.

There are various theoretical explanations behind this asymmetry:

- **Insufficient Competition and Market Power:** The oligopolistic or monopolistic structure of the banking sector gives banks market power. This power allows banks to set interest rates in their favour, particularly in a way that increases their profit margins.
- **Information Asymmetry:** The detailed information banks have about their customers enables them to better assess credit risk. This information advantage gives banks an edge, particularly in determining credit interest rates.
- **Menu Costs:** The fact that adjusting interest rates (software updates, changing printed materials, communication costs, etc.) has a certain cost may cause banks to avoid making small interest rate changes frequently and instead make larger adjustments to offset these costs.
- **Customer Relations and Switching Costs:** The high cost of customers switching banks (opening new accounts, transferring existing payments, etc.) may cause banks to offer less flexible interest rates to their existing customers. If customers are less inclined to switch to another bank, banks may be able to manipulate interest rates more freely.
- **Risk and Expectations:** Banks may be inclined to raise credit interest rates more quickly or refrain from lowering them in order to protect themselves in situations such as economic uncertainty or a potential increase in credit risk. Expectations regarding future policy interest rates may also affect current interest rate adjustments.
- **Liquidity Management:** Banks' liquidity needs and targets play a role in determining interest rates. Especially during periods of liquidity shortages, banks may offer more competitive interest rates to attract deposits while keeping lending rates higher.

Asymmetric pass-through can reduce the effectiveness of monetary policy. In particular, during periods of easing (interest rate cuts), the slow decline in lending rates can slow

efforts to stimulate investment and consumption. Similarly, during tightening (interest rate hike) periods, deposit rates that do not rise sufficiently may fail to adequately encourage savings. Therefore, central banks and regulatory authorities must understand these asymmetries in the monetary transmission mechanism and take them into account in their policy decisions.

3. Related Literature

One of the fundamental challenges faced by central banks in many countries, including Türkiye, when designing and implementing monetary policy is understanding how effectively changes in policy interest rates are reflected in financial markets and ultimately in the real economy. This reflection process is known as interest rate pass-through and is generally not complete or symmetrical; asymmetrical interactions are often observed. This response will provide an evaluation of empirical studies addressing this issue both in the international literature and specifically in the Turkish economy, highlighting leading studies.

Interest rate pass-through and asymmetric interactions have a broad empirical literature in central banking and financial economics. Most studies use advanced econometric techniques such as threshold regression models, nonlinear autoregressive distributed lag (NARDL) models, and regime-switching models. Borio and Fritz (1995) is one of the pioneering studies examining the relationship between monetary policy and the bank credit channel. Such early studies have shown that the heterogeneous structure of the banking sector and market conditions affect interest rate pass-through. Mojon (2000) found that interest rate pass-through in Eurozone countries can change over time and vary across countries. This study highlights the complexity of the monetary transmission mechanism. De Bondt (2005) again conducted a comprehensive study specific to the Eurozone, showing that the transition of official interest rates to market interest rates is complete for money market interest rates up to three months, but not complete for longer-term market interest rates. Furthermore, he concludes that changes in market interest rates are reflected in bank deposit and lending rates by up to 50% immediately, with the final reflection generally close to 100%, particularly for lending rates.

There are also studies in the literature that focus on several key factors explaining the causes of asymmetry. Many studies show that low competition in the banking sector (oligopolistic structures) increases the market power of banks, leading them to be reluctant to reflect interest rate cuts in lending rates. Researchers such as Hofmann and Mizen (2004) have pointed out that the absence of perfect competition in the banking sector contributes to asymmetric pass-through.

It has been argued that the private information banks hold about their customers could cause asymmetry, particularly in small and medium-sized enterprise (SME) lending. When banks establish long-term relationships with such customers, they may be more cautious in setting interest rates (Sharpe, 1990). The managerial and operational costs (menu costs) of changing interest rates may cause banks to avoid making frequent small changes and instead make larger interest rate movements to offset these costs. The findings of Hofmann and Mizen (2004) point that the initial estimates of the relationship between the level of

each individual retail rate by type of product reveals complete pass-through to be the norm in the long run for deposit rates but not for mortgage rates. The non-linear forms of adjustment around these equilibria are consistent with menu cost models and may be of greater significance at low rates of interest and inflation.

Risk and credit quality can also cause asymmetric pass-through in interest rates. The severity of a financial crisis may have repercussions to markets and eventually contributes to a marked slowdown in economic growth. As a result, banks become less willing to provide loans (credit rationing) (Karagiannis et al., 2010). Especially during times of crisis or economic uncertainty, banks may reflect interest rate increases more quickly while reflecting interest rate cuts more slowly in order to price in increased credit risk (Aristei and Gallo, 2014; Hristov et al., 2014).

The Turkish economy provides a rich ground for studies on interest rate pass-through and asymmetric interaction due to its history of high inflation, volatile interest rates, and dynamic banking sector structure. The Central Bank of the Republic of Türkiye (CBRT) regularly analyses the effectiveness of the monetary transmission mechanism. Various studies prepared within the CBRT (e.g., İnal, 2006; Binici et al., 2013, 2016; Çavuşoğlu, 2010) examine the dynamics of interest rate pass-through in Türkiye. These studies generally show that changes in the policy interest rate are reflected in deposit and loan interest rates at different speeds and rates. Studies such as Bulut (2020), Güler (2021), Salihoğlu and Hepsağ (2021) have shown that the pass-through from policy interest rates to bank lending rates is incomplete in Türkiye and that this pass-through decreases further, especially during crisis periods.

Many empirical studies specific to Türkiye strongly support the existence of asymmetric effects in interest rate pass-through. This asymmetry generally refers to the fact that policy interest rate cuts are reflected in credit interest rates more weakly or with a greater delay than policy interest rate increases. Çağlarımak-Uslu and Karahan (2016) have pointed out that there is asymmetric pass-through between deposit and lending rates in Türkiye and that this asymmetry may be related to banks' tendency to protect their profit margins. In particular, they observed upward rigidity in credit interest rates during periods of reduction and downward flexibility during periods of increase. Sekmen (2024) examined asymmetric interest rate pass-through in the Turkish banking sector and concluded that credit interest rates generally exhibited upward rigidity in the long term prior to the financial crisis, but that this rigidity turned into downward and short-term rigidity in the post-financial crisis period. This result implies that, prior to the crisis, banks adjusted credit interest rates more slowly during monetary tightening periods, while their responses were faster during monetary expansion periods.

3. Empirical Analysis

3.1. Method and Data

The non-linear ARDL (NARDL) approach developed by Shin et al. (2014) will be used to investigate whether there is an asymmetric interaction in the transmission mechanism from deposit and policy interest rates to lending rates. The NARDL approach is based on the

principle of separating the positive and negative components of changes in the variable under investigation from the linear (symmetric) ARDL model and testing the difference in the coefficients related to these components.

The interest rate applied to 3-month deposits (DIR) was used as the deposit interest rate, the interest rate applied to consumer loans (CLIR) was used as the loan interest rate, and the one-week repo auction interest rate was used as the Central Bank policy interest rate (PIR). The sample period covers the period from 12 December 2004 to 26 August 2022. There are 911 observations consisting of weekly values. All data were compiled from Electronic Data Delivery System of Central Bank of Republic of Türkiye (CBRT-EDDS).

3.2. Findings

Although the ARDL bounds test used for cointegration analysis allows for series to be integrated to different degrees, the ADF and KPSS unit root tests were used to investigate the integration degrees of the series in order to determine whether there were any second-order integrated series. According to the test results given in Table 1, all variables are I(1).

Table 1. Unit-root tests results

	ADF		KPSS	
	Intercept	Intercept + trend	Intercept	Intercept + trend
CLIR	-2.3919 (0.1443)	-2.4863 (0.3350)	0.5495	0.5236
DIR	-2.4495 (0.1285)	-2.4560 (0.3502)	0.5913	0.5896
DIR +	1.5655 (0.9995)	-0.3687 (0.9885)	3.5854	0.6706
DIR -	0.9206 (0.9958)	-0.9785 (0.9449)	3.5945	0.3991
PIR	-1.9489 (0.3098)	-1.8411 (0.6839)	0.5955	0.5356
PIR +	0.6212 (0.9903)	-1.3842 (0.8652)	3.2731	0.6760
PIR -	-0.2366 (0.9312)	-2.7189 (0.2291)	3.4704	0.2838
Δ CLIR	-25.2168 (< 0.01)	-25.3112 (< 0.01)	0.2515	0.0284
Δ DIR	-9.6577 (< 0.01)	-9.6667 (< 0.01)	0.1395	0.0326
Δ DIR +	-9.9287 (< 0.01)	-10.0788 (< 0.01)	0.5093	0.1481
Δ DIR -	-6.3587 (< 0.01)	-6.4335 (< 0.01)	0.2471	0.1961
Δ PIR	-30.3029 (< 0.01)	-30.3121 (< 0.01)	0.1249	0.0500
Δ PIR +	-30.5553 (< 0.01)	-30.5894 (< 0.01)	0.2333	0.0503
Δ PIR -	-4.8414 (< 0.01)	-4.8574 (< 0.01)	0.1112	0.1039

Note: The lag length in the ADF test was determined according to SIC. KPSS critical values: Intercept: 0.7390 (1%); 0.4630 (5%); 0.3470 (10%); Intercept + trend: 0.2160 (1%); 0.1460 (5%); 0.1190 (10%), the bandwidth is determined according to the Newey-West method.

As the first stage of the analysis, the relationship in question was investigated using the symmetric ARDL method in order to make a comparison. Long-term coefficient estimates and diagnostic statistics are presented in Table 2 below. According to the estimates, there is a statistically significant relationship between deposit and policy interest rates and the credit interest rate. The effect of the deposit interest rate is positive, as expected, while the effect of the policy interest rate is negative. The F statistic calculated to determine the existence of a cointegration relationship indicates a statistically significant long-term relationship between the variables at the 5% level. Similarly, the estimated value of the error correction term coefficient and its p-value indicate that short-term deviations from the equilibrium relationship are being gradually eliminated. Diagnostic statistics also show that there is no autocorrelation, heteroscedasticity, or specification error in the model.

Table 2. Estimation of linear (symmetrical) ARDL model

	Coefficient	St. error	t-statistic	p-value
Intercept	5.6646	1.8276	3.0994	< 0.01
PIR	- 0.7216	0.2927	- 2.4649	0.0139
DIR	1.8063	0.3461	5.2191	< 0.01
ECM	- 0.0356	0.0083	- 4.3041	< 0.01
Critical values		%10: I(0) I(1)	%5: I(0) I(1)	%1: I(0) I(1)
F-statistic	4.6060	2.63 3.35	3.10 3.87	4.13 5.00
Test	Test statistic	p-value		
B-G χ^2	1.7621	0.4143	CUSUM	Stable
B-P-G χ^2	14.1735	0.0774	CUSUM-Square	Stable
RESET-LR	0.0325	0.8569		

For the asymmetric ARDL model, changes in deposit and policy interest rates were first separated into positive (increases) and negative (decreases) directions. According to the estimates of the long-term form of the ARDL(4,3,2,3,2) model constructed with these variables (Table 3), both the positive and negative components of the policy interest rate have a negative effect on the credit interest rate. However, the effect of positive changes is not significant. On the other hand, both positive and negative changes in the deposit interest rate have a positive effect on the credit interest rate. At this point, it can be said that the direction of the effect of increases in the policy interest rate (PIR⁺) and decreases in the deposit interest rate (DIR⁻) does not align with expectations.

As in the linear model, it is observed that the error correction mechanism works albeit slowly in the non-linear model, and that there is no autocorrelation, heteroscedasticity, or specification error in the model. The calculated F statistic indicates that there is a significant long-term relationship between the variables at the 1% level. The CUSUM and CUSUM-square tests indicate that the coefficients generally follow a stable trend over time.

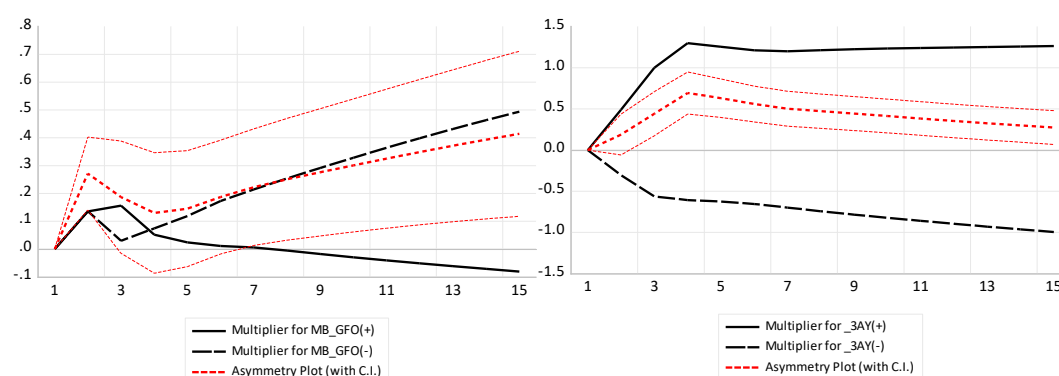
Table 3. Estimation of nonlinear (asymmetrical) ARDL model

	Coefficient	St. error	t-statistic	p-value
Intercept	22.2049	1.7367	12.7853	< 0.01
PIR ⁺	- 0.3512	0.2831	- 1.2405	0.2151
PIR ⁻	- 1.3226	0.4642	- 2.8488	< 0.01
DIR ⁺	1.4303	0.3325	4.3014	< 0.01
DIR ⁻	1.8614	0.3984	4.6714	< 0.01
ECM	- 0.0396	0.0066	- 6.0331	< 0.01
Critical values		%10: I(0) I(1)	%5: I(0) I(1)	%1: I(0) I(1)
F-statistic	6.0324	2.20 3.09	2.56 3.49	3.29 4.37

	Coefficient	St. error	t-statistic	p-value
Test	Test statistic	p-value		
B-G χ^2	0.0184	0.9909	CUSUM	Stable
B-P-G χ^2	160.7633	0.1609	CUSUM-Square	Stable
RESET-LR	0.5879	0.4432		

The multiplier graphs shown in Figure 1 provide important clues about the asymmetric effects of the variables. While there is a significant positive asymmetric effect in both variables, it can be said that the asymmetry is more pronounced and stronger in the deposit interest rate. Positive and negative shocks in the policy interest rate appear to be reflected in credit interest rates in the form of increases, while shocks in deposit interest rates appear to have an effect in the direction of their own signs on their own credit interest rates. Another difference is that while the asymmetry observed in the deposit interest rate tends to disappear in the long term, the asymmetry related to the policy interest rate increases its effect over time, especially in terms of negative shocks.

Figure 1. Multiplier Graphs



It may not be possible to obtain solid evidence about the existence and nature of asymmetry by looking only at the multiplier graphs. Formal tests of the significance of the differences between the coefficients of the positive and negative components shown in Table 3 will provide further evidence in this regard. To this end, the Wald test was conducted on the level and difference values in the error correction model to investigate the existence of short- and long-term asymmetric relationships. The test results presented in Table 4 support the conclusions drawn from the multiplier graphs. According to these results, deposit interest rates have an asymmetric effect on credit interest rates in both the short and long term. In contrast, while the policy interest rate exhibits asymmetric behaviour in the short term, no statistical evidence strong enough to support the existence of this effect in the long term has been found.

Table 4. Results of Wald test for asymmetry

	Short term	p-value	Long term	p-value
DIR	5.2159	0.0224	8.3793	< 0.01
PIR	13.0998	< 0.01	2.3354	0.1265

4. Discussion

The findings of the two different approaches used in the analysis provide a deeper understanding of the dynamics of interest rate pass-through in Türkiye. According to the findings of the linear (symmetric) ARDL model, the negative effect of the policy interest rate on credit interest rates is consistent with the basic functioning mechanism of monetary policy. When the central bank raises the policy interest rate (tightening), banks' funding costs increase, creating pressure to raise credit interest rates. Conversely, when the central bank lowers the policy interest rate (easing), banks' funding costs decrease, creating an incentive for them to lower credit interest rates. Therefore, it is theoretically natural to expect an inverse (negative) relationship between the policy interest rate and credit interest rates. This is a fundamental finding demonstrating that monetary policy is transmitted to the economy through the banking channel.

It is also expected that deposit interest rates will have a positive effect on lending rates. Banks raise funds by collecting deposits, and the interest they pay on these deposits is one of their basic funding costs. When deposit interest rates rise, banks' funding costs increase, and they tend to reflect this increased cost in loan interest rates in order to maintain their profit margins. Therefore, the observation of a positive relationship between deposit interest rates and loan interest rates is consistent with theoretical expectations regarding banks' cost structures.

These linear model findings reveal that the basic monetary transmission channels are functioning in Türkiye and that the expected relationships between interest rates exist. However, real market conditions are often non-linear, and asymmetric interactions may occur. At this point, the findings of the NARDL model become important.

The NARDL model allows us to examine the different effects of upward (positive shocks) and downward (negative shocks) changes in policy interest rates and deposit rates on lending rates. The lack of impact of positive (increase) changes is a finding that deviates from theoretical expectations. Typically, when the central bank raises the policy interest rate (tightening), banks' funding costs rise rapidly, leading to a swift and full upward pass-through to credit interest rates. If increases do not affect credit interest rates, this may suggest that banks are reluctant to pass on these increased costs to credit interest rates or that other factors (e.g., high competition, excess liquidity) neutralise this effect. This situation may indicate a weakness or a different dynamic in the tightening channel of monetary policy in Türkiye. While it is common in the literature for banks to pass on interest rate increases more quickly to protect their profit margins, this finding contradicts the general trend.

The finding regarding the negative impact of negative (declining) changes shows that the expected inverse relationship between the policy rate and the lending rate continues but only applies to interest rate cuts. When the policy rate falls, banks' funding costs decrease, creating room for them to lower lending rates. Although this situation appears to contradict the theoretically expected phenomenon of 'downward rigidity for lending rates,' it actually draws attention to the fact that 'interest rate cuts affect lending rates,' while 'interest rate hikes do not.' A common finding in the literature is that interest rate cuts are reflected more

slowly or to a lesser extent. The finding here, however, suggests that interest rate cuts are effective, but interest rate hikes are not, indicating a Türkiye-specific asymmetric pass-through dynamic. This situation can be interpreted as banks tending to pass on interest rate cuts to customers under profit maximisation or competitive pressures but preferring to absorb interest rate hikes internally.

The finding regarding the asymmetric effect on deposit interest rates is quite surprising and directly contradicts theoretical expectations. The fact that increases in deposit interest rates (which increase the bank's costs) have a negative effect on lending rates means that the bank does not pass on its increased costs to lending rates but rather reduces them. Similarly, the fact that decreases in deposit interest rates (which reduce the bank's costs) also have a negative effect on loan interest rates indicates that these decreases are reflected in loan interest rates.

Possible explanations for this situation include the following:

- **Intense Competition:** Intense competition in the deposit market forces banks to raise interest rates to attract deposits, while at the same time, competitive pressures in the credit market may prevent them from passing on their increased costs to credit interest rates. In fact, they may have to sacrifice their margins in order to attract more deposits and extend credit.
- **Liquidity Management Strategies:** Banks' liquidity positions and liquidity management strategies may explain this finding. Perhaps banks are avoiding lending when deposit rates rise (more expensive funding) or are only lending at lower rates for non-risky loans. However, this explanation does not fully account for the 'negative effect.' A more likely scenario is that competition in the deposit market may have reduced banks' pricing power over loan interest rates and even exerted negative pressure on them.
- **Financial Pressure or Regulations:** Certain financial pressures specific to Türkiye may force banks to raise deposit interest rates during certain periods, while regulations or market conditions may prevent them from raising lending rates above a certain level. This situation may lead to a squeeze on banks' profit margins.

The results of the Wald test are critical in understanding the existence of asymmetry and where it is concentrated. While the asymmetric effect of long-term deposit interest rates is supported, the absence of asymmetry originating from the policy interest rate indicates that long-term dynamics in the deposit market have an asymmetric effect on banks' credit pricing. When combined with the finding that 'rises and falls in deposit interest rates negatively affect credit interest rates,' this indicates that, in the long term, banks reflect changes in deposit costs in credit interest rates in a non-symmetrical manner, meaning that both upward and downward movements in the deposit market create downward pressure on credit interest rates. However, the disappearance of asymmetry in the policy interest rate over the long term may suggest that the effect of monetary policy has settled into a symmetrical equilibrium over the long term or that other factors have neutralised this asymmetry. This situation indicates that the central bank's long-term interest rate increases and decreases have a similar effect on credit interest rates, and that the short-term asymmetry disappears over the long term.

The confirmation of asymmetric effects in both channels in the short term is quite consistent with common findings in the literature. Banks may respond more asymmetrically in the short term to situations such as liquidity shocks, sudden policy interest rate changes, or market uncertainties. The fact that short-term declines in policy interest rates have a negative effect on lending rates, while increases do not, indicates that the easing channel of monetary policy is functioning in the short term, but the tightening channel is not having the expected effect. This situation may suggest that banks tend to avoid raising lending rates during periods of tightening in order to retain customers or maintain market competitiveness. The fact that both increases and decreases in short-term deposit interest rates have a negative impact on credit interest rates in the short term can be interpreted as banks prioritising not only profit margins but also market share and customer relations in terms of short-term liquidity management and funding costs. The tendency to lower credit interest rates even when deposit interest rates rise may be an aggressive market share acquisition or customer retention strategy.

5. Conclusion

When the results obtained from the analyses are evaluated together, it can be said that there is an asymmetric effect between the deposit interest rates applied by banks in Türkiye and the interest rate on consumer loans in the short and long term. This means that changes in deposit interest rates are not reflected in the same way in lending interest rates, regardless of the direction of the change. The multiplier graph in Figure 1 indicates that increases in interest rates are reflected in loan interest rates to a greater extent than decreases. This situation also provides an insight into the level of competition among banks in Türkiye. It is quite difficult to observe such asymmetry in a highly competitive market. Under conditions of intense competition, a bank that reflects a decrease in deposit interest rates to lending rates slowly and at a lower rate, while rushing to reflect an increase in deposit interest rates to lending rates, may find itself in a difficult position vis-à-vis its competitors.

Another finding of the analysis is that the policy interest rate announced by the Central Bank does not fully serve as an indicator for banks. Various factors may have contributed to this situation. The one-week repo auction rate, which is considered as the policy interest rate in the analysis, has been adopted as the Central Bank's policy interest rate since June 2018. Therefore, for a significant portion of the sample period, this interest rate was not used as an indicator by banks. Another factor is related to the Central Bank's interest rate policy. Since the end of 2010, the Central Bank has implemented an unconventional interest rate corridor and funding policy in order to respond promptly to financial volatility. In this context, the composition of short-term funds provided by the CBRT to the market was changed at high frequencies, and it was preferred to allow market interest rates to deviate from the CBRT funding rate and the announced official rates during periods deemed necessary. In this unconventional approach, the interaction between monetary policy and the financial system takes on a more complex structure compared to the classical interest rate corridor application (Binici et al., 2016). One reflection of this complexity may be the inability to achieve a symmetrical and complete parallelism between the lending interest rates applied by banks and the TCMB's policy rate.

It should be noted that the findings obtained from the analyses conducted here are conditional on the interest rate indicators used and the sample period. Although a high level of correlation is expected among alternative indicators, using the 1-month deposit interest rate instead of the 3-month deposit interest rate, the car loan interest rate instead of the consumer loan interest rate, and the weighted average funding cost instead of the repo rate as the policy rate as indicators could lead to significant changes in the findings. Therefore, repeating the analyses using different indicators and sample periods consistent with the CBRT's interest rate policies would help to draw more reliable conclusions in this regard. Additionally, considering that the deposit and loan interest rate indicators used in the analysis are based on average values, it is expected that an analysis conducted at the individual bank level may not reveal an asymmetric relationship for each bank or that the same degree of asymmetry may not apply.

References

- Adanur-Akkan, N. and Nargeleçekenler, M. (2008). The Impact of Monetary Policies on Bank Lending Channel, *I.U. Journal of Political Science Faculty*, 39, 109-132. (In Turkish) <<https://iupress.istanbul.edu.tr/tr/journal/jps/article/para-politikalarinin-banka-kredi-kanali-uzerindeki-etkileri>>
- Aristei, D. and Gallo, M. (2014). Interest rate pass-through in the Euro area during the financial crisis: A multivariate regime-switching approach, *Journal of Policy Modeling*, 37, 273-295. <<https://doi.org/10.1016/j.jpolmod.2013.12.002>>
- Binici, M., Erol, H., Kara, H., Özlü, P. and Ünalmış, D. (2013). Can the interest rate corridor be a macroprudential tool? *CBRT Economy Notes*, No. 20. <https://www.researchgate.net/publication/280723495_Interest_Rate_Corridor_A_New_Macroprudential_Tool>
- Binici, M., Kara, H. and Özlü, P. (2016). Interest Rate Corridor and Bank Interest Rates: Some Findings on the Monetary Transmission Mechanism, *CBRT Working Paper*, No. 16/08, Ankara. (In Turkish) <<https://ideas.repec.org/p/tcb/econot/1513.html>>
- Bulut, Ü. (2020). Monetary Policy Pass-Through to Lending Rates: The Case of Turkey, *Bankacılar Dergisi*, 114, 17-29. (In Turkish) <<https://www.tbb.org.tr/bankacilik/arastirma-ve-yayinlar/bankacilar-dergisi/pdf/827>>
- Çağlarımak Uslu, N. and Karahan, P. (2016). A dynamic analysis on pass-through of monetary policy to loan rates: the case of Turkey, *Yönetim ve Ekonomi*, 23(3), 671-690. (In Turkish) <<https://dergipark.org.tr/tr/download/article-file/263542>>
- Galindo, A. J. and Steiner, R. (2022). Asymmetric interest rate transmission in an inflation-targeting framework: The case of Colombia, *Latin American Journal of Central Banking*, 3(3), 100069. <<https://www.sciencedirect.com/science/article/pii/S2666143822000230>>
- Goodfriend, M. and King, R. (1997). The New Neoclassical Synthesis and the Role of Monetary Policy', Federal Reserve Bank of Richmond, Working Papers, 98-05. <<https://www.nber.org/system/files/chapters/c11040/c11040.pdf>>
- Güler, A. (2021). The Pass-Through of Policy Rates to Retail Bank Rates: The Case of Turkey, *EKEV Akademi Dergisi*, 25(85), 15-38. (In Turkish) <<https://dergipark.org.tr/tr/download/article-file/2568194>>

- Poyraz, E., Türkün-Kaya, B. and Kahraman, E. (2020). The analysis of the effects of changes in the policy interest rates on Borsa Istanbul 100 index by event study methodology, *International Review of Economics and Management*, 8(2), 201-220. (In Turkish) <<https://dergipark.org.tr/download/article-file/1125866>>
- Bondt, G.J. de (2005). Interest Rate Pass-Through: Empirical Results for the Euro Area, *German Economic Review*, 6(1), 37-78. <<https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1465-6485.2005.00121.x>>
- Borio, C. and Fritz W. (1995). The response of short-term bank lending rates to policy rates: a cross-country perspective, BIS Working Papers, No. 27. <<https://www.bis.org/publ/work27.pdf>>
- Hofmann, B. and Mizen, P. (2004). Interest Rate Pass-Through and Monetary Transmission: Evidence from Individual Financial Institutions Retail Rates, *Economica*, 71, 99-123. <<https://onlinelibrary.wiley.com/doi/abs/10.1111/j.0013-0427.2004.00359.x>>
- Hristov, N., Hülsewig, O., and Wollmershäuser, T. (2014). The interest rate pass-through in the Euro area during the global financial crisis, *Journal of Banking and Finance*, 48, 104-119. <<https://www.sciencedirect.com/science/article/abs/pii/S0378426614002714>>
- İnal, D.G. (2006). The impact of monetary policy interest rate decisions on long-term interest rates in Turkey. CBRT Expertise Qualification Thesis, Ankara. (In Turkish) <<https://www3.tcmb.gov.tr/kutuphane/TURKCE/tezler/duygugunesinal.pdf>>
- Karagiannis, S., Panagopoulos, Y. and Vlamis, P. (2010). Interest rate pass-through in Europe and the US: Monetary policy after the financial crisis, *Journal of Policy Modeling*, 32(3), 323-338. <<https://www.sciencedirect.com/science/article/abs/pii/S0161893810000165>>
- Mojon, B. (2000). Financial structures and the interest rate channel of monetary policy, ECB Working Paper Series, No. 40 <<https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp040.pdf>>
- Salihoğlu, E. and Hepsağ, A. (2021). Bank interest rate pass-through: a non-normal approach with RALS regression and cointegration method, *Bankacılar Dergisi*, 117, 40-57. (In Turkish) <<https://www.tbb.org.tr/bankacilik/arastirma-ve-yayinlar/bankacilar-dergisi/pdf/830>>
- Sekmen, T. (2024). Asymmetric interest rate pass-through in Türkiye: The role of global financial crisis, *Eskişehir Osmangazi University Journal of FEAS*, 19(3), 726-751. <<https://dergipark.org.tr/tr/download/article-file/3055866>>
- Sharpe, S.A. (1990). Asymmetric Information, Bank Lending, and Implicit Contracts: A Stylized Model of Customer Relationships, *The Journal of Finance*, 45(4), 1069-1087. <<https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1540-6261.1990.tb02427.x>>

The effect of fiscal decentralization and monetary policy on economic resilience in Indonesia: a panel data

SYAHRIMI

Faculty of Economics, Sriwijaya University, Indonesia
01022682327005@student.unsri.ac.id

Anna YULIANITA

Faculty of Economics, Sriwijaya University, Indonesia
annayulia@unsri.ac.id

Ariodillah HIDAYAT

Faculty of Economics, Sriwijaya University, Indonesia
ariodillahhidayat@fe.unsri.ac.id

Abstract. *Resilience and stability of domestic economic growth on the island of Sumatra requires a collaborative combination of monetary policy and fiscal decentralization amidst the current situation of global economic slowdown, with money circulation as a proxy for monetary policy and government, regional and regional spending. Tax revenues and the Fiscal Independence Index as a proxy for fiscal decentralization policy and the Gini Index. as a moderating variable for inflation and local tax revenues. By using vector error correction model (VECM) analysis tools, Granger causality and cointegration. The test results show that in the long-term period there is a short-term to long-term model adjustment correction vector of 0.01348, which means 0.01348 percent of the regularity of the previous period and replaces the role of other variables in economic growth. In the short term, the money supply and the Fiscal Independence Index have a significant influence on economic growth.*

Keywords: economic growth, monetary policy, decentralization fiscal policy, vector error correction model.

JEL Classification: R41, C32, M10.

1. Introduction

The development of the Indonesian economy at the start of 2024 amidst the global economic slowdown is optimistic that it will continue to grow in the next few years, although overall domestic economic conditions are still considered solid, which is marked by rapidly changing geopolitical conditions, shifts in currency values and soaring prices of several of Indonesia's leading commodities (World Bank, 2024). Facing this challenge, the domestic regional economy demands hard work towards fiscal decentralization which is the authority of the regions. To maintain macroeconomic stability and resilience, collaboration between monetary policy instruments and fiscal decentralization is necessary in the current situation. Monetary and fiscal policies have a role in achieving macroeconomic growth targets and balance through controlling the rate of inflation and public spending (Şen & Kaya, 2014).

Indonesia's monetary policy will focus on stability, maintaining inflation and the value of the rupiah. Pro-stability monetary policy will be implemented with proactive and preventive interest rate policies reinforced with pro-market monetary operations to strengthen the effectiveness of Bank Indonesia's policy transmission to financial markets and the economy, including attracting portfolio inflows, as well as managing capital flows in accordance with international rules to maintain external stability and maintain adequate asset reserves (Bank Indonesia, 2024). According to (Warjiyo & Solikin, 2003), the effectiveness of expansionary monetary policy depends on the relationship between the amount of money in circulation and macroeconomic variables, for example inflation.

The dynamics of money circulation in Indonesia, based on data released by Bank Indonesia, continues to increase. Monetary policy through controlling money circulation in order to maintain balance in the money market (LM curve), according to the monetarist school, monetary policy is more sensitive in controlling a country's inflation. This is based on the principle that monetary policy has a direct impact on aggregate demand. If the value of money circulation increases in a country, consumers will spend money for productive spending by buying goods and services instead of securities (bonds). According to (Tule et al., 2020), a monetarist philosophy, fiscal policy instruments are considered not to respond quickly to influence economic activity because they can create a crowding out effect, so that fiscal policy has no impact on output levels. This research uses the circulation of money for each province with a proxy approach for GDP share.

The monetarist view believes that controlling the circulation of money affects a country's inflation performance. By increasing the amount of money circulating in the money market (LM curve), the balance curve in the product or goods market (IS curve) will reduce interest rates so that inflation will fall. According to Friedman (1970), he believes that the circulation of large amounts of money over a long period (long run) results in a money circulation with high inflation. However, there is no correlation between the money supply and inflation in the short term.

Fiscal decentralization in the era of regional autonomy continues to be improved and innovated in finding sources of regional potential based on the management of the delegated authority. Regional development planning requires financing that originates from

regional fiscal independence through sources of original regional income. The independence of regional autonomy policies that regulate, manage and manage regional financial capacity is reflected in the management of potential sources of Regional Original Income (PAD) through regional tax revenues. According to ("The Relative Effects of Fiscal and Monetary Policies on Ethiopian Economic Growth," 2020) decentralization has been attempted to bring the governance and development decision-making process closer to the general public at the regional level. A centralized government system (Madurapperuma, 2023), ensuring the effectiveness of decentralization requires sufficient financial resources to help run the administrative system and encourage regional development.

Of the four PAD components, the one that has the largest contribution is regional tax revenue, which is the pillar of strengthening local taxing power. It is hoped that increasing fiscal decentralization through regional taxes will become a key instrument in increasing regional fiscal independence, improving public service performance and community welfare. Taxation produces a more representative and accountable state, because revenue extraction creates a fiscal social contract between the state and citizens, where the government tends to bargain with taxpayers, exchanging representation and services to increase taxation (Elhakim & Ali, n.d.).

The role of regional tax revenues in the regional economy itself is shown by comparing the realization of regional taxes to the total income from the provincial regional economy, the local tax ratio, namely the comparison between the realization of regional taxes and the total income from provincial regional economic activities. Regional financial regulation system, the regional tax ratio is a comparison between regional taxes received in accordance with authority and Gross Regional Domestic Income (GRDP), the regional tax ratio figure is influenced by the share of GRDP. Another role of tax revenue will be influencing the expansion or relaxation of production activities, expenditure, and household savings (Sugianti & Millatul Maula, n.d.).

In line with the Central Government's mandate for Regional Governments to have stronger fiscal decentralization, the Central Government, through financial balance, has begun to reduce Transfers to Regions and Village Funds (TKDD), to assess the performance capacity of regional financing in financing development at the regional level. It is hoped that the role of regional governments in managing and regulating finances with reforms in the financial sector will make the government more independent fiscal decentralization (Amponsah et al., 2023).

Government expenditure in the form of expenditure on programs, activities and sub-activities constitutes all obligations of Regional Government entities which are recognized as a reduction in net asset value in the current fiscal year period. Spending on programs, activities and sub-activities is arranged based on regional priority scales due to budget constraints, for example spending to support economic growth. The impact of government expenditure on economic growth can be explained through the endogenous growth model (H. T. Nguyen & Darsono, 2022).

The condition of regional tax revenues cannot be separated from the inequality of population income, this is expressed by the Gini Index. Gini Index, an indicator for

measuring accumulated disparities developed by an Italian statistician named Corrado Gini in 1912 (International NGO Forum on Indonesia Development, 2018). Inequality in the distribution of population income can be caused by unequal employment opportunities among the population. If the Gini Index gap is too large, it could cause individual taxpayers to become indebted at maturity and this will affect the realization of local tax revenues. In many countries, the unequal distribution of income and resources among the population is the main cause defining the challenges of our time. In both developed and developing countries, income inequality (as measured by the decile ratio and Gini coefficient based on the Lorenz curve) between rich and poor is at a high level, and continues to increase (Agung Krisprimandoyo & Bambang Mahargiono, 2023).

2. Literature Review

Regional economic growth is an increase in the value of a region's gross regional domestic product (GRDP) over a certain period of time (Tavares Garcia & Cross, 2024). Key performance indicators of regional regional economic growth are measured using gross regional domestic product (GRDP) per capita. Regional economic growth is characterized by changes that occur in the level of output, income and expenditure on a sustainable and permanent basis (Mdingi & Ho, 2021). The measure of success in regional regional economic growth is measured using the real GDP growth rate, namely the increase in GDP which is influenced by inflation. This real GDP growth rate is used as a performance of regional economic success over time (Tiony, 2023). According to the Keynesian school pioneered by John Maynard Keynes, the economy of a region can be managed using monetary and fiscal policy instruments determined by the government or regional government (M. L. T. Nguyen & Bui, 2022). Fiscal decentralization which delegates authority to regional governments in the form of managing regional taxes and expenditures is suitable for financing development in the regions.

According to Pietrovito et al., (2023), fiscal policy is the government's effort to manage government expenditure and income with the aim of creating economic balance and stable economic growth. In the Keynesian general equilibrium model, macroeconomic policy is a way for the government to provide stimulus to aggregate demand by controlling regional tax revenues and regional government expenditure interventions. When regional expenditure consumption is increased and/or regional tax rates are reduced, there will be a multiplier effect from the government to the private sector in the form of investment which will impact the demand for goods and services and capital will increase, if this is not followed by supply balance it will cause inflation. (Shtewi, 2023) investigate the influence of fiscal and monetary policies in Macedonia. The authors conclude the opposing impacts of these policies on economic growth, more specifically, government spending reduces economic activity but tax revenues have a positive impact on gross output. On the monetary policy side, these results show that an increase in interest rates reduces economic activity.

According to H. T. Nguyen et al., (2022), monetary policy is an economic policy instrument carried out by the central bank to control the circulation of money, interest rates and credit in a region. Through monetary policies set by the government through Bank Indonesia, one

of which is controlling the circulation of money for economic resilience and stability. The circulation of money in a region can be measured using a proxy approach from the share of GRDP to GDP. One of the arrangements in the monetary policy taken is to control inflation in a region, volatile inflation can provide detrimental sentiment to the economy (Tadesse & Melaku, 2019). According to (George-Anokwuru, 2023) monetary policy is the central bank's method of controlling the circulation of money and interest rates to achieve stable economic goals and targets, such as maintaining inflation.

The Keynesian view of uncontrolled inflationary shocks is because the population lives beyond their economic control and capabilities with a priority on how economic activity between population groups can have an impact on demand that is higher than the amount of goods and services provided (Olamide et al., 2022). According to Friedman (1976), shocks caused by inflation continuously and everywhere are a monetary phenomenon. Friedman (1976) refined the quantity expenditure theory by developing a theory of money demand. Inflation can occur due to a demand pull caused by an increase in prices as a result of a shift in aggregate demand upwards, while inflation due to a cost push is caused by an increase in prices which influences an increase in supply and reduces aggregate demand. The theory of money demand is based on the demand for the amount of money circulating in society which is determined by the role of variables in the economy, namely economic growth, changes in interest rates, and uncertain price levels (Saidi et al., 2024).

To measure regional fiscal independence index indicators, an index developed by Hunter (1977) is used. The Hunter Index (1977) is still relevant to use as a proxy for calculating the independence and available regional fiscal capacity (Obayelu & Edewor, 2022). According to Sampurna (2018), regional fiscal independence is grouped into several operational definitions "Not yet Independent", "Towards Independence", "Independent" and "Very Independent". If fiscal independence is defined as high, it will reduce the TKDD transfer ratio and become more independent for regions to fund regional development in the form of productive operating expenditures and capital expenditures.

Several experts argue that income inequality has a negative impact on economic growth (Liu et al., 2020). The Lorenz curve provides an overview of the actual quantitative relationship between the percentage of income recipients and the percentage of total net income they receive during a certain time period, for example one quarter. The Lorenz curve is within the boundaries of a square with the vertical side explaining the cumulative percentage of national income, while the horizontal side explains the cumulative percentage of population. If the Lorenz curve approaches a straight line, it means that the distribution of national income is getting better. However, if the Lorenz Curve moves away from the curve, it shows that the situation is getting worse or the distribution of national income is becoming more unequal and unfavorable (Naufal & Fikriah, 2023). Income inequality is measured using the Gini Index indicator to see the causality between the amount of net income received by the population and total income receipts.

Research regarding the mix of monetary and fiscal policy on the economy of a country or region has been written by many researchers before, including, (Ismail & Sek, 2020), conducting investigations in her research examining and comparing the impact of fiscal (government spending) versus monetary policy (money circulation and real interest rates)

on the economy in ASEAN countries using non-linear regression and the results are that there is an influence of a single threshold of money supply on inflation before and after controlling the crisis in determining economic growth. (Soharwardi et al., 2022) evaluated a comparative analysis of fiscal and monetary policies in Pakistan with the Gross Domestic Product (GDP) variable as the dependent variable and development spending, gross fixed capital formation, labor force participation, corruption, total taxes, trade openness, money supply (M2), government consumption spending as independent variables, showing the results that monetary and fiscal policies have a positive influence, but monetary policy is stronger on economic growth in Pakistan. (Ullah & Khan, n.d.), in their research, examines the impact of fiscal, monetary and open trade policies which have a significant influence on the economy in Pakistan.

According to Beyene & Kotosz, (2021) studied the effectiveness and sensitivity of fiscal and monetary policy for the economy in Ethiopia, with the variables of tax and grant revenues, government expenditure and government loans resulting in the effectiveness of fiscal policy being greater than monetary policy. (Khosravi & Karimi, 2010) investigated in their research, there is a significant influence of fiscal and monetary policies to stimulate the economy in Iran resulting in inflation rates and currency exchange rates having an inverse influence on growth while government spending has a significant influence on growth. (Tadesse & Melaku, 2019) examined in their research that the impact of fiscal and monetary policy on the economy in Ethiopia and the exogeneity of the money circulation variables, government expenditure consumption and GDP proxy variables showed that in the short term, the influence of fiscal policy was greater than monetary policy.

3. Data and method

The focus of this study is on the relationship analysis tools and main indicators of time series and cross section panel data for 2010 - 2023. The variables studied are economic conditions (lnGRDP), money circulation (lnMS), Regional Fiscal Independence Index (IKF), regional inflation (INF) and regional tax revenues (lnPD). Specifically, the inflation and regional tax revenue variables are moderated by the Gini Index variable.

The analytical model used in this research is a dynamic variable relationship approach with an error correction factor model (VECM), stationary test, Granger causality and cointegration consisting of (1) the first model will explain how regional spending, regional fiscal independence index, inflation, regional tax revenues and economic growth together influence the money supply; (2) the second model will explain how the money supply, regional fiscal independence index, inflation, regional tax revenues and economic growth jointly influence regional spending; (3) the third model will explain how the money supply, regional spending, inflation, regional tax revenues and economic growth together influence the regional fiscal independence index; (4) the fourth model will explain how the money supply, regional spending, regional fiscal independence index, inflation and regional tax revenues together influence economic growth; (5) the fifth model will explain how the money supply, regional spending, regional fiscal independence index, economic growth and regional tax revenues together influence inflation; and (6) the sixth model will explain

how the money supply, regional spending, regional fiscal independence index, inflation and economic growth jointly influence regional tax revenues.

Unit root testing in this study uses the methodology carried out by (Levin et al., 2002). The unit root test equation of (Levin et al., 2002) taking into account the ADF test criteria is as follows:

$$\Delta \ln Y_{it} = \rho_{it} Y_{it-1} + \sum_{j=1}^{\rho_{it}} \delta_{it,j} \Delta \ln Y_{it-j} + e_{it} \quad (1)$$

Where: Y is a vector of the main endogenous variables studied, namely economic growth (lnGRDP), amount of money in circulation (lnMS), regional spending (lnGE) Regional Fiscal Independence Index (IKF), inflation (INF) and regional tax revenue (lnPD). Unit root testing by Levin et al. (2002) with the assumption that the accuracy parameter ρ , is identical in the time series and panel cross section (i.e., ρ , ρ for all it), while the lag sequence p , can vary. This mechanism tests the null hypothesis $\rho = 0$ on all it variables for the alternative testing hypothesis $\rho < 0$ on all it variables. The hypothesis is not accepted if $H \neq 0$ indicates the possibility of continuing at the data integration process stage and vice versa.

The unit root test by (Levin et al., 2002) which is also based on equation (1), is different from the unit root test of (Levin et al., 2002), assuming ρ to be heterogeneous between parts. The unit root test by Im et al. (2005) null hypothesis testing is accepted if $\rho = 0$ against the alternative hypothesis $\rho < 0$, ($it=1, \dots, it$); $\rho = 0$, ($it=it, \dots, it$) for all it . Acceptance of the alternative hypothesis allows the individual series to be integrated. The unit root test by (Levin et al., 2002) can be estimated on data at level and first differential in semi-natural logarithmic form.

Empirically, this research method is to see the impact of a mix of monetary policy and fiscal decentralization causally on the money supply (lnMS), regional spending (lnGE), Regional Fiscal Independence Index (IKF), inflation (INF) and regional tax revenues (lnPD) on economic growth (lnGRDP) in Sumatra in the short and long term. This research also uses a cointegration test, to see the maximum possibility of the Johansen cointegration test (Johansen, 1988) to see short-term period relationships. and long term between the variables studied. Granger causality analysis testing also needs to be carried out to get good results from the test results by choosing the right optimal lag length. The Johansen cointegration framework takes its starting point in the vector error correction model (VECM), while its equation can be displayed as follows:

$$x_{it} = A_1 x_{it-p} + \dots + A_p x_{it-p} + B y_{it} + e_{it} \quad (2)$$

Where: x , is the endogenous vector, and the symbol A acts as an autoregressive matrix. y , acts as a deterministic vector and B as a parameter matrix. e is the innovation vector and p is the lag length.

To reveal the direction of causality between money supply (lnMS), regional spending (lnGE), Regional Fiscal Independence Index (IKF), inflation (INF) and regional tax revenues (lnPD) on economic growth (lnGRDP) for time series and cross section panel data. So the VECM Granger causality equation model can be seen as follows:

$$\Delta \ln MS_{it} = \alpha_{1it} + \sum_{l=1}^{m_{IMS_{it}}} \beta_{1it,l} \Delta \ln MS_{it-1} + \sum_{l=1}^{m_{IGE_{it}}} \gamma_{1it,l} \Delta \ln GE_{it-1} + \sum_{l=1}^{m_{IKF_{it}}} \delta_{1it,l} \Delta IKF_{it-1} + \sum_{l=1}^{m_{INF_{it}}} \theta_{1it,l} \Delta INF_{it-1} + \sum_{l=1}^{m_{IPD_{it}}} \pi_{1it,l} \Delta \ln PD_{it-1} + \sum_{l=1}^{m_{GRDP_{it}}} \omega_{1it,l} \Delta \ln GRDP_{it-1} + EC_{it-1} + e_{1t} \quad (3)$$

$$\Delta \ln GE_{it} = \alpha_{2it} + \sum_{l=1}^{m_{IGE_{it}}} \beta_{2it,l} \Delta \ln GE_{it-1} + \sum_{l=1}^{m_{IMS_{it}}} \gamma_{2it,l} \Delta \ln MS_{it-1} + \sum_{l=1}^{m_{IKF_{it}}} \delta_{2it,l} \Delta IKF_{it-1} + \sum_{l=1}^{m_{INF_{it}}} \theta_{2it,l} \Delta INF_{it-1} + \sum_{l=1}^{m_{IPD_{it}}} \pi_{2it,l} \Delta \ln PD_{it-1} + \sum_{l=1}^{m_{GRDP_{it}}} \omega_{2it,l} \Delta \ln GRDP_{it-1} + EC_{it-1} + e_{2t} \quad (4)$$

$$\Delta IKF_{it} = \alpha_{3it} + \sum_{l=1}^{m_{IKF_{it}}} \beta_{3it,l} \Delta IKF_{it-1} + \sum_{l=1}^{m_{IMS_{it}}} \gamma_{3it,l} \Delta \ln MS_{it-1} + \sum_{l=1}^{m_{IGE_{it}}} \delta_{3it,l} \Delta \ln GE_{it-1} + \sum_{l=1}^{m_{INF_{it}}} \theta_{3it,l} \Delta INF_{it-1} + \sum_{l=1}^{m_{IPD_{it}}} \pi_{3it,l} \Delta \ln PD_{it-1} + \sum_{l=1}^{m_{GRDP_{it}}} \omega_{3it,l} \Delta \ln GRDP_{it-1} + EC_{it-1} + e_{3t} \quad (5)$$

$$\Delta \ln GRDP_{it} = \alpha_{4it} + \sum_{l=1}^{m_{GRDP_{it}}} \beta_{4it,l} \Delta \ln GRDP_{it-1} + \sum_{l=1}^{m_{IMS_{it}}} \gamma_{4it,l} \Delta \ln MS_{it-1} + \sum_{l=1}^{m_{IGE_{it}}} \delta_{4it,l} \Delta \ln GE_{it-1} + \sum_{l=1}^{m_{IKF_{it}}} \theta_{4it,l} \Delta IKF_{it-1} + \sum_{l=1}^{m_{INF_{it}}} \pi_{4it,l} \Delta INF_{it-1} + \sum_{l=1}^{m_{IPD_{it}}} \omega_{4it,l} \Delta \ln PD_{it-1} + EC_{it-1} + e_{4t} \quad (6)$$

$$\Delta INF_{it} = \alpha_{5it} + \sum_{l=1}^{m_{INF_{it}}} \beta_{5it,l} \Delta INF_{it-1} + \sum_{l=1}^{m_{IMS_{it}}} \gamma_{5it,l} \Delta \ln MS_{it-1} + \sum_{l=1}^{m_{IGE_{it}}} \delta_{5it,l} \Delta \ln GE_{it-1} + \sum_{l=1}^{m_{IKF_{it}}} \theta_{5it,l} \Delta IKF_{it-1} + \sum_{l=1}^{m_{IPD_{it}}} \pi_{5it,l} \Delta \ln PD_{it-1} + \sum_{l=1}^{m_{GRDP_{it}}} \omega_{5it,l} \Delta \ln GRDP_{it-1} + EC_{it-1} + e_{5t} \quad (7)$$

$$\Delta \ln PD_{it} = \alpha_{6it} + \sum_{l=1}^{m_{IPD_{it}}} \beta_{6it,l} \Delta \ln PD_{it-1} + \sum_{l=1}^{m_{IMS_{it}}} \gamma_{6it,l} \Delta \ln MS_{it-1} + \sum_{l=1}^{m_{IGE_{it}}} \delta_{6it,l} \Delta \ln GE_{it-1} + \sum_{l=1}^{m_{IKF_{it}}} \theta_{6it,l} \Delta IKF_{it-1} + \sum_{l=1}^{m_{INF_{it}}} \pi_{6it,l} \Delta INF_{it-1} + \sum_{l=1}^{m_{GRDP_{it}}} \omega_{6it,l} \Delta \ln GRDP_{it-1} + EC_{it-1} + e_{6t} \quad (8)$$

Where t is the time period ($t = 1, \dots, t$); i is a cross section of panel data ($i = 1, \dots, i$) l lag of each variable; $\ln GRDP$ is Gross Regional Domestic Product; $\ln MS$ is the amount of money in circulation; $\ln GE$ is regional expenditure; IKF is the Regional Fiscal Independence Index; INF is inflation; $\ln PD$ is regional tax revenue; EC is the error correction and $e_1 e_2 e_3 e_4 e_5 e_6$ assumes an error rate in the model (error term).

According to (Granger, 2008), several possibilities will be obtained regarding the coefficient value of each variable, namely (i) for example in the first equation only causality occurs between $\ln MS$ and $\ln GE$ on $\ln GRDP$, meaning only $Y, 0$ (rejection of the null hypothesis), while all hypotheses β_{1it} dan $\theta_{1it} = 0$ means that there is no causality between $\ln MS$, $\ln GE$ and Y between variables (acceptance of the null hypothesis), this indicates that there is at least one relationship or another; (ii) acceptance of the null hypothesis occurs, if all probabilities are at $\gamma_{1t} \beta_{1t} \delta_{1t} = 0$ which means there are no variables that have good causality in the same direction (directional) or in two directions; (iii) rejection of the null hypothesis occurs, if there are other possibilities, for example if $\gamma_{1t} \beta_{1t} \delta_{1t} \neq 0$ which means that all variables have the possibility of a causal relationship, either unidirectional or bidirectional.

Table 1. *Variable Operational Definition*

Variable	Definition	Source
lnGRDP	Total Gross Regional Domestic Product	Indonesian Central Statistics Agency
lnMS	The amount of money in circulation is proxied by the share of GRDP in GDP	Indonesian Central Statistics Agency and Bank Indonesia
lnGE	Consumption of regional government expenditure in the form of regional expenditure (government expenditure)	DJPK, Ministry of Finance
IKF	Regional independence in development financing sourced from PAD	DJPK, Ministry of Finance
lnPD	Regional tax revenues have been moderated by the Gini Index variable	DJPK, Ministry of Finance
INF	Inflation in a region has been moderated by the Gini Index variable	Indonesian Central Statistics Agency
IGNI	Income Inequality as a moderating variable or control variable	Indonesian Central Statistics Agency

Source: Author Compilation, (2025).

4. Results

4.1. Descriptive Statistical Analysis

The results of running data explain descriptive statistics based on table 2 below where the data is in semi-natural logarithmic form. This describes economic growth, money supply, regional spending, Fiscal Independence Index, regional tax revenues and inflation. The highest average values are money supply (34.13371) and regional expenditure (30.58114), this shows that lnMS and lnGE have a stable trend in economic growth. The standard deviation of all variables is positive, with the highest values for lnMS (1.391653) and INF (0.944863).

Table 2. *Descriptive Statistical Results*

Description	lnGRDP	lnMS	lnGE	IKF	lnPD	INF
Mean	32.9686	34.1337	30.5811	0.69853	27.2002	1.37700
Median	33.0050	34.4500	30.6200	0.70650	27.2400	1.12048
Maximum	34.5900	36.1600	31.7900	0.85100	29.0100	3.85175
Minimum	30.9800	29.9500	29.1100	0.47200	25.1400	0.02046
Std. Dev	0.85925	1.39165	0.63539	0.07672	0.78979	0.94486
Skewness	-0.16818	-1.03118	-0.22797	-0.86207	-0.15211	0.88489
Kurtosis	2.37205	3.68366	2.17769	3.94326	2.48338	2.99147
Jarque-Bera	2.96024	27.5376	5.15714	22.5310	2.09705	18.2713
Probability	0.22761	0.00000	0.07588	0.00001	0.35045	0.00010
Sum	4615.61	4778.72	4281.36	97.7950	3808.03	192.780
Sum Sq. Dev	102.625	269.200	56.1186	0.81832	86.7048	124.094
Observation	140	140	140	140	140	140
Multicollinearity						
lnGRDP	1.00000					
lnMS	0.78466	1.00000				
lnGE	0.81412	0.73398	1.00000			
IKF	-0.20104	-0.24967	-0.39854	1.00000		
lnPD	0.95072	0.83636	0.83097	-0.26257	1.00000	
INF	-0.09985	-0.24789	-0.21109	0.14959	-0.15536	1.00000

Source: Author's calculation based on output E-Views 13 (2025).

The relationship matrix between panel data variables above, to determine the extent and direction of the relationship between variables, uses the Pearson correlation test. If the value is 1 then there is a perfect relationship between the variables. Positive and negative symbols describe the direction of the relationship between two variables. If an increase in

one variable increases another variable, then this is indicated by a positive sign, whereas if it is negative, the opposite applies.

4.2. Panel Unit Root Test

Before estimating VECM Granger causality, several econometric criteria must be met, such as testing data stationarity with the unit root test using the Augmented Dickey-Fuller test criteria (ADF-Test) using 2 (two) ADF-Fisher Chi-square and ADF-Choi Z-stat methods, this test was developed by (Levin et al., 2002). The unit root test results can be seen in Table 3.

Table 3. Unit Root Test Results at the First Difference Level

Variable	ADF-Fisher Chi-square		ADF-Choi Z-stat		Information
	t-Statistic	Prob	t-Statistic	Prob	
$\Delta (\ln GRDP)$	35.2897	0.0186	-1.88638	0.0296	stasionary
$\Delta (\ln MS)$	253.215	0.0000	-14.2737	0.0000	stasionary
$\Delta (\ln GE)$	43.1420	0.0020	-3.39115	0.0003	stasionary
$\Delta (IKF)$	52.0909	0.0001	-4.42705	0.0000	stasionary
$\Delta (\ln PD)$	62.0119	0.0000	-5.10421	0.0000	stasionary
$\Delta (INF)$	100.659	0.0000	-7.77308	0.0000	stasionary

Source: Author's calculation based on output E-Views 13 (2025).

Table 3 shows the running test results from the unit root test at the first difference level, where the results show a probability value of <0.05 (stationary). Furthermore, the six variables are $\ln GRDP$; $\ln MS$; $\ln GE$; IKF ; $\ln PD$ and INF can be used to estimate Granger causality with vector error correction models (VECM).

4.3. Lag Optimum Criterion

Selecting the right optimum lag in the causality model. Table 4 shows the results of the optimum lag test. The results of the running test show that determining the length of the data lag that will be used in estimating Granger causality is lag two for the 6 (six) variables tested as follows.

Table 4. Akaike Information Criterion Test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	652.7414	NA	3.15e-13	-11.75893	-11.61164	-11.69919
1	762.1582	204.9080	8.30e-14	-13.09379	-12.06269*	-12.67557
2	842.4268	141.5645*	3.73e-14*	-13.89867*	-11.98378	-13.12198*

Source: Author's calculation based on output E-Views 13 (2025).

Table 4 shows that the minimum Akaike Information Criterion (AIC) parameter value is in the second lag with a value of (-13.89867), this indicates that the optimum lag is in the second lag.

Table 5. Lag Optimum Test

Optimum Lag	$\Delta (\ln GRDP)$	$\Delta (\ln MS)$	$\Delta (\ln GE)$	$\Delta (IKF)$	$\Delta (\ln PD)$	$\Delta (INF)$	Joint
Δ Lag one	25.70110	29.13853	17.87485	33.31129	16.04025	133.8077	295.1997
	[0.0003]	[0.0001]	[0.0066]	[0.0000]	[0.0135]	[0.0000]	[0.0000]
Δ Lag two	21.89274	12.35886	17.87823	6.762935	31.00317	103.9864	191.0199
	[0.0013]	[0.0544]	[0.0065]	[0.3433]	[0.0000]	[0.0000]	[0.0000]
df	6	6	6	6	6	6	36

Source: Author's calculation based on output E-Views 13 (2025).

4.4. Cointegration Test

The Johansen cointegration test was developed to see the long-term relationship between the variables studied. In checking causality, Granger causality analysis also needs to be carried out to get good results from the test results by choosing the right optimal lag length. Johansen's conceptual cointegration takes its starting point in the vector error correction model. Based on the results of the Johansen cointegration test in Table 6, it shows that the trace statistic results are higher than the critical value, as well as the Max-Eigen Statistics value being higher than the critical value. These results show that for the long-term period there is cointegration between the variables of the equation model, the Johansen cointegration test is presented in Table 6.

Table 6. *Johansen Co-integration Test*

Trace Test				
Null Hypothesized (H_0)	Eigenvalue	Trace Statistic	Critical Value 0.05	Prob
None*	0.521315	181.5230	95.75366	0.0000
At most 1*	0.483849	100.4847	69.81889	0.0000
At most 2	0.134838	27.73562	47.85613	0.8250
At most 3	0.073568	11.80336	29.79707	0.9385
At most 4	0.025270	3.397749	15.49471	0.9460
At most 5	0.005280	0.582380	3.841465	0.4454
Maximum Eigenvalue Test				
Null Hypothesized (H_0)	Eigenvalue	Max-Eigen Statistic	Critical Value 0.05	Prob
None*	0.521315	81.03833	40.07757	0.0000
At most 1*	0.483849	72.74910	33.87687	0.0000
At most 2	0.134838	15.93226	27.58434	0.6715
At most 3	0.073568	8.405612	21.13162	0.8772
At most 4	0.025270	2.815369	14.26460	0.9583
At most 5	0.005280	0.582380	3.841465	0.4454

Source: Author's calculation based on output E-Views 13 (2025).

4.5. VECM Estimation Long-Run

The vector error correction model is a form of autoregressive vector model that estimates the existence of non-stationary but cointegrated data levels. VECM is a development of VAR in non-stationary data series that have a cointegration relationship. The VEC model stabilizes the impact of shocks in the long-term period relationship of endogenous variables so that they can unite in a cointegration relationship due to the role of other variables, but remain unified due to the dynamics of the short-term period. The VEC model estimation results can be seen in Table 7.

Table 7. *VECM Estimation in Long-Run Relationships*

Variable Dependent	C	$\Delta (\ln GRDP_{it})$	$\Delta (\ln MS_{it-1})$	$\Delta (\ln GE_{it-1})$	$\Delta (IKF_{it-1})$	$\Delta (\ln PD_{it-1})$	$\Delta (\ln F_{it-1})$	ECT_{it-1}
$\Delta (\ln GRDP)$	0.065603 (0.0094) [6.9751]	0.180485 (0.11428) [1.57929]	0.012489 (0.00656) [1.90360]	-0.089576 (0.05619) [-1.59411]	0.156153 (0.08378) [1.86387]	0.014510 (0.03910) [0.37108]	0.001634 (0.0040) [0.4007]	0.01348 (0.008) [1.547]
$\Delta (\ln MS)$	0.323458 (0.0109) [29.478]	-0.151070 (0.13333) [-1.13307]	-0.006465 (0.00765) [-0.84466]	-0.171358 (0.06556) [-2.61387]	0.161425 (0.09774) [1.65155]	-0.013507 (0.04562) [-0.29608]	0.01221 (0.0047) [2.5669]	0.9947 (0.010) [97.87]
$\Delta (\ln GE)$	0.008082 (0.0145) [0.5547]	0.561286 (0.17703) [3.11409]	0.025059 (0.01016) [2.46569]	0.008707 (0.08704) [0.10003]	-0.025918 (0.12978) [-0.19971]	0.010690 (0.06057) [0.17650]	-0.00537 (0.0063) [-0.8504]	0.0312 (0.013) [2.312]
$\Delta (IKF)$	0.044528	-0.438639	0.008653	-0.144475	0.002787	0.010792	-0.01421	0.0059

Variable Dependent	C	$\Delta (\ln GRDP_{it})$	$\Delta (\ln MS_{it-1})$	$\Delta (\ln GE_{it-1})$	$\Delta (IKF_{it-1})$	$\Delta (\ln PD_{it-1})$	$\Delta (INF_{it-1})$	ECT_{it-1}
	(0.0097)	(0.11894)	(0.00683)	(0.05848)	(0.08719)	(0.04069)	(0.0042)	(0.009)
	[4.5491]	[-3.68800]	[1.26724]	[-2.47047]	[0.03197]	[0.26521]	[-3.3494]	[0.651]
$\Delta (\ln PD)$	0.098822	0.002806	0.017430	0.009587	0.266800	-0.179126	0.026785	0.0845
	(0.0228)	(0.27768)	(0.01594)	(0.13653)	(0.20356)	(0.09501)	(0.0099)	(0.021)
	[4.3243]	[0.01011]	[1.09342]	[0.07021]	[1.31065]	[-1.88538]	[2.7031]	[3.993]
$\Delta (INF)$	0.022987	-4.530243	0.709812	0.617184	5.973854	0.148382	-0.31662	0.0198
	(0.1901)	(2.31004)	(0.13262)	(1.13584)	(1.69347)	(0.79038)	(0.0824)	(0.176)
	[0.1209]	[-1.96111]	[5.35236]	[0.54337]	[3.52759]	[0.18773]	[-3.8410]	[0.112]

Source: Author's calculation based on output E-Views 13 (2025).

4.6. VECM Estimation Short-Run

Estimation of the short-term causality model, at the first model testing stage, the hypothesis value is zero (H_0) for short-term causality, which is the lag in the previous period of the independent variables, namely economic growth, regional spending, regional Fiscal Independence Index and inflation after being moderated simultaneously, it does not significantly influence the dependent variable, namely the circulation of money. The statistical figures illustrate that the Chi-square confidence level is above 0.05, so the acceptance of the null hypothesis is acceptable, which means that there is no relationship between the independent and dependent variables in the short term. The next process stages were tested on the second to sixth models shown in Table 8 below.

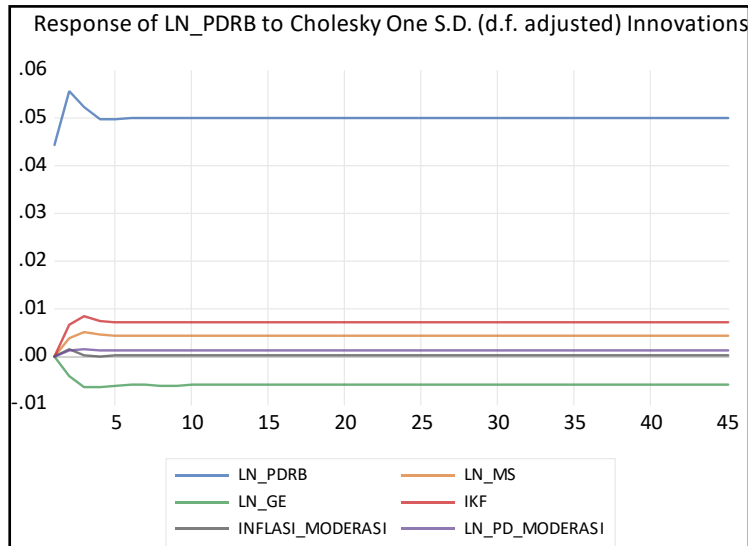
Table 8. VECM Estimation in Short-Term Relationships

Variable Dependent	(Chi ²) dan Probabilitas					
	$\Delta (\ln GRDP)$	$\Delta (\ln MS)$	$\Delta (\ln GE)$	$\Delta (IKF)$	$\Delta (\ln PD)$	$\Delta (INF)$
$\Delta (\ln GRDP)$	-	15.89881	5.473475	9.992067	1.992981	1.923250
	-	0.0004	0.0648	0.0068	0.3692	0.3823
$\Delta (\ln MS)$	2.472839	-	4.028955	5.299149	13.47971	0.313816
	0.2904	-	0.1334	0.0707	0.0012	0.8548
$\Delta (\ln GE)$	6.423859	2.706995	-	4.580428	3.071253	1.088344
	0.0403	0.2583	-	0.1012	0.2153	0.5803
$\Delta (IKF)$	0.626922	2.101839	0.736069	-	1.323283	1.138054
	0.7309	0.3496	0.6921	-	0.5160	0.5661
$\Delta (\ln PD)$	2.296305	23.72315	2.239017	0.131965	-	1.797945
	0.3172	0.0000	0.3264	0.9361	-	0.4070
$\Delta (INF)$	6.473111	162.2818	6.590573	1.145571	1.430300	-
	0.0393	0.0000	0.0371	0.5640	0.4891	-

Source: Author's calculation based on output E-Views 13 (2025).

4.7. Impulse Response

The estimation results of innovation variable shocks were carried out to see the response to instability due to shocks in the innovation variable on other variables. Estimates using an assumption approach between innovation variables do not have a direct relationship due to the influence of surprises on innovation variables. Figure 1 shows the variable response due to the surprise of the innovation variable within the period after the shock occurred. If the shock image shows a change that is getting to a stable point (converging) or returning to the stable point of the previous period, it means that the variable is responding and the longer the period, the more they will cancel each other out so that the shock does not have a permanent influence on the variable.

Figure 1. *Impulse Response*

Source: Author's calculation based on output E-Views 13 (2025)

Figure 1 shows that the shock variable moderated by lnPD and INF responds downward to lnGRDP in the initial period and fluctuates in the following period but will be stable in the long period.

4.8. Variance Decomposition

The role of variations in endogenous variables in the combined shock components of other endogenous variables in the design of VAR model development. The role of this variant can explain the distribution of movements in a time series as a result of the shock of the variable itself when compared with the shock of other innovation variables as shown in Table 9 below.

Table 9. *Variance Decomposition*

Variable	Periode	S.E	$\Delta (\ln GRDP)$	$\Delta (\ln MS)$	$\Delta (\ln GE)$	$\Delta (IKF)$	$\Delta (\ln PD)$	$\Delta (INF)$
$\Delta (\ln GRDP)$	1	0.0424	100.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	10	0.1458	89.3253	0.6480	0.4100	8.3449	0.8936	0.3779
	20	0.2046	88.9961	0.6867	0.3524	8.6153	0.9431	0.4062
	30	0.2498	88.8900	0.7002	0.3323	8.7000	0.9612	0.4159
	45	0.3055	88.8193	0.7093	0.3187	8.7566	0.9734	0.4225
$\Delta (\ln MS)$	1	0.0344	34.9316	65.068	0.0000	0.0000	0.0000	0.0000
	10	0.1216	34.7525	56.859	0.7188	2.5655	4.6976	0.4055
	20	0.1714	35.2619	56.198	0.7658	2.6180	4.6893	0.4664
	30	0.2100	35.4310	55.980	0.7815	2.6331	4.6867	0.4867
	45	0.2572	35.5439	55.835	0.7920	2.6431	4.6850	0.5002
$\Delta (\ln GE)$	1	0.0670	0.74501	16.911	82.343	0.0000	0.0000	0.0000
	10	0.2450	14.6994	18.242	65.901	0.1623	0.9144	0.0797
	20	0.3520	15.1249	18.620	65.145	0.0904	0.9768	0.0413
	30	0.4333	15.2551	18.742	64.911	0.0670	0.9955	0.0290
	45	0.5326	15.3403	18.821	64.757	0.0516	1.0077	0.0209
$\Delta (IKF)$	1	0.0445	15.8106	0.0161	0.0871	84.086	0.0000	0.0000
	10	0.1013	3.81778	7.5172	0.1903	77.657	2.8458	7.9710

Variabel	Periode	S.E	$\Delta (\ln GRDP)$	$\Delta (\ln MS)$	$\Delta (\ln GE)$	$\Delta (IKF)$	$\Delta (\ln PD)$	$\Delta (INF)$
	20	0.1388	2.03889	8.7257	0.1410	76.826	3.1919	9.0753
	30	0.1681	1.39124	9.1625	0.1229	76.530	3.3147	9.4777
	45	0.2043	0.94269	9.4651	0.1104	76.325	3.3997	9.7562
$\Delta (\ln PD)$	1	0.0943	13.0563	21.452	7.8140	3.7446	53.931	0.0000
	10	0.2107	12.7749	16.222	12.5303	4.4192	53.587	0.4654
	20	0.2872	11.5208	15.856	13.6795	4.5623	53.854	0.5265
	30	0.3473	11.0544	15.721	14.1014	4.6316	53.943	0.5474
	45	0.4217	10.7306	15.627	14.3945	4.6797	54.005	0.5620
$\Delta (INF)$	1	0.5040	2.56395	0.1695	1.58385	2.4428	0.3343	92.905
	10	1.0340	20.50053	29.9627	2.50183	15.8872	1.6762	29.471
	20	1.4113	23.19537	35.5058	1.72315	18.3254	1.8004	19.449
	30	1.7074	24.16778	37.5193	1.43985	19.2470	1.8468	15.779
	45	2.0737	24.84271	38.9190	1.24297	19.8873	1.8788	13.229

Source: Author's calculation based on output E-Views 13 (2025).

Table 9 above indicates that as the time period increases, the role of the independent variable on the dependent variable fluctuates greatly, there are variables whose role becomes stronger, but there are also variables whose role in economic growth decreases.

4.9. Moderating Variable Test Results

Based on the model formed from equations (3), (4), (5), (6), (7) and (8), there are variables that moderate the $\ln PD$ and INF variables. Table 10 below presents the results of testing the moderating variable (Gini Index) using the EGLS (cross-section SUR) panel method.

Table 10. Moderating Variable Test Results

Variable	S.E	t-Statistic	Prob	Information
$\Delta (\ln PD)$	0.288417	2.114878	0.0364	$\ln PD$ moderated Gini Index
$\Delta (INF)$	0.284409	3.188933	0.0018	INF moderated Gini Index

Source: Author's calculation based on output E-Views 13 (2025).

Table 10 shows that with partial testing the Gini Index variable strengthens the $\ln PD$ variable after being moderated and has a significant influence with a prob value < 0.05 and the Gini Index variable strengthens the INF variable after being moderated and has a significant influence with a prob value < 0.05 , thus the Gini Index acts as a Quasi moderator.

4.10. Hypothesis Testing

The results of hypothesis testing using the EGLS (cross-section SUR) panel method are shown in Table 11 below.

Table 11. Hypothesis Testing Results

Variable dependent: $\ln GRDP$					
Hipotesis	Variable	Coeffisient	S.E	t-Statistic	Prob**
	C	9.875954	0.953251	10.36029	0.0000
H1	$\Delta (\ln MS)$	0.049302	0.012901	3.821520	0.0002
H2	$\Delta (\ln GE)$	0.399010	0.033696	11.84135	0.0000
H3	$\Delta (IKF)$	0.819808	0.080874	10.13684	0.0000
H4	$\Delta (\ln PD)$	0.318741	0.032960	9.670532	0.0000
H5	$\Delta (INF)$	-0.025292	0.005383	-4.698282	0.0000
H6	Simultan			12903.97	0.000000

Source: Author's calculation based on output E-Views 13 (2025).

Table 11 shows the first hypothesis (H1) with a t-statistic of 3.821520 and a probability value of less than 0.05 ($0.0002 < 0.05$) which means that the circulation of money has a positive and significant relationship to the economic growth variable or H1 is accepted, the second hypothesis (H2) with a t-statistic of 11.84135 and a probability value of less than 0.05 ($0.0000 < 0.05$) which means regional spending has a positive and significant relationship with economic growth or H2 is accepted. The third hypothesis (H3) with a t-statistic of 10.13684 and a probability value of less than 0.05 ($0.0000 < 0.05$) which means the Fiscal Independence Index has a positive and significant relationship to economic growth or H3 is accepted, the fourth hypothesis (H4) with a t-statistic of 9.670532 and a probability value of less than 0.05 ($0.0000 < 0.05$) which means regional tax revenue (after moderated) has a significant influence and a positive relationship or H4 is accepted. The fifth hypothesis (H5) with a t-statistic of -4.698282 and a probability value of less than 0.05 ($0.0000 < 0.05$) which means that inflation (after moderation) has a significant influence and a negative relationship or H5 is accepted and the sixth hypothesis (H6) tested simultaneously shows that money circulation, regional spending, the Fiscal Independence Index, regional tax revenues and inflation have a significant influence with the F-statistic 12903.97 and the probability value is less than 0.05 ($0.000000 < 0.05$).

5. Discussion

The estimation results of the first VEC model, shown in model equation (3), indicate that in short-term causality modeling Table 8, the regional tax revenue variable after being moderated has a significant influence with a smaller chi-square probability value $0.0012 < 0.05$ on the dependent variable money circulation. In the long-term causality modeling Table 7 there is a correction vector for adjusting the short-term period to the long-term period of 0.9947, which means that around 99.47 percent of the shock imbalance in Figure 1 from the previous period and normal returns to the balance point after the fifth period due to the role of other variables in this research. The role of other variables in the research in Table 9, suggests that as the period increases, the role of the money circulation variable on economic growth decreases and is replaced by other variables in the research, a significant increase in the role of regional spending, the influence of the strength of the Fiscal Independence Index, regional tax revenues and inflation after being moderated.

Statistically, the decline in economic growth in the previous period with a coefficient of -0.15070, which means that if the economy gets better and increases by 1 percent, it will have the impact of reducing the amount of money in circulation by 0.15 percent in current conditions. This agrees with research conducted by (Ismail & Sek, 2020) and (Ullah & Khan, n.d.). Regional spending in the previous period had a significant influence where the t-statistic value was higher than the t-table value $2.61387 > 1.977692$ and inflation in the previous period had a significant influence where the t-statistic value was higher than the t-table value $2.5669 > 1.977692$ on the dependent variable money supply. This is in accordance with the inflation theory put forward by (Friedman, 1970).

The estimation results of the second VEC model, shown in model equation (4), indicate that in short-term causality modeling Table 8, the economic growth variable has an influence on regional spending where the chi-square probability is $0.0403 < 0.05$. In the long-term causality modeling Table 7 there is a correction vector for adjusting the short-term period to the long-term period of 0.0312, which means that 3.12 percent of the imbalance is due to the shock in Figure 1 in the previous period and will be normal at the balance point in the next period due to the role of other variables in this research.

As the time period increases, the role of regional spending will decrease and be replaced by the role of other variables in Table 9 which give an increase in the research, namely money supply, regional tax revenues after moderation and economic growth, but this is not followed by the role of the inflation variable after moderation and the regional Fiscal Independence Index which experiences a downward trend. Statistically, the influence of economic growth in the previous period has a coefficient of 0.561286, which suggests that a 1 percent increase in economic growth in the previous period will increase regional spending by 0.56 percent. This is not in line with the research of (Abu Hasan, 2016) and in line with the research of (Soharwardi et al., 2022) and (Ullah & Khan, n.d.). Economic growth in the previous period had a significant influence where the t-statistic was greater than the t-table $3.11409 > 1.977692$ and the impact of money supply in the previous period had a significant influence where the t-statistic was greater than the t-table $2.46569 > 1.977692$ on regional spending.

The third VEC model estimate shown by model equation (5) indicates that modeling with short-term causality Table 8 does not have a significant variable on the dependent variable, namely the regional Fiscal Independence Index, where the chi-square and probability values for all variables are above 0.05. In the long-term causality modeling Table 7, there is a correction vector for adjusting the short-term period to the long-term period of 0.0059, which means that 0.59 percent of the imbalance is due to the shock in Figure 1 of the previous period and will return to the balance point in the next period due to the role of other variables in the research in line with the research of (Syakur et al., n.d.) and (Bildirici et al., 2023).

As the time period increases, the role of the regional Fiscal Independence Index variable decreases and is replaced by the role of other variables in Table 9 which give an increase in the research, namely money supply, regional tax revenues after moderation and inflation after moderation, but this is not followed by the role of the economic growth variable which experiences a downward trend. Statistically, the influence of economic growth in the previous period has a coefficient of -0.438639, which means that a 1 percent increase in economic growth in the previous period will reduce the performance of the Fiscal Independence Index by 0.44 points. Economic growth in the previous period had a significant influence where the t-statistic was greater than the t-table value $3.68800 > 1.977692$, regional spending in the previous period had a significant influence $2.47047 > 1.977692$ and inflation in the previous period had a significant influence $3.34494 > 1.977692$ on the Fiscal Independence Index.

The estimation results of the fourth VEC model, shown in model equation (6), indicate that modeling with short-term causality Table 8, the money circulation variable has an influence on chi-square and probability $0.0004 < 0.05$ and the regional Fiscal Independence Index variable has a significant influence $0.0068 < 0.05$ on economic growth. Modeling with long-term causality Table 7 there is a correction vector for adjusting the short-term period to the long-term period of 0.01348, which means that 0.1348 percent of the shock imbalance in Figure 1 in the previous period will return to normal to the balance point in the next period due to the role of the innovation variable in this research in line with the research of (El Husseiny, 2023).

The impact of other variables in this research can be seen in Table 9, where as the time period increases, the influence of economic growth itself will decrease and be replaced by the role of other variables which experience an increasing trend in the role of the variables of money supply, regional spending, regional Fiscal Independence Index, regional tax revenues and inflation after being moderated. Economic growth in the previous period had a coefficient of 0.180, which means that a 1 percent increase in economic growth in the previous period will increase economic growth performance by 0.180 percent in the current period. In the long-term model Table 7 there are no variables that influence the dependent variable economic growth, where the t-statistic value is smaller than the t-table value.

The estimation results of the fifth VEC model, shown in model equation (7), indicate that modeling with short-term causality Table 8 economic growth variables have a significant influence with chi-square and probability values $0.0393 < 0.05$, money supply $0.0000 < 0.05$ and regional spending $0.0371 < 0.05$ on moderated inflation. In the long-term causality modeling Table 7 there is a correction vector for adjusting the short-term period to the long-term period of 0.0198, which means that 0.198 percent of the shock imbalance in Figure 3 from the previous period will return to normal at the balance point in the next period. This is due to the role of other variables in the research in line with the research of (M. L. T. Nguyen & Bui, 2022).

The influence of the role of other variables in this research can be seen in Table 9, where as the time period increases, the role of the inflation variable after moderation will decrease, replaced by an increasing role in the variables of economic growth, money supply, regional Fiscal Independence Index, regional tax revenues after moderation, while the role of regional spending will experience a decreasing trend. Economic growth in the previous period had a coefficient of -4.530243, which means that a 1 percent increase in economic growth will reduce inflation by 4.53 percent in the current period. This agrees with research conducted by (Khosravi & Karimi, 2010) but is not in line with research conducted by (Muhafidin, 2020). The money supply variable for the previous period has a significant influence with a t-statistic value greater than the t-table $5.35236 > 1.977692$, the regional Fiscal Independence Index variable for the previous period $3.52759 > 1.977692$ and the inflation variable which has been moderated in the previous period $3.8410 > 1.977692$ on the dependent variable inflation.

The final estimate of the sixth VEC model, shown in model equation (8), indicates that modeling with short-term causality Table 8, the money circulation variable has an influence on local tax revenues after being moderated by chi-square and a probability value of less than 0.05 $0.0000 < 0.05$. Modeling with long-term causality Table 7 there is an adjustment correction vector from the short-term period to the long-term period of 0.0198, which means that 1.98 percent of the imbalance due to shock in Figure 1 from the previous period will return to normal in the next period as a result of the role of other variables in this research. in line with the research of (Alavuotunki et al., 2019).

The influence of the role in Table 9, as the time period increases, the role of other variables fluctuates greatly up and down. Economic growth in the previous period had a coefficient of 0.0028, which means that a 1 percent increase in economic growth will increase regional tax revenues after being moderated by 0.0028 percent in the current period. This agrees with research conducted by (Adegboyo et al., 2021) (Tiony, 2023) and (Terblanche et al., 2024). The inflation variable after being moderated in the previous period has a significant influence on regional tax revenues after being moderated with a t-statistic value greater than the t-table value $2.7031 > 1.977692$.

In the VEC model equation, there is a Gini Index variable which acts as a moderating variable in the regional tax revenue and inflation variables, which has a significant influence with a probability value of less than 0.05. This can be seen from its role in model equation (3) in the short-term relationship as well as in model equations (3), (5), (8) and (9) in the short-term relationship, that moderated inflation strengthens the relationship with the dependent variable.

6. Conclusion

The collaboration of monetary policy and fiscal decentralization in maintaining macroeconomic stability is a policy instrument that is in line with economic growth and controlling inflation in the region. The short-term causality of the role of monetary policy which is proxied by the circulation of money has a significant influence on economic growth. This suggests that the more effective monetary policy is, the more independent the region in fiscal independence has a significant influence on economic growth. In a long-term relationship, all variables studied in the previous period have no influence on economic growth in the current period.

Inflation moderated by the Gini Index variable has a significant influence, where the shock interval in Figure 1 is the largest compared to other variables, followed by the regional expenditure variable which greatly influences economic growth at the beginning of the period. This is because the greater the inequality gap in per capita income, the worse the inflation will be, while in terms of regional expenditure it has not yet fully demonstrated productive expenditure performance in controlling regional inflation.

The existence of a moderating variable by the Gini Index in the regional tax revenue variable causes regional tax revenues not to reach the optimum point, especially taxes

imposed on individuals, so that in the long-term and short-term causality relationship regional tax revenues do not have a significant influence on economic growth. Regional governments must reduce the Gini Index inequality gap which can affect inflation by intervening in regional spending to support the people's economic activity in the Micro, Small and Medium Enterprises (MSME) theme, providing regional fiscal relaxation for small industries (home industry).

Control inflation with massive simultaneous movements for the community by changing the consumer mindset to producers, controlling commodity prices and regional spending interventions for connectivity between regions so that distribution flows smoothly. Maximize tax opportunity patterns so as to strengthen local taxing power based on regional tax databases to reduce dependence on central transfers and make regional Fiscal Independence Index performance more independent.

Many previous studies have studied the relationship between inflation in influencing economic growth, where this research is in accordance with inflation theory, if inflation performance gets worse, it will cause disruption to other variables in the macro economy, but in this study, inflation which has been moderated by the Gini Index variable, will strengthen the inflation variable, the greater the gap in the Gini Index will worsen inflation performance and can disrupt economic growth. Recommendations for further research to examine regional tax opportunity variables in strengthening local taxing power for regional economic growth.

References

- Abu Hasan, M. (2016). The Relative Effectiveness of Monetary and Fiscal Policies on Economic Growth in Bangladesh. *Economics*, 5(1), 1. <<https://doi.org/10.11648/j.eco.20160501.11>>
- Adegboyoye, O.S., Keji, S.A., and Fasina, O.T. (2021). The impact of government policies on Nigeria economic growth (case of fiscal, monetary and trade policies). *Future Business Journal*, 7(1). <<https://doi.org/10.1186/s43093-021-00104-6>>
- Agung Krisprimandoyo, D., and Bambang Mahargiono, P. (2023). The Influence of Fiscal Policy and Monetary Policy on Economic Growth in Indonesia. In *ENDLESS: International Journal of Futures Studies* (Vol. 6, Issue 2). <<http://endless-journal.com/index.php/endless>>
- Alavuotunki, K., Haapanen, M., and Pirttilä, J. (2019). The Effects of the Value-Added Tax on Revenue and Inequality. *Journal of Development Studies*, 55(4), 490–508. <<https://doi.org/10.1080/00220388.2017.1400015>>
- Amponsah, M., Agbola, F.W., and Mahmood, A. (2023). The relationship between poverty, income inequality and inclusive growth in Sub-Saharan Africa. *Economic Modelling*, 126. <<https://doi.org/10.1016/j.econmod.2023.106415>>
- Beyene, S.D., and Kotosz, B. (2021). Is fiscal or monetary policy more effective on economic growth? An empirical evidence in the case of Ethiopia. *IBIMA Business Review*, 2020. <<https://doi.org/10.5171/2020.124855>>

- Bildirici, M., Genç, S.Y., and Ersin, Ö.Ö. (2023). Effects of Fiscal and Monetary Policies, Energy Consumption and Economic Growth on CO2 Emissions in the Turkish Economy: Nonlinear Bootstrapping NARDL and Nonlinear Causality Methods. *Sustainability (Switzerland)*, 15(13). <<https://doi.org/10.3390/su151310463>>
- El Husseiny, I.A. (2023). The relative effectiveness of fiscal and monetary policies in promoting Egypt's output growth: an empirical investigation using an ARDL approach. *Journal of Economic Structures*, 12(1). <<https://doi.org/10.1186/s40008-023-00298-8>>
- Elhakim, L., and Ali, H. (n.d.). *The Influence of Fiscal Policy, Monetary Policy and International Trade on Economic Growth in Indonesia (Literature Reviews)*. <<https://doi.org/10.38035/dijefa.v4i3>>
- George-Anokwuru, C.C. (2023). MONETARY POLICY AND MISERY INDEX IN NIGERIA. *European Journal of Economic and Financial Research*, 7(2). <<https://doi.org/10.46827/ejefr.v7i2.1494>>
- Granger, C.W.J. (2008). Investigating Causal Relations by Econometric Models and Cross-Spectral Methods. *Essays in Econometrics Vol II: Collected Papers of Clive W. J. Granger*, 37(3), 31–47. <<https://doi.org/10.1017/ccol052179207x.002>>
- Ismail, S.F., and Sek, S.K. (2020). Investigating the effects of monetary and fiscal policy on economic growth in ASEAN: A threshold modelling approach. *ASM Science Journal*, 13, 1–6. <[https://doi.org/10.32802/asmscj.2020.sm26\(1.10\)](https://doi.org/10.32802/asmscj.2020.sm26(1.10))>
- Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12(2–3), 231–254. <[https://doi.org/10.1016/0165-1889\(88\)90041-3](https://doi.org/10.1016/0165-1889(88)90041-3)>
- Khosravi, A., and Karimi, M.S. (2010). To Investigation the Relationship between Monetary, Fiscal Policy and Economic Growth in Iran: Autoregressive Distributed Lag Approach to Cointegration. *American Journal of Applied Sciences*, 7(3), 415–419.
- Levin, A., Lin, C.-F., and James Chu, C.-S. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. In *Journal of Econometrics* (Vol. 108). <www.elsevier.com/locate/econbase>
- Liu, W., Li, J., and Zhao, R. (2020). Rural Public Expenditure and Poverty Alleviation in China: A Spatial Econometric Analysis. *Journal of Agricultural Science*, 12(6), 46. <<https://doi.org/10.5539/jas.v12n6p46>>
- Madurapperuma, W. (2023). Money supply, inflation and economic growth of Sri Lanka: cointegration and causality analysis. *Journal of Money and Business*, 3(2), 227–236. <<https://doi.org/10.1108/jmb-08-2022-0039>>
- Mdingi, K., and Ho, S.Y. (2021). Literature review on income inequality and economic growth. *MethodsX*, 8. <<https://doi.org/10.1016/j.mex.2021.101402>>
- Muhafidin, D. (2020). The role of fiscal policy and monetary policy in environmental degradation in Indonesia. *International Journal of Energy Economics and Policy*, 10(3), 504–510. <<https://doi.org/10.32479/ijee.9586>>
- Naufal, A., and Fikriah, F. (2023). Regional Nexus of Economic Growth, Income Inequality and Poverty. *Ekonomikalia Journal of Economics*, 1(2), 61–68. <<https://doi.org/10.60084/eje.v1i2.114>>
- Nguyen, H.T., and Darsono, S.N.A.C. (2022). The Impacts of Tax Revenue and Investment on the Economic Growth in Southeast Asian Countries. *Journal of Accounting and Investment*, 23(1), 128–146. <<https://doi.org/10.18196/jai.v23i1.13270>>
- Nguyen, H.T., Nguyen, S. Van, Dau, V.H., Le, A.T.H., Nguyen, K.V., Nguyen, D.P., Bui, X.T., and

- Bui, H.M. (2022). The nexus between greenhouse gases, economic growth, energy and trade openness in Vietnam. *Environmental Technology and Innovation*, 28. <<https://doi.org/10.1016/j.eti.2022.102912>>
- Nguyen, M.L.T., and Bui, N.T. (2022). Government expenditure and economic growth: does the role of corruption control matter? *Heliyon*, 8(10), e10822. <<https://doi.org/10.1016/j.heliyon.2022.e10822>>
- Obayelu, A.E., and Edewor, S.E. (2022). Economic Inequality and Poverty Dynamics: What does Literature tell us? *International Journal of Social Sciences and Economic Review*, 21–31. <<https://doi.org/10.36923/ijsser.v4i4.166>>
- Olamide, E., Ogujiuba, K.K., Maredza, A., and Semosa, P. (2022). Poverty, ICT and Economic Growth in SADC Region: A Panel Cointegration Evaluation. *Sustainability (Switzerland)*, 14(15). <<https://doi.org/10.3390/su14159091>>
- Petrovito, F., Pozzolo, A.F., Resce, G., and Scialà, A. (2023). Fiscal decentralization and income (re)distribution in OECD countries' regions. *Structural Change and Economic Dynamics*, 67, 69–81. <<https://doi.org/10.1016/j.strueco.2023.07.002>>
- Saidi, Y., Labidi, M.A., and Ochi, A. (2024). Economic Growth and Extreme Poverty in Sub-Saharan African Countries: Non-Linearity and Governance Threshold Effect. *Journal of the Knowledge Economy*, 15(2), 7819–7851. <<https://doi.org/10.1007/s13132-023-01421-7>>
- Şen, H., and Kaya, A. (2014). Crowding-out or crowding-in? Analyzing the effects of government spending on private investment in turkey. *Panoeconomicus*, 61(6), 631–651. <<https://doi.org/10.2298/PAN1406631S>>
- Shtewi, M.S. (2023). The Impacts of Government Expenditure on Poverty Alleviation in Arab Spring Countries. *International Journal of Academic Research in Public Policy and Governance*, 9(1), 57–70. <<https://doi.org/10.6007/IJARPPG/v9-i1/7436>>
- Soharwardi, M.A., Sarwar, J., Khan, M.I., and Miraj, M. (2022). Fiscal and Monetary Policy Dilemma in Pakistan to Support Economic Growth. *Journal of Economic Impact*, 4(3), 233–243. <<https://doi.org/10.52223/jei4032210>>
- Sugartini, P., and Millatul Maula, I. (n.d.). Analysis Of The Impact Of Government Fiscal And Monetary Policies On Economic Growth In Indonesia: Government Economic Approach. <<http://ijsr.internationaljournallabs.com/index.php/ijsr>>
- Syakur, R.M., Tri, I., Reviane, A., and Paddu, A.H. (n.d.). *The Influence of Fiscal and Monetary Policy on Indonesia's Economic Growth A R T I C L E I N F O Jurnal Economic Resources*. <<https://doi.org/10.33096/jer.v%vi%vi.1079>>
- Tadesse, T., and Melaku, T. (2019). Analysis Of The Relative Impact Of Monetary And Fiscal Policies On Economic Growth In Ethiopia, Using Ardl Approach To Co-Integration: Which Policy Is More Potent? *Copernican Journal of Finance & Accounting*, 8(2), 89. <<https://doi.org/10.12775/cjfa.2019.010>>
- Tavares Garcia, F., and Cross, J.L. (2024). The impact of monetary policy on income inequality: Does inflation targeting matter? *Finance Research Letters*, 61. <<https://doi.org/10.1016/j.frl.2024.105006>>
- Terblanche, J., van Lill, D., and Hollander, H. (2024). Fiscal policy and dimensions of inequality in South Africa: A time-varying coefficient approach. *South African Journal of Economics*, 92(1), 105–119. <<https://doi.org/10.1111/saje.12369>>
- The Relative Effects of Fiscal and Monetary Policies on Ethiopian Economic Growth. (2020). *Public Policy and Administration Research*. <<https://doi.org/10.7176/ppar/10-11-01>>

- Tiony, O.K. (2023). The Effects of Fiscal Policy Shocks on Aggregate Demand and Economic Growth in Kenya: A VAR Analysis. *Modern Economy*, 14(08), 1074–1107. <<https://doi.org/10.4236/me.2023.148056>>
- Tule, M.K., Onipede, S.F., and Ebu, G.U. (2020). Monetary and fiscal policy mix in a small open economy: Evidence from Nigeria. *Scientific African*, 8. <<https://doi.org/10.1016/j.sciaf.2020.e00346>>
- Ullah, R., and Khan, B. (n.d.). Empirical Investigation Of Fiscal, Monetary And Trade Policies Impact On Economic Growth Of Pakistan. *Academic Journal of Social Sciences*, 5, 54–72.
- Warjiyo, P., and Solikin. (2003). Kebijakan Moneter Indonesia. In *Jurnal Manajemen Maranatha* (Vol. 3, Issue 1).

The implications of demographic changes on economic performance – a comparative analysis of RO vs EU 27

Ioana-Victoria BĂDICIOIU

The Bucharest University of Economic Studies, Romania
ioanavictoriabadicioiu@gmail.com

Ionuț JIANU

The Bucharest University of Economic Studies, Romania
ionut.jianu@economie.ase.ro

Abstract. *The demographic risks have a major impact on our lives, since the acceleration of population ageing and the decline in the fertility rate represent major challenges, which may significantly affect economic developments and fiscal outcomes. In this context, the policymakers should take into account all demographic challenges when adopting new economic policies and setting relevant priorities. To support the need to increase the focus of economic policies on demographic issues, this paper aims to explore the developments and outlooks for the demographic indicators, as well as their linkage to the economic dimension in European Union (including in Romania).*

Keywords: demography, ageing, economic, GDP, birth, population.

JEL Classification: J10, J11, J13, O10, P44.

1. Introduction

The EU has a population of 447 million people, and the total value of goods and services produced on its territory (GDP) is 17 trillion euros. In recent years, the population has been growing in most Member States, but according to Eurostat projections, it is estimated that from 2035 onward the population in the 27 EU Member States will decrease so that in 2100 it will reach 420 million inhabitants, due to a decrease in the working-age population, and a simultaneous increase in the number of elderly people. In the long term, the decrease in the birth ratio in the context of an increase in life expectancy leads to an ageing population. This has a considerable influence on the sustainability of public finances, amplified by the increase in public debt in some Member States, the slowdown in economic growth and global uncertainty.

To mitigate the impact on the economy, fiscal policy strategy should focus on strengthening fiscal sustainability, rebuilding budgetary buffers, so as to achieve sustainable economic growth that will ensure the resilience of the EU in the face of any possible crises in the future. In this regard, various economic and budgetary scenarios have been presented and are reflected in the 2024 Ageing Report for all EU Member States. The forecasts prepared by the Economic Policy Committee cover public spending on population ageing for the period 2022-2070. One of the main findings of the Ageing Report 2024 is related to the increase in the dependency ratio of the elderly population (over 65 years) to the working-age population, from three working-age people for every person over 65 years today to less than two people in 2070, which will increase the pressure on public finances.

2. Literature review

According to the European Commission (2024), the population in the euro area is ageing and demographic pressure is expected to increase. The birth ratio is insufficient to maintain a stable population, even if life expectancy continues to increase gradually.

The International Labour Organization (2020) observed that, globally, the median age of the labour force – comprising people of working age, employed or unemployed but willing to work – increased from 37.6 years in 2010 to 38.9 years in 2019, with the largest increases in southern Europe (3.3 years), eastern Asia (2.6 years), south-east Asia (2.0 years) and South America (2.0 years). In 2019, the regions with the oldest workforces were Southern Europe (median age 43.9 years), Western Europe (43.2 years) and Eastern Asia (42.1 years).

Van Del Berg et al. (2010) suggest that if the elderly population didn't have health problems, they would be productive for longer, moderating the economic effects. The influence of the ageing workforce on productivity and GDP (Gross Domestic Product) per capita was also studied by Feyer (2007, 2008) who concluded that the maximum productivity growth is reached between the ages of 40 and 49. Werding (2008) reached the same result for OECD countries, while Liu & Westlius (2016) found this conclusion for Japan. Expanding on Feyer's model, Aiyar & Ebeke (2016) predict a reduction in total factor productivity for Europe by 0.2% annually between 2014 and 2035.

The decline in the active population associated with population ageing is assumed to have a negative impact on productivity and potential growth. As the labour market attracts fewer people and the participation ratio of older people decreases, labour resources are limited, negatively influencing potential output (the maximum level of real GDP) through the labour component (Nerlich & Schroth, 2018).

Population ageing influences both components of labour supply: the active population and the labour force participation ratio. However, other authors have an opposite view on the relationship between the elderly labour force and the reduction in labour productivity (Acemoglu & Restrepo, 2017; Börsch-Supan & Weiss, 2016; National Research Council, 2012; Siliverstovs et al., 2011), since the decline in physical abilities with advancing age may be compensated by other cognitive abilities.

Demographic challenges put additional pressure also on monetary and fiscal policy, as Liu & Yang (2018) showed, which expose the countries facing these challenges to fiscal crisis risks. As the working population continues to decline, tax revenues from personal income taxes and social contributions are expected to be adversely impacted, which may lead to fiscal imbalances (Bodnár & Nerlich, 2022). In this case, governments may prefer short-term policy options such as increasing tax ratios to compensate the fiscal shocks, even if such measures may distort the economy and generate additional risks (Crowe et al., 2022).

3. Methodology

This paper analyses a series of indicators extracted from the Ageing Report 2024 (published by the European Commission), as well as other indicators published by Eurostat. I considered the analysis for the period 2013-2023 because that period reflects important moments with a major impact on the population and economy of the European Union: the post-economic crisis period, the Covid pandemic (2020-2022) and the war in Ukraine (from 2022).

The analysis will use the graphical method to assess the main factors of population ageing and their influence on the economy. In addition, Pearson statistical correlation was used to assess the relationships between indicators. The main objective is to identify the degree to which these factors influence the economy of EU countries.

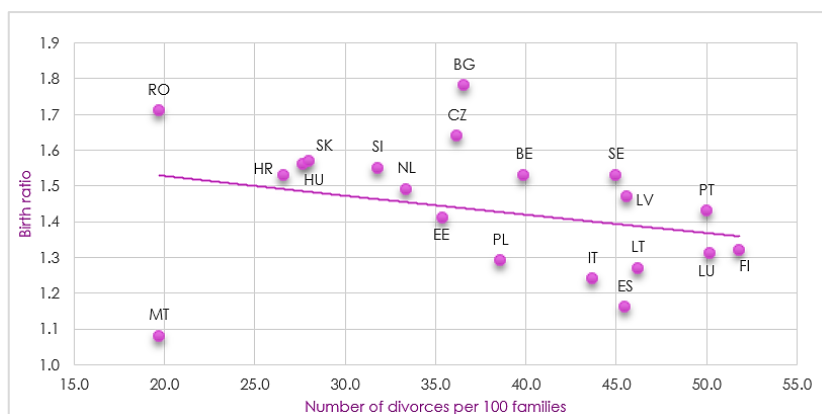
In this regard, I will assess the reaction of GDP per capita measured in purchasing power standard (PPS) and pension expenditure to the variation of demographic indicators, such as life expectancy and the dependency ratio of the elderly population. In order to achieve the most accurate and objective analysis, other specific indicators will be used, such as: the divorce ratio, the birth ratio, but also Eurostat projections regarding the dependency ratio of the population.

4. Results and interpretations

Within this section, several data series on the demography of the European Union and the influence of various factors of population ageing on GDP per capita (expressed in purchasing power standard) were analysed and interpreted.

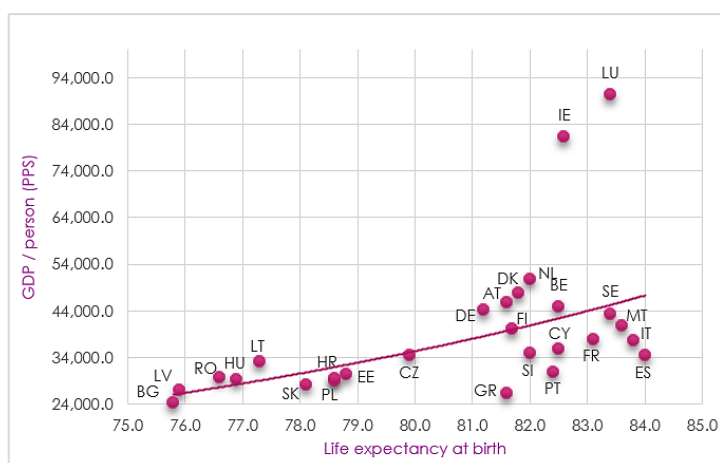
One of the causes of population ageing is the low birth ratio (number of live births per woman) compared to the natural replacement ratio. Data recorded for 2022 for 20 European Union countries for which data were available were analysed. An average birth ratio in the EU of 1.46 live births per woman is observed, with the lowest birth ratios being recorded in Malta, Spain, Italy and Lithuania (values below 1.3 live births per woman), while the highest are recorded in Bulgaria, Romania, Czech Republic (values above 1.6 live births per woman). One of the factors that exercise an important impact on the birth ratio is the number of divorces. In 2022, a negative correlation of 31.28% was observed between the positioning of the Member States from the perspective of these indicators (for 1/3 of analysed countries, an unfavourable position regarding the birth ratio is associated with a higher position from the perspective of divorce ratio, which is also observed in *Figure 1*).

Figure 1. *The relationship between the divorce ratio and the birth ratio*



Source: own processing in Microsoft Office Excel, based on Eurostat data.

Figure 2. *The relationship between life expectancy at birth and GDP/place measured in PPS in EU*



Source: own processing in Microsoft Office Excel, based on Eurostat data/

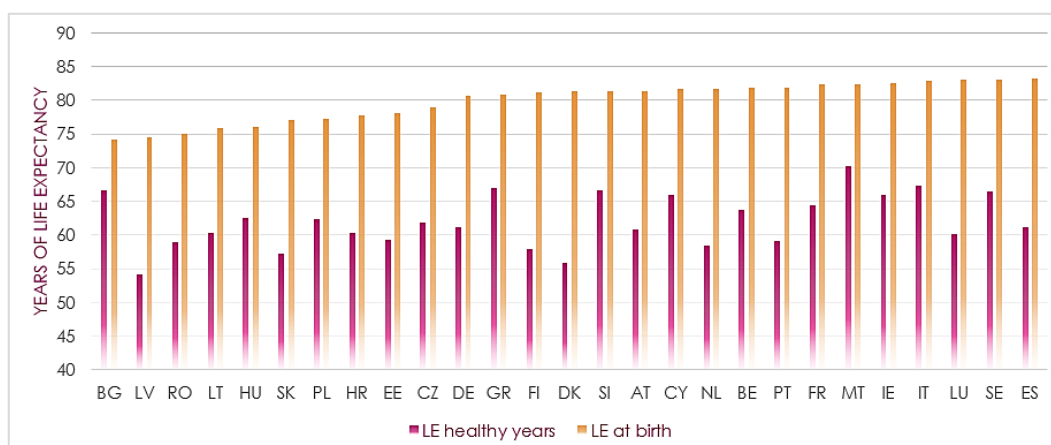
Another important factor for population ageing is increasing life expectancy. *Figure 2* presents the data recorded in 2023 in European Union regarding the life expectancy at birth and GDP per capita measured in purchasing power standard (PPS) and highlights a positive relationship between these.

The countries with the highest life expectancy but also with a high GDP per capita (measured in PPS) are Luxembourg and Ireland (countries with a life expectancy of over 81 years and a GDP per capita - PPS - of over 80,000 units/capita). At the opposite end are Bulgaria and Latvia with a life expectancy of just over 75 years and a GDP per capita of around 24,000 PPS units/capita. In Romania, life expectancy is 76.6 years, compared to the European Union where it stands at 81.5 years. According to the results, there is a positive correlation of 51.68% between the analysed indicators, in over half of the cases, the favorable positioning from the perspective of life expectancy being associated with a favorable positioning of GDP per capita (PPS), which reflects a positive relationship between life expectancy and the level of economic development.

In *Figure 3*, I compared the healthy life expectancy with life expectancy at birth for European Union countries using Eurostat data for 2022. The analysis revealed a gap (between the examined indicators) ranging from 7.5 years (Bulgaria) to 25.4 years (Denmark). Even if the results may appear counterintuitive, it is important to take into consideration the limits of the data, since in more developed countries, people may report health issues more frequently than those living in poorer countries.

In Romania, the healthy life expectancy is 59 years compared to the life expectancy at birth of 75.1 years, which reflects a gap of 16.1 years. This reveals a worse position of Romania compared to the EU-specific value (62.6 years for the healthy life expectancy and 80.6 years for the life expectancy at birth).

Figure 3. Life expectancy in the EU - 2022



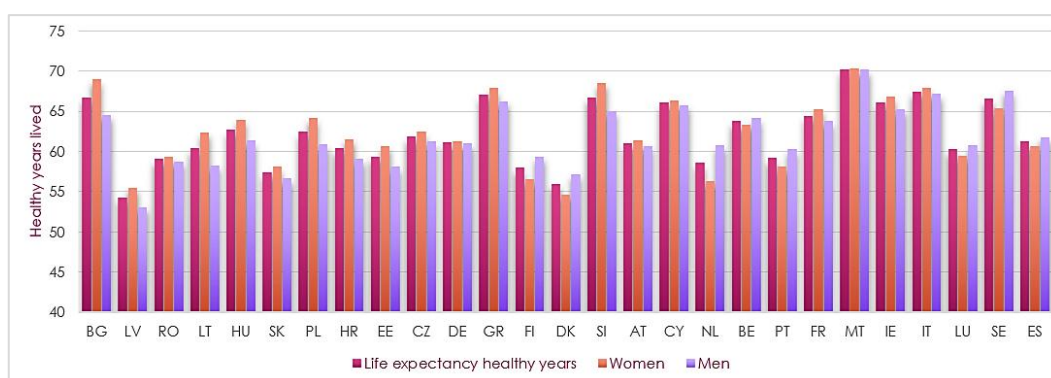
Source: own processing in Microsoft Office Excel, based on Eurostat data.

In order to adequately substantiate the analysis, the expectation of healthy years lived for women and men was also compared, using data for 2022 (*Figure 4*). The data show that in

two-thirds of the analysed countries, women live longer than men. The specific value for the European Union is 62.8 years for women and 62.4 years for men, while in Romania is 59.3 years for women and 58.7 years for men, which shows that women are more genetically resistant than men and less prone to risk factors (jobs, alcohol, tobacco).

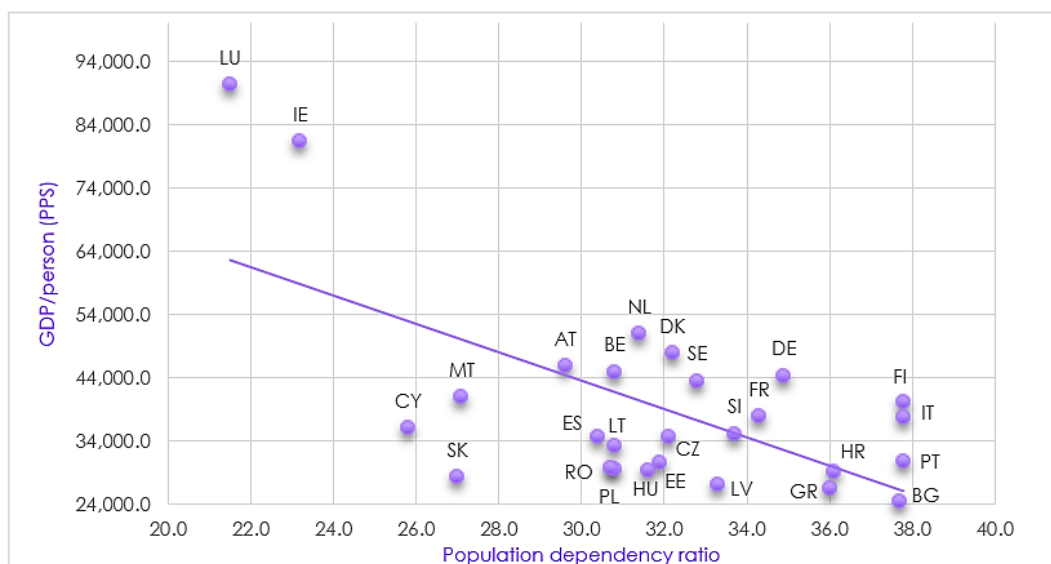
In addition, I analysed the dependency ratio data (the percentage of the population aged over 65 in the population aged between 15-64) for 2023, while examining the correlation with the GDP per capita (PPS) for each country (Figure 5).

Figure 4. Expected healthy years lived by gender – 2022



Source: own processing in Microsoft Office Excel, based on Eurostat data

Figure 5. Relationship between population dependency ratio and GDP/capita (PPS) in the EU (2023)

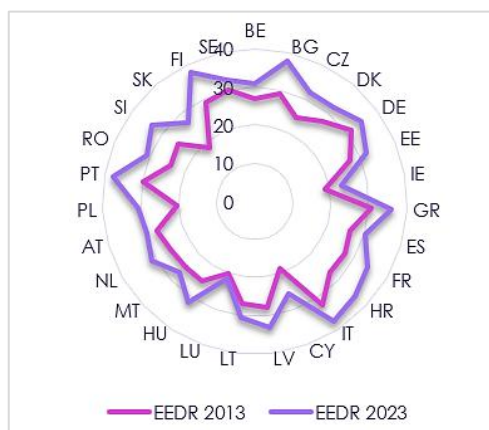


Source: own processing in Microsoft Office Excel, based on Eurostat data

The lowest population dependency ratio was recorded in Luxembourg (21.5%) and Ireland (23.2%), with a GDP per capita expressed in PPS of 90,308.8 PPS units/capita (LU) and 81,217.60 PPS units/capita (IE). At the opposite are Italy, Portugal, and Finland with a

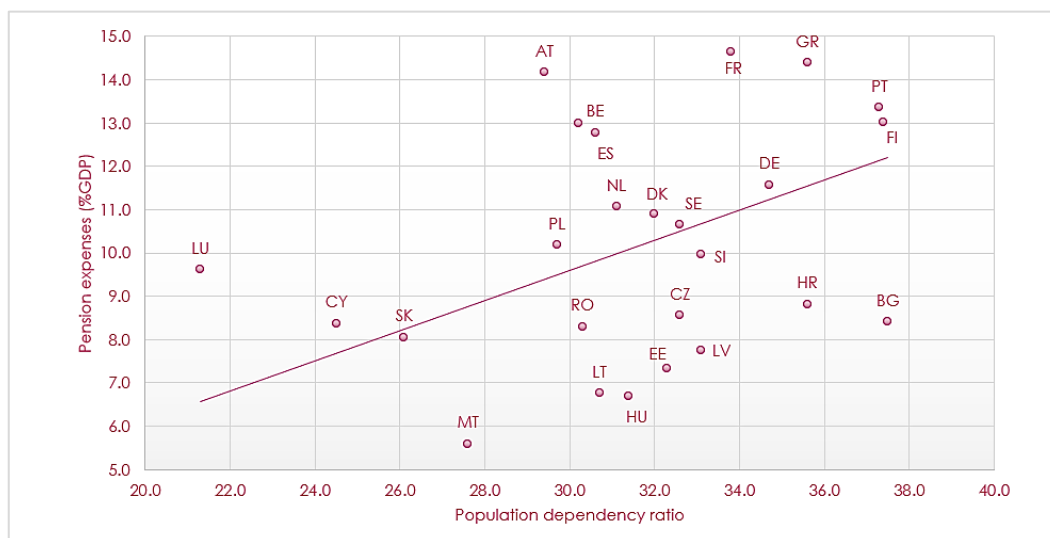
dependency ratio of 37.8% (with a GDP per capita expressed in PPS of over 30,000 PPS units/capita) and Bulgaria with 37.7% (with a GDP per capita expressed in PPS of 24,335.70 PPS units/capita). The specific value for the European Union is 33.4% (with a GDP per capita expressed in PPS of 38,132.0 PPS units/capita), while in Romania the dependency ratio reached 30.7% in 2023 (with a GDP per capita expressed in PPS of 29,694.4 PPS units/capita). The correlation between the positions of the Member States from the perspective of the two indicators shows a negative relationship, where a lower dependency ratio is associated with a higher GDP per capita expressed in PPS in 62.91% of cases.

Figure 6. Evolution of the elderly dependency ratio over the period 2013 – 2023 in the EU Member States



Source: own processing in Microsoft Office Excel, based on Eurostat data

Figure 7. Relationship between population dependency ratio and pension expenditure (% of GDP) in the EU (2022)



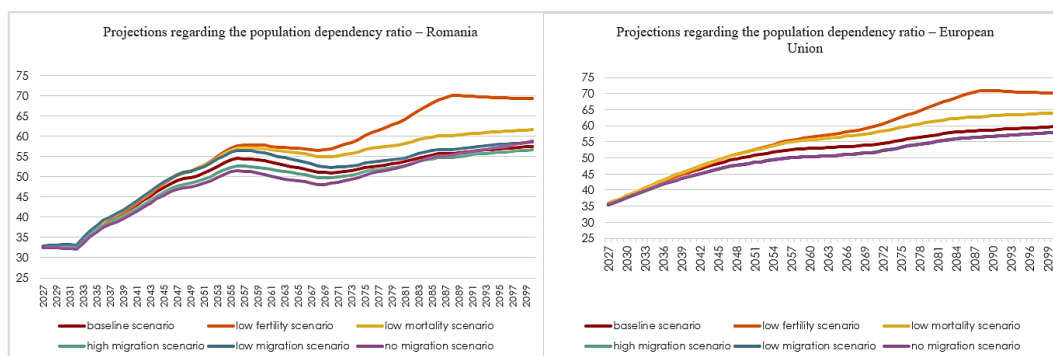
Source: own processing in Microsoft Office Excel, based on Eurostat data

The evolution of the dependency ratio over the period 2013-2023 (*Figure 6*) shows an increase is observed in all Member States, with the highest increase being recorded in Poland (+10.4 percentage points) and the lowest in Luxembourg (+1.3 percentage points). The increase in the dependency ratio puts a high pressure on public finances and on the increase in pension expenditure (% GDP). In this context, *Figure 7* highlights the positive relationship between the positions of the Member States found in 2022 from the perspective of dependency ratio and that of the pension expenditure as a percentage of GDP.

The data show that the high dependency ratios are associated with high levels of pension expenditure (% of GDP) in 49.74% of the analysed cases. The country with the lowest percentage of GDP allocated to pension expenditure is Ireland (3.87%), which has a population dependency ratio of 23%, while the highest allocation of GDP to pensions is found in Italy (15.49%) with a dependency ratio of 37.5% (along with Bulgaria being the country with the highest dependency ratio in 2022). However, even if demographic pressures are also observable in Romania, the risks are lower compared to those specific to other EU countries. To this end, in 2022, pensions expenditure reached 8.3% of GDP in Romania (compared to the EU value of 12.27% of GDP), while dependency ratio was 2.8 percentage points lower than the EU value (30.3% vs 33.1%).

Additional data were extracted from Eurostat to support the examination of the demographic outlooks (forecasts on dependency ratio) up to 2100, both for Romania and for the European Union (*Figure 8*). These forecasts have as a starting point 6 hypothetical scenarios: a baseline scenario in which there are no policy changes, a scenario with a low birth ratio, a scenario with a low death ratio, a scenario with a high migration ratio, a scenario with a low migration ratio and a scenario reflecting the absence of migration. In all scenarios, an upward trend in the dependency ratio is observed over time, with a more pronounced increase until 2050, after which the growth rate gradually approaches to zero.

Figure 8. Projections regarding the population dependency ratio in the European Union and Romania – time horizon 2100



Source: own processing in Microsoft Office Excel, based on Eurostat data

It is worth noting that the dependency ratio, both in Romania and in the EU, starts at around 35% currently and peaks at approximately 65% by the end of the forecast horizon, although in Romania the trend is slightly more oscillatory. A dependency ratio of 65% is a worrying prospect, both for Romania and for all the Member States of the European Union, because

it means a huge pressure on the sustainability of public finances, which will exert negative effects on future generations. This can only be mitigated if policymakers promote and adopt policies that encourage active ageing and improve the quality of the health system, while addressing other demographic challenges through increasing the birth ratio.

5. Conclusions

Population ageing is the result of the interference of several factors that can be managed through fiscal, social or demographic policies so that the impact on the economy is positive.

The birth ratio is negatively influenced by the divorce ratio due to the reduction in the number of marriages, and in this regard it is worth mentioning that the divorce ratio is higher and the birth ratio lower in Western countries where the emphasis is on increasing the standard of living and on professional achievement to the detriment of the traditional family. In this context, for the modern woman, childbirth is an option that depends on the level of information, education, religion, health, age and, last but not least, income, the number of children compared to the adult population being on a downward trend. Budgetary allocations for birth ratio increase programs can be sustainable in the long term in terms of preparing future young people for a faster integration into the labour market.

The increase in purchasing power has positively influenced life expectancy, with a sustainable economy being able to more easily bear the costs generated by ageing. In this respect, the analysis confirmed the positive relationship between life expectancy and the level of economic development measured by GDP per capita (PPS). The difference between life expectancy at birth (80.6 years for 2022 in the EU) and the healthy life expectancy (62.6 years) has a significant impact on the public finances of countries. The cost of pensions and healthcare for an ageing population, against the background of an increase in the population dependency ratio, can affect fiscal sustainability, the positive relationship between the population dependency ratio and pension expenditure (% of GDP) also being confirmed in the analysis carried out.

In addition, the paper highlights that the difference between life expectancy at birth and that expressed in healthy years lived is greater in the case of Member States with a higher GDP/capita (PPS), which benefit from better living conditions and medical services. Even if, from country to country, the expectation of healthy years lived is different, a small difference (on average 6 months) is observed between men and women in the same country, in favor of women. It is worth noting that the active period (15-65 years) is difficult to extend in many countries because it significantly exceeds the expectation of healthy years lived (in Romania the retirement age is 65 years, and the expectation of healthy years lived is 59 years).

The dependency ratio has increased in all Member States, the trend being maintained in the long-term forecasts. Following the hypothetical scenarios that formed the basis for building the population dependency ratio forecasts for both Romania and the European Union, an increase in the dependency ratio is expected starting with 2032 once the so-called baby-boomer generation (the generation born between 1960 and 1970) will retire. The increase

will be maintained until around 2050 when the growth ratio will be lower. Starting with 2050, the forecasts show differences between the scenarios, the effects of the birth ratio decrease being reflected more strongly.

Demography has been, is and will be a permanent challenge for the world economy. The way people live, how long they live, where they live, and how they live has major implications for macroeconomic indicators. Age, number of children, standard of living are variables that governments and companies must take into account both in budgetary policy and in the design of development policies.

References

- Acemoglu, D., and Restrepo, P. (2017). Secular stagnation? The Effect of Aging on Economic Growth in the Age of Automation. *American Economic Review*, 107(5), 174-179.
- Aiyar, S., and Ebeke, C.H. (2016). The Impact of Workforce Aging on European Productivity. *International Monetary Fund Working Papers*. 16/238, 4-8.
- Bodnár, K., and Nerlich, C. (2022). The Macroeconomic and Fiscal Impact of Population Ageing European Central Bank. *ECB Occasional Paper Series*, No. 296, 26-29.
- Börsch-Supan, A., and Weiss, M. (2016). Productivity and Age: Evidence from Work Teams at the Assembly Line. *The Journal of the Economics of Ageing*, 7 (C), 30-42.
- National Research Council. (2012). Aging and the Macroeconomy: Long-Term Implications of an Older Population. *The National Academies Press*. 16.
- Crowe, D., Haas, J., Millot, V., Rawdanowicz, L., and Turban, S. (2022). Population Ageing and Government Revenue: Expected Trends and Policy Considerations to Boost Revenue Economics. *Department Working Papers*, 1737, 6-33.
- European Commission. (2024). 2024 Aging Report: Economic and Budgetary Projections for the EU Member States (2022-2070). IP/23/279, 312-314.
- Eurostat. (2025). Eurostat Database [online], available at: <<https://ec.europa.eu/eurostat>>
- Feyer, J. (2007, 2008). Demographics and productivity. *The Review of Economics and Statistics*, 89(1), 100-109.
- International Labor Organization. (2020). Statistics on the Working-Age Population and Labor Force.
- Liu, B., and Yang, Z. (2018). Population Aging Shock and Fiscal Sustainability in China: Mechanism Analysis and Effect Simulation. *The Singapore Economic Review*, 66(06), 1687-1708.
- Liu, Y., and Westlius, N.J. (2016). The Impact of Demographics on Productivity and Inflation in Japan. *International Monetary Fund Working Papers*, 8(02).
- Nerlich, C., and Schroth, J. (2018). The Economic Impact of Population Ageing and Pension Reforms. *Economic Bulletin Articles*, 2, 89-94.
- Siliverstovs, B., Kholodilin, K.A., and Thiessen, U. (2011). Does Aging Influence Structural Change? *Economic Systems*, 35(2), 244-260.
- Van den Berg, T., Schuring, M., Avendano, M., Mackenbach, J., and Burdorf, A. (2010). The Impact of Ill Health on Exit from Paid Employment in Europe Among Older Workers. *Occupational and Environmental Medicine*, 67(12), 845-852.
- Werdinger, M. (2008). Ageing and Productivity Growth: Are There Macro-Level Cohort Effects of Human Capital? *CESifo Working Paper Series*. 2207.

Pensions under pressure: economic and demographic drivers of Romania's public retirement system

Mădălina-Gabriela ANGHEL

Romanian Academy, Institute of National Economy, Romania
"Artifex" University of Bucharest, Romania
madalinagabriela_anghel@yahoo.com

Elena IONIȚĂ

National University of Science and Technology POLITEHNICA Romania
elena.ionita@upb.ro

Abstract. *The paper explores recent and long-term developments in the public pension system in Romania, analyzing both the dynamics of the number of pensioners and the average pension, as well as their relationship with indicators of poverty and social exclusion. The approach combines descriptive statistical analysis with an econometric perspective, with the main objective of identifying the main trends and determinants of the sustainability and adequacy of pensions. Although the nominal increases in the average pension seem consistent, the research highlights that they are not reflected in an immediate improvement in the standard of living for the elderly. The comparison between the evolution of pensions and the relative poverty threshold shows that a significant part of pensioners remains exposed to the risk of economic vulnerability, which raises essential questions regarding the efficiency of public policies in the field of social protection. The comparative analysis at the European level highlights significant differences between Romania and other European Union Member States. While in some Western countries social protection levels ensure a high degree of economic security for the elderly population, in Central and Eastern Europe much higher rates of poverty risk persist among pensioners, creating a picture marked by structural inequalities and disparities. The results obtained confirm the importance of correlating pension policies with macroeconomic dynamics and social inclusion indicators. They also highlight the need for reforms that target not only the financial sustainability of the system, but also the adequacy of benefits, so that they effectively contribute to reducing poverty and increasing the quality of life among the elderly population.*

Keywords: public pension, intergenerational equity, relative poverty threshold, demographic pressure, salary earnings.

JEL Classification: H55, J11, J26.

Introduction

The issue of public pensions is one of the central themes of social and economic policies in Romania, with direct implications for the financial sustainability of the system, but also for the living standards of the elderly. In a context marked by profound demographic changes – population aging, declining birth rates and migration – and economic volatility, the public pension system faces complex challenges that require a rigorous analysis of the main determinants.

This paper investigates developments within the public pension system in Romania, with a focus on the average state social insurance pension, the total number of pensioners and the ratio between the average pension and the average gross salary, during the period 1996-2024. The focus is placed both on recent trends, from the period 2022-2024, and on long-term dynamics, which reflect the structural transformations of the system and changes in its fundamental indicators.

The analysis proposes a dual approach. On the one hand, descriptive statistical methods are used to capture general trends, differences by pension category and territorial disparities at county level. On the other hand, the research is consolidated by applying a multiple linear regression model for the period 2014-2024, which allows estimating the relative effects of some essential macroeconomic variables, such as the average gross salary, inflation and the dynamics of the pensioner population, on the level of the average pension.

In this framework, the research formulates two working hypotheses:

- H1. The average pension in Romania does not uniformly ensure a decent living for pensioners, a significant part of whom remain below the relative poverty threshold.
- H2. The increase in the average gross salary determines the increase in the average pension, reflecting the indexation mechanism and the direct correlation between the dynamics of salary income and the level of social benefits.

By combining descriptive statistical analysis with econometric tools, the study aims to provide a robust framework for assessing the structural and macroeconomic determinants of the public pension system, revealing the short, medium and long-term implications, as well as the intergenerational equity challenges that define the current social protection model in Romania.

Literature review

Akyol and Atalay (2025) conducted a study on a pension reform in Australia, showing that raising the eligibility age by seven years reduced the availability of grandparents to provide informal care for grandchildren, which led to a decrease in the fertility rate of their daughters, highlighting the intergenerational impact of pension policies on reproductive decisions. Andersen et al (2021) highlighted that the early retirement reform in Norway increased the labor supply of the elderly, but amplified income inequality. Anghel and Ioniță (2025) showed that the employment of the elderly reduces the number of pensioners,

and the demographic effects in Romania are contradictory, which calls for integrated policies for the sustainability of the pension system. Anghelache and Anghel (2017) highlighted inequalities in income distribution and the risk of poverty across Member States, through monetary and non-monetary indicators, and stressed the need for strong social inclusion measures, focusing on the situation in Romania. Blundell (2023) shows that poor health explains up to 15% of the decline in employment between 50 and 70 years old, with stronger effects on the less educated. Börsch-Supan et al (2023) analysed the trade-offs between the financial and social sustainability of pension reforms, highlighting their uneven effects on welfare and intergenerational equity and explaining why public support for these reforms has declined in Europe. Cho and Lee (2025) considered that the impact of population ageing on pensions increases with decreasing government efficiency, and better governance supports the sustainability of pension systems. Choi et al (2024) argued that while access to and quality of healthcare services have increased longevity and reduced years of life lost, the number of years lived with ill health has increased, requiring health systems to adapt to the needs of an ageing population. Díaz-Giménez and Díaz-Saavedra (2025) highlighted that the sustainability of pensions in Europe is threatened by a failure to adapt to long-term demographic trends, but well-designed reforms of PAYG systems can improve pension design and bring benefits to all without the risk of short-term political losses. He et al (2021) analysed the optimal contribution rate for PAYGO pensions, showing how the age and political influence of older cohorts affect preferences and contribution adjustments. Hernæs et al (2024) studied the Norwegian early retirement reform, concluding that work incentives and more flexible access to pensions increased employment and reduced participation in disability programs. Kitamura and Nakashima (2025) highlighted that financial incentives, in the form of pension increases or offers of short-term personal insurance, provided in Japan can postpone the time of claiming public benefits, highlighting significant differences between individuals. Kudrna et al (2019) studied the impact of pension cuts versus the effect of tax increases, in order to finance aging-related expenditures, highlighting different effects on welfare and preferences of generations. Kuitto et al (2021) analyzed the role of public pensions in reducing the risk of poverty in old age, emphasizing that income-based systems are effective, but do not significantly help the most disadvantaged pensioners. Möwisch et al (2023) showed that active time use increases well-being in older people, and that education and income levels influence how active they remain, even into very old age. Peng and Fan (2025) analyzed optimal investment strategies in DC pensions and found that access to information increases investment in stocks, but that a minimum guarantee requirement reduces this effect. Schmidhuber et al (2021) showed that labor and pension policies have led to an increase in the retirement age, with visible gender differences in Austria and inequalities related to education in Germany. Scott (2023) considered that increasing life expectancy requires adapting economic behaviors and policies to ensure well-being in a longer-living society. Waddell et al (2025) considered that the term "successful ageing" should be replaced by "ageing well" and stressed the need for a clear and inclusive definition to more effectively support healthy ageing.

Research methodology

To achieve the proposed objectives, the research uses complementary statistical and econometric methods.

The structure of the empirical analysis follows a gradual logic, intended to capture both the current situation of pensioners in Romania, as well as long-term developments and the causal mechanisms that explain these trends. Deliberately, the order of the periods analyzed is not strictly chronological, but a functional one, built to meet the research objectives.

Thus, the analysis begins with the period 2022-2024, selected for its immediate relevance in relation to the central issue of the study: the level of pensions and the risk of poverty among the elderly. This period reflects the impact of the most recent social policies and the macroeconomic context marked by high inflation, being essential to outline the current picture of social vulnerabilities.

Subsequently, the study is extended to the period 1996-2024, divided into distinct sub-periods, in order to follow the evolution of the pension system in the long term, in correlation with the post-socialist transition, European integration and the stages of economic convergence. This stage of the analysis has the role of highlighting the structural dynamics of the relationship between pensions, salaries and demography, as well as the main breaks or changes in trends.

Finally, in order to capture the causal relationships between the relevant socio-economic indicators, an econometric model is estimated for the period 2014-2024. The choice of this interval is justified by the availability and comparability of statistical data, but also by the need to capture the relationships within a recent period, characterized by significant transformations in income policies and the labor market. The regression model thus offers an additional quantitative interpretation, complementary to the descriptive analysis, regarding the impact of salaries, the number of pensioners and inflation on the level of pensions.

Therefore, this “stepped” structure allows for a coherent articulation between the current situation, the overall long-term evolution and the econometric explanations of the phenomenon, which strengthens both the social relevance and the scientific robustness of the study.

A comparative analysis is carried out between years and pension categories, also highlighting the territorial gaps between counties.

The econometric analysis is based on a linear multiple regression model, applied for the period 2014-2024, which examines the average state social insurance pension as a dependent variable, in relation to the selected macroeconomic variables. This approach allows capturing recent relationships between economic and demographic indicators and the level of pensions, without being influenced by very old historical values. The choice of the average gross salary is justified by the fact that contributions to the public pension system (CAS) are calculated and paid from the gross income of employees, and their level directly influences the funds available for the payment of pensions. Thus, the average gross salary is the most relevant economic indicator for assessing the financial resources of the

system and for analyzing the relationship between labor income and social benefits. The use of net salary or other income indicators would not adequately reflect the pension financing mechanism and the structural link between salaries and pension levels.

The data source is the National Institute of Statistics, through press releases and the TEMPO online database, as well as Eurostat, thus ensuring official character and statistical relevance.

Data, results and discussions

▪ *Recent dynamics of the average number of pensioners and the average monthly pension in Romania (2022-2024)*

Table no. 1 presents the average values regarding the average number of pensioners and the average monthly pension recorded in the recent period 2022-2024. Choosing a series of three consecutive years allows the identification of recent trends and provides a clear picture of the short and medium-term evolution, essential for assessing the sustainability of the public pension budget. The analysis for this recent period focuses on the relationship between the average pension and the poverty threshold. This approach allows highlighting the immediate effects of pension indexation policies and adjustments related to salary increases. Comparing the average pension values with the poverty threshold provides a clear picture of the real capacity of the system to ensure minimum social protection, as well as the socio-economic impact of recent increases in the context of inflation and legislative changes.

To determine the average monthly pension, the amounts paid to all categories of pensioners through all pension funds in Romania are taken into account, namely: the National House of Public Pensions, the Ministry of National Defense, the Ministry of Internal Affairs, the Romanian Intelligence Service, the State Secretariat for Religions and the Lawyers' Insurance House. It is important to emphasize that the majority of pensioners are included in the state social insurance system, which gives statistical and practical relevance to the analysis of this segment.

Table no. 1. *Average number of pensioners and average monthly pension in Romania, 2022-2024*

	Average number of pensioners (thousands of people)			Average monthly pension (lei)		
	2022	2023	2024	2022	2023	2024
Total	5004	4980	4959	1855	2113	2580
of which, by retirement system:						
Social insurance,	5003	4980	4959	1855	2113	2581
of which, state social insurance	4607	4601	4590	1775	2006	2459
of which, social insurance by pension categories:						
- Retirement age	3984	3982	3976	2061	2346	2864
- Early retirement	9	7	5	2480	2828	3405
- Partial early retirement	102	102	102	2108	2522	3200
- Disability	409	402	397	815	888	1041
- Survivor	499	487	479	996	1127	1362

Source: National Institute of Statistics, Press Releases no. 75/29 March 2024 and no. 74/28 March 2025, authors' systematization.

The data analysis indicates that the average number of pensioners has decreased slightly, from 5,004 thousand in 2022 to 4,959 thousand in 2024, reflecting both demographic effects, such as population aging, declining birth rates, and recent policies regarding the retirement age. This decrease is also observable within the state social insurance system, where the number of pensioners has decreased from 4,607 thousand in 2022 to 4,590 thousand in 2024. According to data published by the National Institute of Statistics, during the period 2022-2024, the ratio between the average number of state social insurance pensioners and that of employees stabilized at 0.8 (equivalent to 8 pensioners to 10 employees), without variations during the three years analyzed. By comparison, in 2021 this indicator recorded a higher value of 0.9 (9 pensioners per 10 employees), which reflects a slight improvement in the ratio between the employed and retired population starting with 2022. This evolution suggests a tendency to alleviate the pressure exerted on the public pension system. The average monthly pension increased from 1,855 lei in 2022 to 2,580 lei in 2024 (+39.1%), with increases in all pension categories. Thus, old-age pensions increased from 2,061 lei in 2022 to 2,864 lei in 2024, early pensions from 2,480 lei to 3,405 lei, and partially early pensions from 2,108 lei to 3,200 lei. The average disability pension increased from 815 lei to 1,041 lei, and survivors' pensions from 996 lei to 1,362 lei. This evolution reflects both legislative adjustments and government policies to increase the pension point.

Overall, the three-year series allows the observation of recent trends, characterized by a slight decrease in the number of pensioners and increases in average pensions, highlighting both the pressure on the pension budget and the efforts to maintain the purchasing power of pensioners. This analysis provides an empirical framework for evaluating social policies and the sustainability of the public pension system in the short and medium term.

Over the entire analyzed period, the lowest average monthly state social insurance pension was recorded in Botoșani (948 lei in 2022, 1588 lei in 2023 and 1946 lei in 2024), and the highest in Hunedoara (2357 lei in 2022, 2667 lei in 2023 and 3197 lei in 2024). During the same period, Bucharest Municipality consistently ranked second, with 2250 lei in 2022, 2545 lei in 2023 and 3115 lei in 2024. Also, territorial gaps were pronounced, the gap between the county with the minimum and the maximum value of the average monthly pension increasing from 948 lei in 2022, to 1079 lei in 2023 and 1251 lei in 2024, which highlights the increasing regional inequalities in terms of pensioner income.

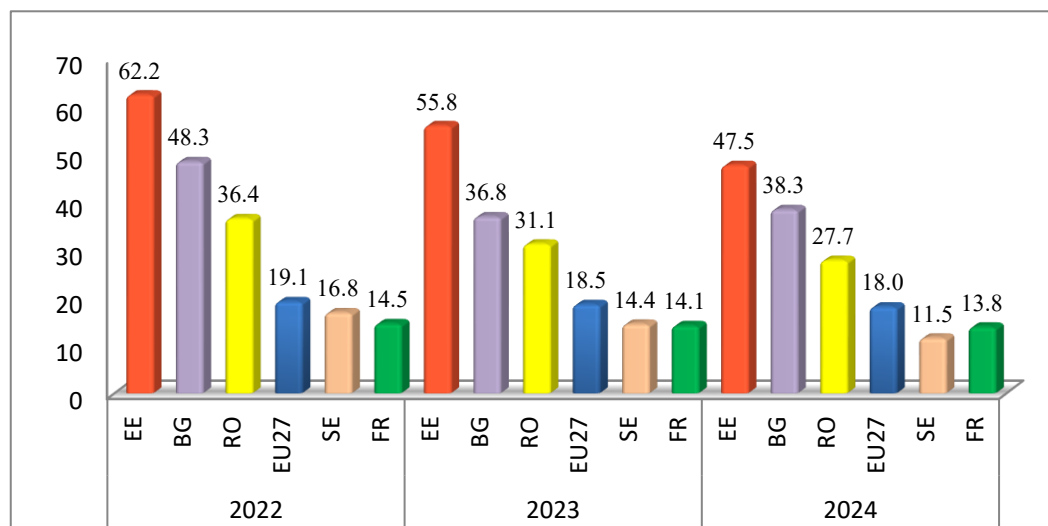
Although, at first glance, the percentage increases in the average monthly pension within the state social insurance system seem to be consistent, careful analysis raises the fundamental question of whether these increases are sufficient to ensure a decent living for pensioners. In this regard, simply highlighting the percentage increases does not provide a complete picture of the standard of living of the elderly; it is necessary to compare the value of the average pension with the relative poverty threshold, which is a recognized indicator for assessing minimum living conditions.

In Romania, during the analyzed period, the relative poverty threshold evolved as follows: 16,278 lei/person/year in 2022, 19,433 lei/person/year in 2023 and 23,262 lei/person/year in 2024. This implies that pensioners who received monthly pensions below 1,356.5 lei in

2022, 1,619.4 lei in 2023 and 1,938.5 lei in 2024 are below the relative poverty threshold and can be considered persons at risk of poverty.

This situation means that, despite nominal increases in pensions, a large part of the elderly population remains economically vulnerable. The comparative analysis between the average pension and the relative poverty threshold shows that percentage increases do not automatically reflect increased purchasing power and the achievement of a comfortable standard of living, which emphasizes the need for public policies aimed at ensuring the sustainability and adequacy of pensions, especially for vulnerable categories.

Figure no. 1. Retired persons at risk of poverty or social exclusion, age class 65 years or over, in Romania, compared to the EU and some selected member states, during the period 2022-2024 (%)



Source: authors' representation based on Eurostat data, Persons at risk of poverty or social exclusion. Statistics Explained, accessed 25 August 2025.

In Romania, in 2022, 36.4% of pensioners aged 65 or over were at risk of poverty, a very high percentage compared to the European average of 19.1%. In 2023, this indicator decreased to 31.1%, suggesting an improvement in the situation, although the level remains almost double the EU27 average (18.5%). The downward trend continued in 2024, when the percentage of pensioners aged 65 or over at risk of poverty reached 27.7%, indicating a positive evolution, but the level remains significantly above the European average of 18.0%. Within the EU27, the values reflecting the proportion of pensioners at risk of poverty are almost two times lower than those recorded in Romania.

Looking at other relevant European references, Bulgaria has a very high level of pensioners aged 65 or over at risk of poverty, with 48.3% in 2022, 36.8% in 2023 and 38.3% in 2024, characterised by greater fluctuations. Estonia has the highest values in the European Union, with 62.2% in 2022, 55.8% in 2023 and 47.5% in 2024, however showing a downward trend. Lower percentages, below the EU27 average, were recorded in France (between 14.5% in 2022 and 13.8% in 2024) or Sweden (11.5% in 2024).

In conclusion, during the years 2022-2024, Romania consistently presented a poverty level among pensioners aged 65 or over much higher than the EU27 average. However, a gradual decreasing trend in the percentage can be noted, indicating a slow improvement in the situation. Comparatively, the Nordic and Western European countries record much lower rates, below the European average, reflecting more effective social protection for pensioners. In contrast, in Eastern Europe, fluctuations are more pronounced, and in some states, such as Estonia and Bulgaria, the level remains extremely high, highlighting considerable inequalities within the European Union.

▪ *Longitudinal analysis of the main statistical indicators regarding the public pension system in Romania (1996-2024))*

Table 2 presents an extended series for the period 1996-2024, covering a long period, including several historical stages and significant reforms of the pension system. The aim is to identify long-term trends and assess how legislative changes, economic crises and labor market developments have influenced the level of pensions and their correlation with salaries. The period is analyzed in relevant sub-stages, which allows for a detailed examination of the effects of different policies and a comparison of the system's performance over time. Indicators such as the average state social insurance pension, the number of pensioners and the average gross salary earning are analyzed, along with the ratio of average state social security pension to average gross salary earnings, an essential indicator for assessing the equity and sustainability of the public pension system.

Table no. 2. *Key statistical indicators regarding the public pension system in Romania, during the period 1996-2024*

Year	Average state social security pension		Average gross salary earnings		State social security pensioners		AV_AGSE ratio (%)**
	lei	Δ(%)*	lei	Δ(%)*	thousand people	Δ(%)*	
1996	123988	-	426038	-	3652	-	29.10
1997	254917	105.60	843316	97.94	3782	3.56	30.23
1998	388228	52.30	1318605	56.36	3924	3.75	29.44
1999	669777	72.52	1921754	45.74	4074	3.82	34.85
2000	911321	36.06	2840449	47.81	4246	4.22	32.08
2001	1305119	43.21	4220357	48.58	4426	4.24	30.92
2002	1634945	25.27	5320559	26.07	4535	2.46	30.73
2003	1870402	14.40	6637868	24.76	4570	0.77	28.18
2004	2321110	24.10	8183317	23.28	4597	0.59	28.36
2005	267	15.09	968	18.34	4611	0.30	27.58
2006	311	16.48	1146	18.39	4633	0.48	27.14
2007	399	28.30	1396	21.82	4643	0.22	28.58
2008	593	48.62	1761	26.15	4664	0.45	33.67
2009	711	19.90	1845	4.77	4718	1.16	38.54
2010	739	3.94	1902	3.09	4767	1.04	38.85
2011	773	4.60	1980	4.10	4744	-0.48	39.04
2012	778	0.65	2063	4.19	4702	-0.89	37.71
2013	809	3.98	2163	4.85	4681	-0.45	37.40
2014	845	4.45	2328	7.63	4682	0.02	36.30
2015	886	4.85	2555	9.75	4683	0.02	34.68
2016	931	5.08	2809	9.94	4678	-0.11	33.14
2017	1026	10.20	3223	14.74	4678	0.00	31.83
2018	1126	9.75	4357	35.18	4684	0.13	25.84
2019	1247	10.75	4853	11.38	4672	-0.26	25.70
2020	1450	16.28	5213	7.42	4675	0.06	27.82
2021	1602	10.48	5535	6.18	4654	-0.45	28.94

Year	Average state social security pension		Average gross salary earnings		State social security pensioners		AV_AGSE ratio (%)**
	lei	$\Delta(\%)^*$	lei	$\Delta(\%)^*$	thousand people	$\Delta(\%)^*$	
2022	1775	10.80	6126	10.68	4607	-1.01	28.97
2023	2006	13.01	7042	14.95	4601	-0.13	28.49
2024	2459	22.58	8508	20.82	4590	-0.24	28.90

Notes: for the year 2024, the value of the average gross salary indicator was estimated by the author, based on the average monthly values published by the National Institute of Statistics in the Press Releases during the period 2024-2025; * authors' calculations; $\Delta(\%)$ = change compared to the previous year, ** AV_AGSE ratio = Ratio of average state social security pension to average gross salary earnings.

Source: National Institute of Statistics, tempo online, accessed on August 23, 2025.

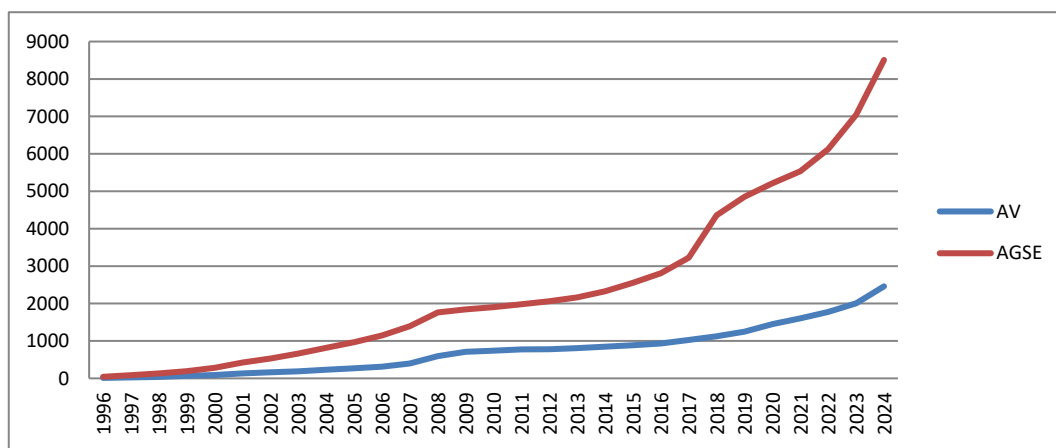
During the period 1996-2024, the average state social insurance pension, expressed in absolute values, recorded a spectacular increase, from 123,988 old lei (approximately 12 new lei) in 1996 to 2,459 lei in 2024, which means an increase of almost 200 times. This evolution was determined by the denomination of the national currency in 2005, the application of successive indexation mechanisms and the decisions to increase the pension point. However, the analysis of the growth rates compared to the previous year allows for a more complex interpretation, of a cyclical type, in which economic and social political factors are combined. Thus, between 1996 and 2001, pensions recorded very high annual increases, between 36% and 105%, amid the recovery of galloping inflation and the initial adjustment reforms, and the 105% jump in 1997 clearly reflects the accelerated indexations imposed by an inflation of over 150%. During the period 2002-2007, the growth rates moderated to 15-28%, with macroeconomic stabilization and the reduction of inflation, but these increases were lower than the salary increases, which led to a decrease in the pension/salary ratio to values of 27-29%. The 2008-2010 period saw two distinct phases: a strong increase in 2008 (+48.6%), followed by a drastic slowdown during the financial crisis, when pensions were protected, but their growth rate decreased to 3-20%. In 2011-2017, the dynamics were modest, with indexations of 0.6-10% annually, oriented more towards preserving the real value than towards significant increases. The period 2018-2020 brought an acceleration of the pace, between 10% and 16% annually, as a result of successive increases in the pension point, especially in 2019 and 2020. The period 2021-2024 was marked by new significant increases, reaching an advance of +22.6% in 2024, the result of post-pandemic inflationary pressures and government decisions to increase pensions.

The average gross salary increased from 426,038 old lei (approximately 43 new lei) in 1996 to 8,508 lei in 2024, which means an increase of about 200 times. This dynamics highlights a long-term convergence between the growth rate of salaries and pensions, even if there were significant temporary gaps. During the period 1996-2001, salaries recorded increases ranging between 45% and 98% annually, as a result of hyperinflation and the initial economic liberalization reforms. The interval 2002-2007 brought consistent rates, of 18-27% annually, but more moderate than in the 1990s, reflecting macroeconomic stabilization and Romania's preparation for accession to the European Union. The year 2008 marked a 26% increase, despite international turbulence, due to domestic salary policies. In contrast, between 2009 and 2013 there was a massive slowdown, with values below 5% annually in 2009-2011, reflecting the impact of the financial crisis and austerity

measures. The recovery took place during the period 2014-2017, when salaries increased by 7-15% annually, against the backdrop of economic expansion and fiscal easing. The year 2018 was marked by an explosive growth of 35.2%, driven by the transfer of social contributions from employer to employee and salary increases in the public sector. Between 2019 and 2024, salaries followed a moderate but constant pace of 7-21% annually, and in 2024 the estimated increase of 20.8% reflects both the impact of high inflation and union pressure for salary adjustments.

Figure 2 graphically represents the evolution of the average state social insurance pension and the average gross salary, recorded during the period under analysis.

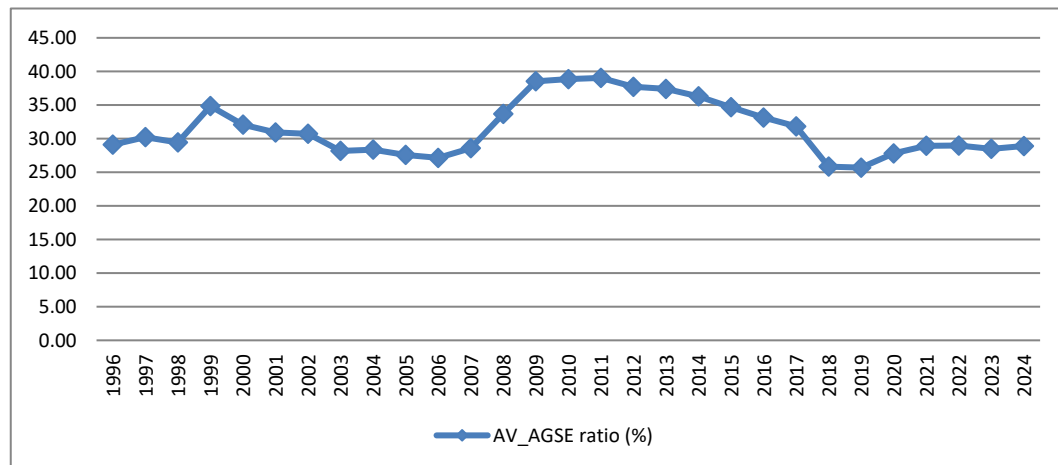
Figure no. 2. *Evolution of the average state social insurance pension and the average gross salary, during the period 1996-2024*



Source: authors' representation.

The number of pensioners initially increased from 3.65 million in 1996 to around 4.7 million in 2010-2014, after which it started to decline slightly, reaching 4.59 million in 2024. This evolution reflects both demographic changes, such as population ageing, declining birth rates and labour migration, and legislative reforms, in particular the increase in the retirement age. Between 1996 and 2001, the number of pensioners grew steadily, at an annual rate of 3.5-4.2%, due to the entry of the baby boomers into retirement. During the period 2002-2008, the growth rate slowed to less than 1% per year, indicating the reaching of a structural ceiling of around 4.6-4.7 million pensioners. During 2009-2010, there was a slight increase, reaching a maximum of 4.767 million in 2010, after which, between 2011 and 2024, the number of pensioners gradually decreased, by approximately -0.1% to -1% annually, to the level of 4.59 million in 2024. This decrease is determined by the combination of the increase in the retirement age, labor migration and the decrease in the birth rate recorded after 1990. Another important indicator that must be analyzed in the study of the public pension system is the ratio between the average state social insurance pension and the average gross salary, which measures the degree of replacement of salary income by pension and represents an essential indicator for assessing the sustainability and adequacy of the public pension system.

Figure no. 3. *Evolution of the ratio between the average state social security pension and the average gross salary*



Source: Authors' representation based on own calculations.

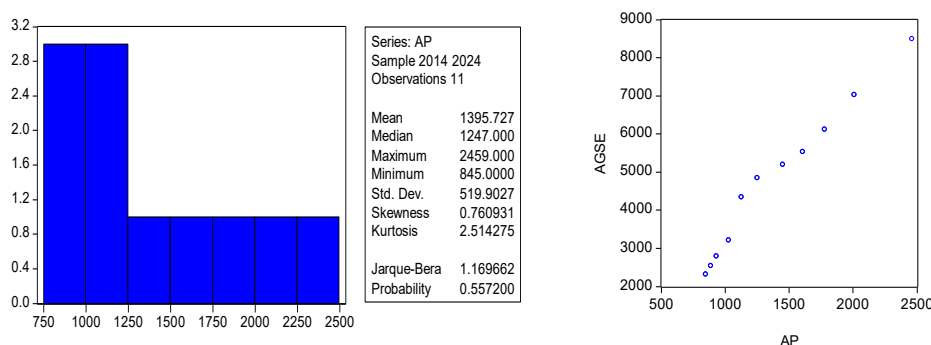
Between 1996 and 2002, the ratio of the average state social security pension to the average gross salary was relatively stable, ranging between 29% and 31%, with a peak of 34.9% in 1999, in the context of an economic crisis and high inflation, which eroded salaries more than pensions. Between 2003 and 2007, the ratio recorded a downward trend, oscillating between 27% and 29%, as a result of the accelerated growth of salaries determined by European integration and foreign investments, which exceeded the pace of pension increases. Between 2008 and 2014, this ratio was high, reaching highs of 38-39% in 2009-2011, due to social protection policies applied during the global financial crisis; During this period, pensions were better protected than salaries, which stagnated or even decreased, and during the austerity years, salaries grew slowly. In 2015-2017, there was a downward trend, from 33% to 32%, reflecting faster salary growth in the context of fiscal easing and economic expansion. In 2018-2019, the ratio reached a historical low of 25.7%, as a result of explosive salary increases following the transfer of social contributions and salary increases in the public sector, while pensions could not immediately keep up. Finally, in 2020-2024, the ratio stabilized around 28-29%, indicating a structural balance between income and pensions and maintaining pensions at just under a third of average gross earnings.

▪ *Econometric modeling of the interdependencies between the average state social insurance pension and the dynamics of some macroeconomic variables*

The period 2014-2024 is used to build a regression model aimed at measuring the quantitative relationship between the average state social insurance pension, considered as the dependent variable, and three independent variables: the average gross salary, the number of pensioners in the state social insurance system and the consumer price index of the population. In this sense, multiple regression is applied, which allows the simultaneous assessment of the influence of each variable on the average pension. This methodological step provides a clear picture of recent trends in salary earnings and demographic pressure,

focusing on current data and avoiding the inclusion of very old historical values, which could distort the interpretation of quantitative relationships in the recent context of the pension system.

Figure no. 4. Descriptive statistics of the variable "Average state social insurance pension"



Source: Authors' representation.

The histogram and descriptive statistics presented for the "AP" series (2014-2024) show that the average pension of pensioners in the state social insurance system has an average value of 1,395.7 lei, with a relatively large dispersion (standard deviation of 519.9), indicating significant variability between years. The distribution is positively skewed (skewness = 0.76), which suggests that there are years with higher values of the average pension that pull the average up. The kurtosis of 2.51 indicates a slightly platykurtic distribution, close to normality. The Jarque-Bera test (probability = 0.557) confirms that there is no statistical evidence to reject the hypothesis of the normality of the series, so the data can be considered approximately normally distributed.

The graphical representation of the data series on the average gross salary (AGSE) and the average state social insurance pension (AP) (Figure no. 4) in the form of a point cloud shows a clear positive relationship between the two variables. As AGSE increases, AP increases proportionally, and the points seem to align approximately on a straight line. This suggests that the use of a linear regression to model AP according to AGSE is justified.

In the analysis of the correlation between the four proposed variables, the following multiple linear regression model is used:

$$AP = x_0 + x_1 \times AGSE + x_2 \times NP + x_3 \times CPI + \varepsilon \quad (1)$$

where:

AP = average state social insurance pension;

AGSE = average gross salary earnings;

NP = number of pensioners in the state social insurance system;

CPI = consumer price index of the population (previous year = 100);

x_0, x_1, x_2, x_3 = parameters of the linear regression model;

ε = residual value of the regression model.

Table no. 3. *Estimation of regression model parameters by the least squares method*

Dependent Variable: AP
 Method: Least Squares
 Date: 08/24/25 Time: 13:05
 Sample: 2014 2024
 Included observations: 11

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	26352.56	5068.718	5.199058	0.0013
AGSE	0.199766	0.017012	11.74242	0.0000
NP	-5.215966	1.014965	-5.139059	0.0013
CPI	-15.65550	5.597666	-2.796790	0.0266
R-squared	0.993619	Mean dependent var		1395.727
Adjusted R-squared	0.990885	S.D. dependent var		519.9027
S.E. of regression	49.63695	Akaike info criterion		10.92264
Sum squared resid	17246.79	Schwarz criterion		11.06733
Log likelihood	-56.07450	F-statistic		363.3563
Durbin-Watson stat	1.880166	Prob(F-statistic)		0.000000

Source: Authors' representation.

$$AP = x_0 + 0.199766 \times AGSE - 5.215966 \times NP - 15.65550 \times CPI + \varepsilon \quad (2)$$

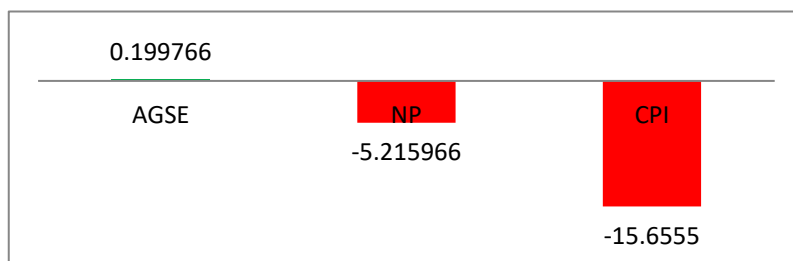
The results presented in Table no. 3 highlight a strong correlation between the variables included in the multiple linear regression model and the level of the average state social insurance pension (AP).

Thus, the coefficient associated with the average gross salary (AGSE) is positive and statistically significant ($p < 0.001$), which confirms the hypothesis that an increase in the average salary determines the increase in the average pension, given the indexation mechanism and the correlation of income from work with social benefits. An increase of 100 lei in the average gross salary leads to an increase of +20 lei in the average pension. It is the direct and strongest relationship (reflects the indexation and correlation of pensions with salaries).

In contrast, the coefficient related to the number of pensioners (NP) is negative and significant ($p < 0.01$), suggesting that an increase in the population in payment puts pressure on the sustainability of the system and tends to reduce the average pension, reflecting a wider distribution of available resources. An increase of 1,000 pensioners reduces the average pension by ~5 lei. The explanation: limited budgetary resources cause more beneficiaries to "dilute" the available fund.

At the same time, the consumer price index (CPI) also presents a negative and statistically significant effect ($p < 0.05$), which indicates that inflation erodes the real value of pensions, affecting the system's ability to maintain the purchasing power of beneficiaries. If prices increase by 1 pp, the real average pension decreases by 15 lei, which shows that indexations do not immediately compensate for inflation.

Figure no. 6. *Coefficients of the regression model regarding the average pension in the state social insurance system*



Source: Authors' representation.

The interpretation of the bar graph confirms the relevance of the coefficients estimated by multiple regression. The green bar, corresponding to the AGSE variable, highlights that the average gross salary has the largest positive effect on the average pension, which suggests that an increase in it directly contributes to improving the level of benefits in the pension system. In contrast, the red bar, associated with the NP variable, shows the negative and significant impact of the increase in the number of pensioners on the average pension, which reflects the demographic pressure on the system's resources. This visual representation completes the statistical analysis, making it easier to understand that economic factors (AGSE) stimulate the increase in pensions, while demographic factors (NP) limit this evolution. At the same time, the role of the CPI, which functions as a control variable for purchasing power, must be emphasized. Even in the conditions of an increase in the average pension determined by the AGSE, if the CPI dynamics are accelerated, the net effect on the real welfare of pensioners may be eroded. The interaction between structural determinants (AGSE, NP) and macroeconomic factors (CPI) highlights the importance of integrating the nominal and real dimensions in the analysis of the sustainability and adequacy of the pension system.

The global indicators of the multiple regression model show good robustness of the estimation: the R-squared value of 0.9936 and the adjusted value of 0.9909 indicate that approximately 99% of the variation in the average pension is explained by the introduced independent variables. The high and significant F-statistic ($p < 0.001$) confirms the general validity of the model, and the value of the Durbin-Watson statistic (1.88) suggests an absence of autocorrelation of the residuals, which supports the consistency of the results. Overall, the model used describes with a high degree of accuracy the relationships between macroeconomic indicators and the level of the average state social insurance pension, highlighting both the structural dependence on salary dynamics and the vulnerability in relation to the number of beneficiaries and inflationary pressures.

Conclusions

The analysis confirms the research hypotheses regarding the economic and demographic factors influencing the level of the average state social insurance pension. During the period 1996-2024, average pensions have proven to be relatively flexible in relation to earnings, but visible gaps appear during periods of rapid salary growth or during economic crises,

reflecting the sensitivity of the system to the macroeconomic context. The number of pensioners has remained stable, around 4.6-4.7 million people, indicating constant pressure on the public budget, even in the context of a recent decline. The average pension/salary ratio illustrates the transition from episodic protection during the 2008-2011 crisis to the period 2018-2024, characterized by relative stability, with values around 28-29%, signaling a gradual but limited adjustment of the system to economic realities.

The results support hypothesis H1, highlighting that, although Romania recorded a slight improvement between 2022 and 2024, the poverty rate among pensioners over 65 remains high, confirming the structural vulnerability of the pension system. Compared to Western European countries, where social protection for the elderly is much more robust, Romania is in a fragile position, while also approaching Eastern countries with extremely high values. This situation emphasizes the need to strengthen redistribution mechanisms and adapt social policies to the domestic economic and demographic context. Hypothesis H2, according to which the increase in the average gross salary determines the significant increase in the average pension, is supported by the multiple regression model, the associated coefficient AGSE being positive and statistically significant. This demonstrates the direct link between gross income and social benefits and confirms the efficiency of the pension indexation mechanism in relation to salary earnings. The average gross salary exerts the strongest positive effect on the average pension, while the increase in the number of pensioners and the consumer price index negatively influence its level, highlighting the way in which economic and demographic factors interact and underlining the vulnerabilities of the system in the face of inflationary and demographic pressures.

The average pension/salary ratio, used as an indicator of the adequacy and fairness of the system, reflects the cumulative influence of salaries, inflation and demographic factors, and the negative coefficient associated with the consumer price index confirms that inflation reduces the real purchasing power of pensioners, even in the context of nominal pension increases.

Overall, the public pension system in Romania provides social stabilization and minimum protection to pensioners, adjusting benefits according to salary developments, without guaranteeing the full maintenance of the standard of living after retirement. The average pension/salary indicator reflects both the adequacy and the limits of the system in ensuring intergenerational equity and long-term budgetary sustainability, highlighting the persistent challenges and the need for more efficient social policies, adapted to the current economic and demographic context.

References

- Akyol, P. and Atalay, K. (2025). The intergenerational impact of pension reforms: How grandmothers' pension eligibility affects daughters' fertility. *Economics Letters*, 248, March, 112239.
- Andersen, A.G., Markussen, S. and Røed, K. (2021). Pension reform and the efficiency-equity trade-off: impacts of removing an early retirement subsidy. *Labour Economics*, 72, 102050.

- Anghel, M.G. and Ioniță, E. (2025). Analysis of the influence of population structure on the dynamics of the number of pensioners in Romania. *Romanian Statistical Review, Supplement*, Trim. 2, pp. 76-85.
- Anghelache, C. and Anghel, M.G. (2017). The European Union's strategy for increasing the living conditions of the population in the member states. *Theoretical and Applied Economics*, XXIV, 3 (612), Autumn, pp. 5-18.
- Blundell, R., Britton, J., Dias, M.C. and French, E. (2023). The impact of health on labor supply near retirement. *Journal of Human Resources*, 58(1), pp. 282-334.
- Börsch-Supan, A., Härtl, K., Leite, D.N. and Ludwig, A. (2023). Preventing reforming unequally. *Journal of Population Economics*, 36, pp. 2889-2924.
- Cho, D. and Lee, K. (2025). Pension sustainability and government effectiveness in the presence of population aging. *Economic Modelling*, 147, June, 107048.
- Choi, M., Sempungu, J.K., Lee, E.H., Lee, Y.H. (2024). Living longer but in poor health: Healthcare system responses to ageing populations in industrialised countries based on the findings from the Global Burden of Disease study in 2019, *BMC Public Health*, 12, 576.
- Díaz-Giménez, J. and Díaz-Saavedra, J. (2025). Public pensions reforms: Financial and political sustainability. *European Economic Review*, 175, June, 104988.
- He, L., Liang, Z., Song, Y. and Ye, Q. (2021). Optimal contribution rate of PAYGO pension. *Scandinavian Actuarial Journal*, (6), pp. 505-531.
- Hernæs, E., Markussen, S., Piggott, J. and Røed, K. (2024). The impact of pension reform on employment, retirement, and disability insurance claims. *Journal of Population Economics*, 37, 76.
- Kitamura, T. and Nakashima, K. (2025). Financial incentives for delaying the public pension claiming age. *Journal of Behavioral and Experimental Finance*, 45, March, 101009.
- Kudrna, G., Tran, C. and Woodland, A. (2019). Facing demographic challenges: pension cuts or tax hikes? *Macroeconomic Dynamics*, 23(2), pp. 625-673.
- Kuitto, K., Madia, J. and Podestá, F. (2021). Public Pension Generosity and Old-Age Poverty in OECD Countries. *Journal of Social Policy*, 52 (2), pp. 256-275.
- Möwisch, D., Brose, A. and Schmiedek, F. (2023). Active time use and well-being in older adulthood: Results from a day reconstruction method study. *Work, Aging and Retirement*, 9(1), pp. 7-18.
- Peng, X. and Fan, S. (2025). Asset allocation for a DC pension plan with dynamic attention. *Finance Research Letters*, 82, September, 107513.
- Schmidhuber, L., Fechter, C., Schröder, H. and Hess, M. (2021). Active ageing policies and delaying retirement: comparing work-retirement transitions in Austria and Germany. *Journal of International and Comparative Social Policy*, 37 (2), 176-193.
- Scott, A.J. (2023). The economics of longevity - An introduction. *The Journal of the Economics of Ageing*, 24, 100439.
- Waddell, C., Van Doorn, G., Power, G. and Statham, D. (2025). From Successful Ageing to Ageing Well: A Narrative Review. *The Gerontologist*, 65 (1), 8
- *** National Institute of Statistics, Press Releases no. 75/29 March 2024 and no. 74/28 March 2025, tempo online database.
- *** Eurostat, Persons at risk of poverty or social exclusion. Statistics Explained.

Productivity shocks, exchange rate and migration: a new open economy macroeconomics approach

Wataru JOHDO

Tokyo Keizai University, Japan
johdo@tku.ac.jp

Abstract. *This paper uses the Redux model to analyze the impact of migration on the effects of productivity shocks on consumption and the exchange rate in one country. We demonstrate that, when the elasticity of substitution between two goods is high, an increase in productivity in the home country decreases the level of consumption in that country. Conversely, if the rate of time preference is low, the relative consumption level in the home country increases due to the productivity shock. Additionally, when the rate of time preference is low, an increase in productivity causes the country's currency to appreciate.*

Keywords: productivity shocks, redux model, migration, exchange rate, consumption.

JEL Classification: E21, F16, F22, F31, F41, J61.

1. Introduction

This paper uses the New Open Economy Macroeconomics (NOEM) model to show the effects of productivity shocks on consumption and world welfare through exchange rate changes and international worker migration. Until now, the effects of productivity shocks analyzed using NOEM have been considered changes in the leisure-consumption preference parameter in the utility function. In Obstfeld and Rogoff's (1995) two-country Redux model, a forerunner of the NOEM model, a productivity shock is defined as a decrease in the preference for leisure over consumption and does not necessarily reflect a change in firms' productivity. On the one hand, Obstfeld and Rogoff (1995) show that a relative productivity shock in the home country increases the home country's consumption level relatively and causes the home currency to appreciate. On the other hand, many researchers have conducted extensive research analyzing the impact of expansionary monetary policies or increases in government spending that directly increase aggregate demand⁽¹⁾. Surprisingly, however, no papers other than Obstfeld and Rogoff (1996) analyze the impact of productivity shocks using the NOEM model. In this paper, we focus on the productivity parameter of the firm's production function, capturing productivity shocks as changes to it. Additionally, unlike previous NOEM studies, our model takes into account labor mobility across international borders. Thus, our model allows us to demonstrate how a rise in relative productivity in the home country affects each country's consumption and exchange rate through international worker migration. This study contributes to the NOEM literature by showing the macroeconomic effects of productivity shocks through international worker migration, a topic that has been overlooked in the NOEM. In recent years, the migration of workers from emerging market countries to developed countries in search of higher wages has expanded rapidly. This means that, if nominal wages are sticky, changes in nominal exchange rates affect worker migration. Changes in nominal exchange rates affect both countries' price indexes, altering relative real wages and resulting in international worker migration. The NOEM literature has constructed dynamic general equilibrium models of open economies that incorporate microfoundations, a feature lacking in the Mundell-Fleming model. These models have analyzed the international spillover effects of various policy shocks. However, most NOEM models with nominal wage rigidity assume that workers cannot cross borders. Consequently, few studies have investigated the relationship between international labor mobility, nominal exchange rates, and consumption. One exception is Johdo (2022). This study endogenizes international worker mobility in a NOEM model and shows the international spillover effects of expansionary monetary shocks. However, this study only shows the international spillover effects of policy shocks affecting the demand side and does not show those of productivity shocks affecting the supply side.

In this paper, we show that an unanticipated permanent productivity shock in the home country decreases the relative consumption level in that country if the elasticity of substitution between the two goods is large. Conversely, if the rate of time preference is small, the relative consumption level in the home country increases due to the productivity shock. Furthermore, we show that when the rate of time preference is small, an increase in productivity appreciates the country's currency, causing workers to migrate from the

foreign country to the home country in the short and long runs. We also show that an increase in productivity always increases the world's welfare level.

The remainder of this paper is structured as follows: Section 2 outlines the Redux model with worker migration. Section 3 presents a log-linearized version of the model and examines the effects of an unanticipated permanent productivity shock on international worker migration between two countries, the exchange rate, and cross-country consumption differences. Section 4 examines the world welfare effects of productivity shocks. The final section summarizes the findings and concludes the paper.

2. Model

The size of the world population is normalized to one. Workers in the interval $[0, n_t]$ are located in the home country, while those in the interval $(n_t, 1]$ are located in the foreign country. Monopolistically competitive firms continuously exist in the world in the $[0, 1]$ range. Each firm produces a single differentiated product that is freely tradable. Additionally, we assume that firms in the range $[0, s]$ are located in the home country and those in the range $(s, 1]$ are located in the foreign country, where s is exogenous. Home and foreign households (or workers) have perfect foresight and share the same utility function. The intertemporal objective of household $i \in [0, n_t]$ in the home country at time t is to maximize the following lifetime utility:

$$U_t(i) = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left(\log C_{\tau}(i) + \chi \log(M_{\tau}(i)/P_{\tau}) - (\eta/2)(\ell_{\tau}^S(i))^2 \right), \quad (1)$$

where E_t represents the mathematical expectation conditional on the information set made available to household i in period t , β is a constant subjective discount factor ($0 < \beta < 1$), $\ell_t^S(i)$ is the amount of labor, and the consumption index $\log C_t(i)$ is defined as follows: $C_t(i) = (\int_0^1 C_t(i, j)^{(\theta-1)/\theta} dj)^{\theta/(\theta-1)}$, $\theta > 1$, where θ is the elasticity of substitution between any two differentiated goods and $C_t(i, j)$ is the consumption of good j . $M_t(i)$ denotes nominal money balances, and P_t is the home country consumption price index (CPI), which is defined as $P_t = (\int_0^1 P_t(j)^{1-\theta} dj)^{1/(1-\theta)}$, where $P_t(j)$ is the home-currency price of good j . Similarly, the foreign country CPI is $P_t^* = (\int_0^1 P_t^*(j)^{1-\theta} dj)^{1/(1-\theta)}$, where $P_t^*(j)$ is the foreign-currency price of good j . Because there are no trade costs between the two countries, the law of one price holds for any variety j ; i.e., $P_t(j) = \varepsilon_t P_t^*(j)$, where ε_t is the nominal exchange rate, defined as the home currency price per unit of foreign currency. Given the law of one price, purchasing power parity is represented by $P_t = \varepsilon_t P_t^*$. At each point in time, a typical domestic household faces the following budget constraint:

$$P_t B_{t+1}(i) + M_t(i) = P_t(1 + r_t)B_t^i + M_{t-1}(i) + W_t(i)\ell_t^S(i) + \int_0^s \Pi_t(j) dj + \int_s^1 \varepsilon_t \Pi_t^*(j) dj - P_t C_t(i) + P_t \tau_t(i), \quad (2)$$

where $B_{t+1}(i)$ denotes real bonds; r_t denotes the real interest rate; $W_t(i)$ denotes the nominal wage rate; $\int_0^s \Pi_t(j) dj$ ($\int_s^1 \varepsilon_t \Pi_t^*(j) dj$) represents the total nominal profit flows of

firms located in the home (foreign) country; and $\tau_t(i)$ denotes real lump-sum transfers. The government budget constraint is $(M_t - M_{t-1})/P_t = \tau_t$, where M_t is the aggregate money supply, and $\tau_t = \int_0^{n_t} \tau_t(i) di$. Firm $j \in [0, n_t]$ hires a continuum of differentiated labor inputs domestically and produces a single product according to $y_t(j) = \kappa(n_t^{-1/\phi} \int_0^{n_t} (\ell_t^d(i, j))^{(\phi-1)/\phi} di)^{\phi/(\phi-1)}$, where $y_t(j)$ denotes the production of home-located firm j , $\ell_t^d(i, j)$ is the firm j 's input of labor from household i , and $\phi > 1$ is the elasticity of substitution between any two differentiated inputs. Given the firm's cost minimization, firm j 's optimal labor demand for household i 's labor input is as follows:

$$\ell_t^d(i, j) = n_t^{-1} (W_t(i)/W_t)^{-\phi} (y_t(j)/\kappa), \quad (3)$$

where $W_t \equiv (n_t^{-1} \int_0^{n_t} W_t(i)^{(1-\phi)} di)^{1/(1-\phi)}$. We now consider the optimization problem of households. Households in the home (foreign) country maximize the consumption index $C_t(i)$ ($C_t^*(i)$) subject to $P_t C_t(i) = \int_0^1 P_t(j) C_t(i, j) dj$ ($P_t^* C_t^*(i) = \int_0^1 P_t^*(j) C_t^*(i, j) dj$) by optimally allocating differentiated goods. This problem yields the following demand functions for good j :

$$C_t(i, j) = (P_t(j)/P_t)^{-\theta} C_t(i), \quad C_t^*(i, j) = (P_t^*(j)/P_t^*)^{-\theta} C_t^*(i). \quad (4)$$

Aggregating the demands in (4) across all households worldwide and equating $y_t(j)$, yields the following market-clearing condition for any product j :

$$y_t(j) = n_t C_t(i, j) + (1 - n_t) C_t^*(i, j) = (P_t(j)/P_t)^{-\theta} C_t^w, \quad (5)$$

where $P_t(j)/P_t = P_t^*(j)/P_t^*$ from the law of one price, and $C_t^w \equiv (n_t C_t(i) + (1 - n_t) C_t^*(i))$ is aggregate per capita world consumption. Similarly, we obtain $y_t^*(j) = (P_t^*(j)/P_t^*)^{-\theta} C_t^w$. In the second stage, households maximize (1) subject to (2). The first-order conditions with respect to $B_{t+1}(i)$ and $M_t(i)$ can be written as

$$1/C_t(i) = \beta E_t[(1 + r_{t+1})/C_{t+1}(i)], \quad (6)$$

$$M_t(i)/P_t = \chi C_t(i)((1 + i_{t+1})/i_{t+1}), \quad (7)$$

where i_{t+1} is the nominal interest rate for home-currency loans, defined by $1 + i_{t+1} = (1 + r_{t+1})E_t[(P_{t+1}/P_t)]$. The terminal condition is $\lim_{T \rightarrow \infty} (1/\prod_{v=1}^{t+T} (1 + r_v)) [B_{t+T+1} + M_{t+T}/P_{t+T}] = 0$. In the monopolistic goods markets, given W_t , P_t , C_t^w , and n_t and subject to (3) and (5), the profit-maximization problem for home-located firm j is as follows: $\max_{P_t(j)} \Pi_t(j) = P_t(j)y_t(j) - \int_0^{n_t} W_t(i) \ell_t^d(i, j) di = (P_t(j) - W_t/\kappa)y_t(j)$. By substituting $y_t(j)$ into $\Pi_t(j)$ and differentiating the resulting equation with respect to $P_t(j)$, we obtain the following price mark-up:

$$P_t(j) = (\theta/\theta - 1)(W_t/\kappa). \quad (8)$$

Since W_t is given, from (8), all home-located firms charge the same price, $P_t(j) = P_t(h)$, where the firm index j is omitted due to symmetry. Foreign-located firms also have identical price markups, so $P_t^*(j) = P_t^*(f)$.

The driving force behind the migration of workers is the difference in real wages between two countries. The adjustment processes for the migration of workers are as follows:

$$(n_t - n_{t-1})/n_{t-1} = \gamma[(W_t(i)/P_t)/(W_t^*(i)/P_t^*) - 1], \quad (9)$$

where γ ($0 \leq \gamma < \infty$) is a constant positive parameter that determines the degree of worker mobility between the two countries: a larger value of γ implies higher worker mobility between two countries. Following Corsetti and Pesenti (2001), we introduce nominal rigidities into the model in the form of one-period wage contracts under which nominal wages in period t are predetermined at time $t - 1$. The equilibrium labor-market conditions for the home and foreign countries are $\ell_t^s(i) = \int_0^s \ell_t^d(i, j) dj$, $i \in (0, n_t)$ and $\ell_t^{s*}(i) = \int_s^1 \ell_t^{d*}(i, j) dj$, $i \in (n_t, 1]$. Taking $W_t, P_t, y_t(j)$, and n_t as given, by substituting $\ell_t^s(i) = \int_0^s \ell_t^d(i, j) dj$ and equation (3) into (2), and maximizing (1) with $W_t(i)$, we obtain the following first-order condition:

$$\phi(W_t(i)/P_t)^{-1} E_{t-1} [\eta(\ell_t^s(i))^2] = (\phi - 1) E_{t-1} [\ell_t^s(i)/C_t(i)]. \quad (10)$$

Each household uses equation (10) to determine its wage rate. Finally, the equilibrium condition for the international bond market is given by $\int_0^{n_t} B_{t+1}(i) di + \int_{n_t}^1 B_{t+1}^*(i) di = 0$. The equilibrium conditions for the money markets are given by $M_t = \int_0^{n_t} M_t(i) di$ and $M_t^* = \int_{n_t}^1 M_t^*(i) di$.

3. Productivity shocks

To examine the macroeconomic effects of an unanticipated, permanent productivity shock, we solve a log-linear approximation of the system around the initial zero-shock steady state. We assume the economy begins at the zero-shock steady state in period 0. At the end of period 1, the nominal wage rates are determined by one-period contracts, which carry over into period 2. After the one-period wage contracts are completed, the productivity shocks occur. This means that the nominal wages agreed upon at the end of period 1 cannot instantly adjust to the unanticipated productivity shocks of period 1. Additionally, the condition for the optimal nominal wage (equation 10) does not hold; therefore, households are willing to satisfy any level of labor demand at predetermined wage rates because their real wage rates dominate their marginal labor costs. We refer to the period of the shock as the short run. In periods 2 and beyond, nominal wages perfectly adjust to their new steady-state values, which are consistent with the optimal wage conditions given by equation (10). The time from period two onwards is referred to as the long run. Following Obstfeld and Rogoff (1995), we use $\hat{X}$ to denote short-run percentage deviations from the initial steady-state value of any variable X . These short-run percentage deviations are consistent with the length of nominal wage contracts. Thus, in the short-run log-linearized equations, nominal wages and goods prices can be determined as $\hat{W} = \hat{W}^* = \hat{P}(h) = \hat{P}^*(f) = 0$. Additionally, we use $\bar{X}$ to denote long-run percentage deviations from the initial steady-

state value, consistent with flexible nominal wages. We assume that the nominal money supply is held constant in both countries so that $\hat{M} = \bar{M} = \hat{M}^* = \bar{M}^* = 0$.

We obtain the following log-linearized expression for the international distribution of workers by log-linearizing equation (9) around the symmetric steady state:

$$\hat{n} = -\gamma\hat{\varepsilon}. \quad (11)$$

Equation (11) shows that exchange rate depreciation induces the migration of workers from the home country to the foreign country. Intuitively, with fixed nominal wages causing nominal product prices to be sticky, depreciation decreases (increases) the foreign (home) price level because $\hat{P}^* = -(1/2)\hat{\varepsilon}$ ($\hat{P} = (1/2)\hat{\varepsilon}$) from the price indexes. This increases the real wage of foreign-located workers and decreases the real wage of home-located workers. Consequently, some workers migrate to the foreign country. Similarly, by log-linearizing equation (9) in the long run, we obtain the following log-linearized expression for international worker migration:

$$\bar{n} = -\gamma(\hat{\varepsilon} - (\bar{W} - \bar{W}^*)). \quad (12)$$

Equation (12) shows that the long-run migration of workers is positively affected by the difference in nominal wages between two countries and negatively affected by the exchange rate.

Now, we will consider the macroeconomic effects of an unanticipated permanent productivity shock on three key variables: short- and long-run relative consumption, the nominal exchange rate, and short- and long-run worker migration. First, we analyze the impact of an unanticipated permanent relative productivity shock on short- and long-run relative consumption and the nominal exchange rate. The effects on these variables are as follows:

$$\hat{C} - \hat{C}^* = DA(\theta-1) \left(\frac{((\theta-1)/\theta)[2/(\theta+1+2\gamma)] - (\delta/\theta)(\theta+2\gamma)}{D(1+\delta A) + \delta A((\theta-1)/\theta)(\theta-1+2\gamma)} \right) (\bar{\kappa} - \bar{\kappa}^*). \quad (13)$$

$$\hat{\varepsilon} = \left(\frac{\delta A((\theta-1)/\theta) - G(1+\delta A) - 2A((\theta-1)/\theta)[(\theta-1)/(\theta+1+2\gamma)]}{D(1+\delta A) + \delta A((\theta-1)/\theta)(\theta-1+2\gamma)} \right) (\bar{\kappa} - \bar{\kappa}^*), \quad (14)$$

where

$$A \equiv \left(1 + ((\theta-1)/\theta) \left(\frac{\theta-1+4\gamma((\theta-1)/\theta)}{\theta+1+4\gamma((\theta-1)/\theta)} \right) \right)^{-1} > 0,$$

$$D \equiv \left(1 - 2\gamma \left(\frac{\delta}{1+\delta} \right) \right) \left(1 + \left(\frac{1}{1+\delta} \right) \left(\frac{2\gamma}{\theta+1+2\gamma} \right) \right)^{-1},$$

$$G \equiv \left(\frac{\theta-1}{1+\delta} \right) \left(\frac{2\gamma}{\theta+1+2\gamma} \right) \left(1 + \left(\frac{1}{1+\delta} \right) \left(\frac{2\gamma}{\theta+1+2\gamma} \right) \right)^{-1}.$$

Equation (13) shows that the effect of an unanticipated, permanent relative increase in the home country's productivity on its relative consumption compared to the foreign country's is indeterminate. This paper focuses on four effects of a relative increase in the relative

home productivity on the relative consumption of the home country to determine the sign of equation (13). First, an increase in the relative productivity of the home country decreases the demand for domestic labor for a given level of domestic production. In the short run, this results in a decrease in the domestic labor supply and an increase in domestic consumption. This occurs because an increase in the home country's productivity allows more consumption with the same labor supply. Additionally, the relative labor supply of the home country decreases due to consumption smoothing behavior. This paper defines this as the short-run consumption smoothing effect. Conversely, in the long run, the rise in domestic relative productivity increases the income of the home country relative to the foreign country and increases the current account surplus. This increases short-term consumption due to consumption smoothing behavior. In this paper, this is defined as the long-run consumption smoothing effect. Furthermore, due to the aforementioned effects, the value of the home country's currency increases. The reason for this is as follows: When the money supply remains constant and consumption rises, the demand for money also rises. Given the condition of money market equilibrium, the home country's currency must appreciate, leading to a decrease in home country prices and an increase in the real money supply. This appreciation decreases the home country's production and increases the foreign country's production through the consumption switching effect. This results in decreased profits for home country firms and increased profits for foreign firms. Consequently, domestic consumption decreases while foreign consumption increases. This effect is called the consumption switching effect in this paper. Finally, appreciation of the domestic currency increases the domestic real wage through falling domestic prices and decreases the foreign real wage. This leads to the migration of workers from foreign countries to the domestic country. This migration increases domestic production and decreases foreign production, which increases the domestic current account surplus and relative consumption due to the increase in domestic net foreign assets and the resulting consumption smoothing effect. This effect is defined as the migration effect in this paper. The net consumption effect of a domestic rise in productivity is determined by the relative magnitude of the consumption shifting effect, the short-run consumption smoothing effect, the long-run consumption smoothing effect, and the migration effect. In this paper, we examine the elasticity of substitution between two goods and the time preference rate to determine the sign of the consumption effect of a domestic relative productivity shock. First, when the elasticity of substitution between the two goods is large enough, the consumption switching effect, which reduces the home country's relative consumption, becomes significant and surpasses the other three effects. This results in a decrease in the home country's relative consumption level: $\hat{C} - \hat{C}^* = \bar{C} - \bar{C}^* < 0$. This occurs because a large elasticity of substitution between two goods makes the substitution of home goods for foreign goods more sensitive to exchange rate appreciation. Second, a smaller time preference rate results in a greater consumption smoothing effect caused by an increase in the current account surplus and the resulting increase in external assets. This occurs because, when the time preference rate is low, a greater proportion of the relative income increase effect of the home country, caused by an increase in its productivity, is absorbed by consumption. Therefore, when the time preference rate is sufficiently small, an increase in

the relative productivity of the home country increases the relative consumption level of the home country: $\hat{C} - \hat{C}^* = \bar{C} - \bar{C}^* > 0$. The above results can be summarized as follows:

$$\hat{C} - \hat{C}^* = \bar{C} - \bar{C}^* < 0, \text{ if } \theta \text{ is large,} \quad (15)$$

$$\hat{C} - \hat{C}^* = \bar{C} - \bar{C}^* > 0, \text{ if } \delta \text{ is small.} \quad (16)$$

Similarly to the results in (13), equation (14) shows that the effect of an unanticipated permanent relative productivity shock in the home country on the nominal exchange rate is ambiguous. Therefore, to evaluate this effect, we must first examine how an unanticipated permanent productivity shock in the home country influences the value of that country's currency. According to equation (13), if the rate of time preference is small, an unanticipated permanent relative productivity shock in the home country increases relative home consumption and demand for money. Given a constant money supply, therefore, the home currency must appreciate and the price level in the home country must fall to balance supply and demand in the money market. This paper defines this effect as the money demand effect. Second, an unanticipated permanent relative productivity shock in the home country causes the home price level to fall directly and the real money supply to rise. Therefore, even if demand for money remains constant, the home currency must depreciate, and the price level must rise to balance supply and demand in the money market. This paper defines this effect as the productivity effect. The effect on the exchange rate is determined by the relative magnitude of the money demand effect, which appreciates the exchange rate, and the productivity effect, which depreciates the exchange rate. In this paper, we focus on the time preference rate to determine the sign of the exchange rate effect of a relative home productivity shock. The smaller the time preference rate, the greater the consumption smoothing effect caused by an increase in the current account surplus and the resulting increase in external assets. This occurs because, when the time preference rate is low, a greater proportion of the relative income increase effect of the home country, caused by an increase in home country productivity, is absorbed into consumption. Therefore, the smaller the time preference rate, the larger the money demand effect. Consequently, when the time preference rate is low, the money demand effect of an increase in relative home productivity exceeds the productivity effect, causing the value of the home country's currency to increase ($\hat{\epsilon} < 0$). In summary, when the time preference rate is low, the money demand effect of an increase in relative home productivity exceeds the productivity effect, causing the value of the home country's currency to increase. The above result can be summarized as follows:

$$\hat{\epsilon} < 0, \text{ if } \delta \text{ is small.} \quad (17)$$

Next, we analyze the impact of an unanticipated, permanent productivity shock on short- and long-run international worker migration. First, the short-run change in worker migration is as follows:

$$\hat{n} = -\gamma \left(\frac{\delta A((\theta-1)/\theta) - G(1+\delta A) - 2A((\theta-1)/\theta)[(\theta-1)/(\theta+1+2\gamma)]}{D(1+\delta A) + \delta A((\theta-1)/\theta)(\theta-1+2\gamma)} \right) (\bar{K} - \bar{K}^*). \quad (18)$$

Equation (18) shows that the short-run effect of an unanticipated permanent productivity shock on the direction of international migration is ambiguous. In equation (11), note that

the effect of an unanticipated permanent relative productivity shock on worker migration in the short run depends on the exchange rate. However, as shown in equation (17), when the time preference rate is small, the home country's currency appreciates due to an increase in relative productivity. This causes the home country's relative real wage to rise. This occurs because exchange rate appreciation decreases (increases) the home (foreign) price level, causing the relative real wage of home-located (foreign-located) workers to increase (decrease). Consequently, workers relocate from the foreign country to the home country. Thus, when the time preference rate is low, an increase in the home country's relative productivity results in workers moving from abroad to the home country:

$$\hat{n} > 0, \text{ if } \delta \text{ is small.} \quad (19)$$

Similar to the short-run results in (18), the long-run effect of an increase in relative productivity on the direction of worker migration is as follows:

$$\bar{n} = \left(\frac{\gamma}{\theta+1+2\gamma} \right) \left[AD(\theta-1) \left(\frac{((\theta-1)/\theta)[2/(\theta+1+2\gamma)] - (\delta/\theta)(\theta+2\gamma)}{D(1+\delta A) + \delta A((\theta-1)/\theta)(\theta-1+2\gamma)} \right) + \theta \right] (\bar{\kappa} - \bar{\kappa}^*). \quad (20)$$

Equation (20) shows that the effect of an unanticipated permanent relative productivity shock in the home country on long-run worker migration is ambiguous. To assess this effect, we must pay attention to equations (10) and (12), which are meaningful in long-run equilibrium. Note that the right-hand side of equation (10) represents the marginal utility of additional labor income resulting from an increase in labor effort. The left-hand side represents the marginal disutility of an increase in work effort. In our model, each worker uses equation (10) to determine the wage rate. Equation (12), on the other hand, shows that the long-run change in migration is positively affected by the difference in nominal wages between the two countries and negatively affected by the exchange rate. Equations (10) and (12) show that an unanticipated permanent relative productivity shock in the home country has two effects on long-run worker migration. First, equation (12) shows that there is a decrease in the price level in the home country and an increase in the price level in the foreign country due to the appreciation of the home country's currency. This occurs under the assumption that δ is small. Consequently, the real wage in the home country exceeds the real wage in the foreign country, inducing foreign workers to migrate to the home country. The second effect occurs through a labor-leisure trade-off condition, as shown in equation (10). As shown in equation (16), when δ is small and the relative consumption in the home country increases ($\hat{C} - \hat{C}^* = \bar{C} - \bar{C}^* > 0$), the marginal utility resulting from the additional labor supply on the right side of equation (10) decreases. Therefore, workers in the home country will increase their nominal wage to satisfy equation (10) and reduce their labor supply further. This increases the real wage in the home country relative to the foreign country, providing an incentive for workers to migrate from the foreign country to the home country. Thus, if δ is small, an increase in the home country's tariff will cause workers to migrate from the foreign country to the home country in the long run ($\bar{n} > 0$).

4. Welfare effects

Following Obstfeld and Rogoff (1995), who disregarded the welfare effects of real balances, we focus on the real component of an agent's utility, comprising terms involving consumption and labor effort. Defining this real component as U_0^R , we can rewrite equation (1) as $U_0^R = E_t \sum_{\tau=0}^{\infty} \beta^\tau \left(\log C_\tau^i - (\eta/2)(\ell_\tau^{si})^2 \right)$. The impact of an unanticipated permanent productivity shock in the home country on the welfare of the home country is as follows

$$dU_0^R = (1/2)(\hat{C} - \hat{C}^*) - ((\phi-1)/\phi)((\theta-1)/\theta) \left(-\bar{\kappa}^W + (1/2)(\widehat{\ell}^S - \widehat{\ell}^{*S}) \right) + (1/\delta)\bar{\kappa}^W + (1/2\delta)(\hat{C} - \hat{C}^*) - (1/2\delta)((\phi-1)/\phi)((\theta-1)/\theta)(\bar{\ell}^S - \bar{\ell}^{*S}). \quad (21)$$

Similarly, the impact on foreign welfare is

$$dU_0^{R*} = -(1/2)(\hat{C} - \hat{C}^*) - ((\phi-1)/\phi)((\theta-1)/\theta) \left(-\bar{\kappa}^W + (1/2)(\widehat{\ell}^S - \widehat{\ell}^{*S}) \right) + (1/\delta)\bar{\kappa}^W - (1/2\delta)(\hat{C} - \hat{C}^*) + (1/2\delta)((\phi-1)/\phi)((\theta-1)/\theta)(\bar{\ell}^S - \bar{\ell}^{*S}). \quad (22)$$

From equations (21) and (22), we can derive the effect on world welfare of an unanticipated, permanent relative productivity shock in the home country. For this purpose, we define world welfare as $U_t^W = n_t U_t^R + (1 - n_t) U_t^{R*}$, where $n_{ss,0} = 1/2$ denotes the initial steady-state distribution of workers and $U_{ss,0}^R = U_{ss,0}^{R*}$. The world welfare effect of a monetary expansion then is

$$dU^W = (1/2)(dU_0^R + dU_0^{R*}) = [((\phi-1)/\phi)((\theta-1)/\theta) + 1/\delta]\bar{\kappa}^W > 0. \quad (23)$$

Equation (23) shows that an unanticipated permanent relative productivity shock in the home country improves the welfare of the world economy. The intuitive explanation for this result is as follows: First, note that world welfare is unaffected by the international movement of workers. This is because the impact of this factor on world welfare is offset equally between the home and foreign countries. Therefore, world welfare is only affected by consumption utility and labor disutility via exchange rate fluctuations. Recall that this paper begins with an initial steady state in which monopolistic distortions exist. The effects of an unanticipated permanent relative productivity shock in the home country are then analyzed. In our model, a productivity shock increases domestic and foreign production. This creates disutility from the increased labor supply. However, the negative impact is smaller than the utility gained from increased consumption due to the underproduction distortion caused by the initial monopoly. Consequently, in our model, a productivity shock improves economic welfare worldwide.

5. Conclusion

This paper has presented the impact of an unanticipated permanent relative productivity shock in the home country on consumption, exchange rate, and world welfare using a two-country intertemporal model with international migration of workers. The main results of our analysis are as follows: (i) When the elasticity of substitution between the two goods

is large, an unanticipated permanent relative productivity shock in the home country decreases the relative consumption level in the home country. However, when the rate of time preference is small, the relative consumption level in the home country increases due to the relative productivity shock. (ii) If the rate of time preference is small, the exchange rate appreciates due to the productivity shock. (iii) If the rate of time preference is small, an unanticipated permanent relative productivity shock in the home country induces workers to migrate from the foreign country to the home country in both the short and long runs. Finally, (iv) an unanticipated permanent relative productivity shock in the home country improves world welfare.

Notes

- ⁽¹⁾ Researchers have employed an extended Redux model to analyze the international spillover effects of monetary policy shocks in several studies. These include those by Betts and Devereux (2000a, 2000b), Hau (2000), Bergin and Feenstra (2001), Corsetti and Pesenti (2001), Cavallo and Ghironi (2002), Devereux and Engel (2002), Kollmann (2001), Smets and Wouters (2002), and Johdo (2013a, 2015). In addition, the international spillover effects of government expenditure policies have been analyzed using an extended Redux model in studies such as those by Betts and Devereux (2000), Caselli (2001), Corsetti and Pesenti (2001), Ganelli (2003, 2005a, 2005b), Chu (2005), Johdo (2013b, 2019), Di Giorgio et al. (2015), and Lai and Chen (2015). For a survey of NOEM models, see Lane (2001).

References

- Betts, C. and Devereux, M. (2000a). Exchange rate dynamics in a model of pricing-to-market. *Journal of International Economics*, 50(1), 215-244. <[http://dx.doi.org/10.1016/S0022-1996\(98\)00036-1](http://dx.doi.org/10.1016/S0022-1996(98)00036-1)>
- Betts, C. and Devereux, M. (2000b). International monetary policy coordination and competitive depreciation: A reevaluation. *Journal of Money, Credit, and Banking*, 32, 722-745. <<https://doi.org/10.2307/2601180>>
- Caselli, P. (2001). Fiscal consolidation under fixed exchange rates. *European Economic Review*, 45(3), 425-450. <[https://doi.org/10.1016/S0014-2921\(00\)00071-4](https://doi.org/10.1016/S0014-2921(00)00071-4)>
- Cavallo, M. and Ghironi, M. (2002). Net foreign assets and the exchange rate: Redux revised. *Journal of Monetary Economics*, 49(5), 1057-1097. <[https://doi.org/10.1016/S0304-3932\(02\)00122-8](https://doi.org/10.1016/S0304-3932(02)00122-8)>
- Chu, H. (2005). Welfare and public: The role of internationalized production. *Economic Inquiry*, 43(3), 542-557. <<https://doi.org/10.1093/ei/cbi037>>
- Corsetti, G. and Pesenti, P. (2001). Welfare and macroeconomic interdependence. *Quarterly Journal of Economics*, 116(2), 421-444. <<https://doi.org/10.1162/00335530151144069>>
- Devereux, M and Engel, C. (2002). Exchange rate pass-through, exchange rate volatility, and exchange rate disconnect. *Journal of Monetary Economics*, 49(5), 913-940. <[https://doi.org/10.1016/S0304-3932\(02\)00130-7](https://doi.org/10.1016/S0304-3932(02)00130-7)>

- Di Giorgio, G., Nisticò, S. and Traficante, G. (2015). Fiscal shocks and the exchange rate in a generalized Redux model. *Economic Notes: Review of Banking, Finance and Monetary Economics*, 44(3), 419-436. <<https://doi.org/10.1111/ecno.12042>>
- Ganelli, G. (2003). Useful government spending, direct crowding-out and fiscal policy interdependence. *Journal of international money and finance*, 22(1), 87-103. <[https://doi.org/10.1016/S0261-5606\(02\)00050-5](https://doi.org/10.1016/S0261-5606(02)00050-5)>
- Ganelli, G. (2005). Home bias in government spending and quasi neutrality of fiscal shocks. *Macroeconomic Dynamics*, 9(2), 288-294. <<https://doi.org/10.1017/S1365100505040162>>
- Ganelli, G. (2005). The new open economy macroeconomics of government debt. *Journal of international Economics*, 65(1), 167-184. <<https://doi.org/10.1016/j.jinteco.2004.03.001>>
- Hau, H. (2000). Exchange rate determination: The role of factor price rigidities and nontradeables. *Journal of International Economics*, 50(2), 421-447. <[https://doi.org/10.1016/S0022-1996\(99\)00002-1](https://doi.org/10.1016/S0022-1996(99)00002-1)>
- Johdo, W. (2013a). Does monetary expansion improve welfare under habit formation? *Economics Bulletin*, 33(3), 1959-1968. <<https://EconPapers.repec.org/RePEc:ebl:ecbull:eb-13-00403>>
- Johdo, W. (2013b). Consumption tax, nontraded goods and welfare. *Theoretical Economics Letters*, 3(05), 262-266. <<https://doi.org/10.4236/tel.2013.35044>>
- Johdo, W. (2015). Monetary policy, foreign welfare and international firm mobility. *International Journal of Economic Theory*, 11(3), 311-328. <<https://doi.org/10.1111/ijet.12068>>
- Johdo, W. (2019). Fiscal policy, relocation of firms, and the exchange rate. *Seoul Journal of Economics*, 32(4), 397-419. <<https://doi.org/10.22904/sje.2019.32.4.002>>
- Johdo, W. (2022). International worker mobility and the effects of monetary policy shocks. *Economics Bulletin*, 42(2), 523-535. <<https://EconPapers.repec.org/RePEc:ebl:ecbull:eb-20-00937>>
- Kollmann, R. (2001). Explaining international comovements of output and asset returns: The role of money and nominal rigidities. *Journal of Economic Dynamics and Control*, 25(10), 1547-1583. <[https://doi.org/10.1016/S0165-1889\(99\)00063-9](https://doi.org/10.1016/S0165-1889(99)00063-9)>
- Lai, C.F. and Chen, D.T. (2015). Fiscal expenditure, pricing-to-market and exchange rate behavior. *International Journal of Economics and Finance*, 7(10), 91-99. <<https://doi.org/10.5539/ijef.v7n10p91>>
- Lane, P.R. (2001). The new open economy macroeconomics: A survey. *Journal of International Economics*, 54(2), 235-266. <[https://doi.org/10.1016/S0022-1996\(00\)00073-8](https://doi.org/10.1016/S0022-1996(00)00073-8)>
- Obstfeld, M. and Rogoff, K. (1995). Exchange rate dynamics redux. *Journal of Political Economy*, 103(3), 624-660. <<http://dx.doi.org/10.1086/261997>>
- Obstfeld, M. and Rogoff, K. (1996). *Foundations of International Macroeconomics*. MIT press, Cambridge, MA.
- Smets, F and Wouters, R. 2002. Openness, imperfect exchange rate pass-through and monetary policy. *Journal of Monetary Economics*, 49(5), 947-981. <[https://doi.org/10.1016/S0304-3932\(02\)00126-5](https://doi.org/10.1016/S0304-3932(02)00126-5)>

The role of total assets in financial performance in North America: evaluating econometrics and machine learning approaches

Nargis SULTANA

Comilla University, Bangladesh
nargisultana.resrch@gmail.com

Fahad ZEYA

Comilla University, Bangladesh
fahadzeya@cou.ac.bd

K.M. ZAHIDUL ISLAM

Jahangirnagar University, Bangladesh
kmz@juniv.edu

Antonio J. RODRIGUEZ

Texas A&M International University, USA
rodriguez@tamiu.edu

Abstract. *This study examines the financial performance of North American firms, accentuating the significant role of total assets in firm's profitability, measured through EBITDA. By incorporating traditional econometric models—Fixed Effects and Random Effects—with machine learning techniques, exclusively Support Vector Machines (SVM), the research assesses both explanatory and predictive capabilities. The findings reveal that total assets significantly influence EBITDA, with the Fixed Effects model offering robust explanatory power (adjusted $R^2 = 77.86\%$) and SVM exhibiting superior predictive accuracy (89.4%). Additionally, the nuanced effects of financial ratios, such as liquidity and leverage, emphasize their indirect contributions to financial performance. These results offer actionable insights for stakeholders to improve asset use and financial strategies. This study's implications extend to advancing predictive methodologies in financial analysis, providing a scalable framework for analyzing profitability across diverse firms and contexts. This research specifies constructive insights for stakeholders, investors, and policymakers, enhancing their understanding of the financial dynamics of North American firms.*

Keywords: Profitability (EBITDA), Total Assets, Fixed Effects Model, Random Effects Model, Support VectorMachines (SVM).

JEL Classification: G32, C33, G17, C45.

A critical area of review in finance and management research involves understanding the financial performance of firms because it offers fundamental insights on operational efficacy, resource application and whole profitability. Total assets, a key part of a firm's structure, are instrumental in terms of affecting a prime financial outcome, named Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA).

Traditionally, initial theories such as Modigliani and Miller's (1958) capital structure irrelevance proposition have provided the groundwork for discovering the relationship between financial structure and firm performance. Successive empirical studies, such as those by Fama and French (1995) and Kester (1986), have explored financial ratios and their projecting capabilities in altering firm outcomes. Nevertheless, much of this research is either geographically confined or sector-specific, placing vague questions about the interaction between asset structures and profitability in cross-country contexts. Also, while total assets are recognized as critical drivers of financial performance, their role has been mainly examined through customary econometric lenses, habitually skipping enhanced predictive models.

Although current research emphasizes the significance of total assets in leading financial performance, many critical gaps continue. First, while widespread studies have discovered financial performance system of measurement, inadequate attention has been given to understanding the role of total assets across assorted datasets surrounding firms from diverse regulatory and economic contexts, such as the U.S. and Canada. Second, the interface between total assets and other financial variables, such as liabilities, debt ratios, and liquidity measures, is still underexplored, leaving gaps in how these factors jointly affect profitability. Third, conventional econometric models, while expensive for describing relationships, dearth the predictive power provided by advanced machine learning techniques, which are still underutilized in financial performance research. By showing these gaps, this study contributes by using a comprehensive dataset of U.S. and Canadian firms to expose generalizable insights, mixing econometric models with machine learning techniques to augment predictive and explanatory capabilities, and delivering actionable strategies for improving the management of asset use by the firm. These improvements bridge theoretical and methodological gaps, offering real value to stakeholders while improving the field of financial performance analysis.

This study aims at addressing these gaps by mixing vigorous theoretical arguments with empirical methodologies that amalgam conventional econometric models—namely Fixed Effects and Random Effects—with machine learning techniques, precisely Support Vector Machine (SVM) classification. Compared with most other learning techniques, SVM lead to increase performance in pattern recognition, regression estimation, and so on; financial time-series forecasting (Kim, 2003, Mukherjee et al., 1997, Tay and Cao, 2001), marketing (Ben-David & Lindenbaum, 1997), estimating manufacturing yields (Stoneking, 1999), text categorization (Joachims, 2002), face detection using image (Osuna, Freund, & Girosi, 1997), hand written digit recognition (Burgess and Scholkopf, 1997, Cortes and Vapnik, 1995), medical diagnosis (Tarassenko, Hayton, Cerneaz, & Brady, 1995). By concentrating on a thorough dataset of U.S. and Canadian firms spanning 1950–2023, the research seeks

to interpret how total assets influence EBITDA and estimate the comparative efficiency of these analytical approaches.

The primary research questions steering this investigation are given as follows:

1. What does existing literature expose about the role of total assets in figuring out firm profitability, and where do essential gaps continue?
2. How do asset and liability structures differentially affect financial outcomes across U.S. and Canadian firms?
3. Can the integration of traditional econometrics and machine learning offer better explanatory and predictive insights into firm performance?

The study makes many contributions by addressing these questions. Conceptually, it expands the conversation on asset use and financial performance, providing novel perspectives on how asset structures affect profitability across diverse economic landscapes. Procedurally, it sets up the corresponding strengths of econometric and machine learning models, reducing the gap between explanatory and predictive analyses. Reasonably, the findings provide valuable insights for corporate managers, investors, and policymakers aiming to boost financial strategies and increase decision-making.

The focus on U.S. and Canadian firms is markedly proper due to their aged financial markets and the readiness of broad historical data. Asset and liability structures are key to financial health, affecting profitability, risk management, and operational efficiency. For example, total assets offer the base for revenue generation, while liabilities show a firm's approach to financing and risk. Identification of these dynamics is vital not only for corporate decision-making but also for investors and policymakers managing the economies in North America.

The study gives substantial contributions to financial performance research by progressing methodological, theoretical, and practical measurements. Procedurally, it contributes by incorporating traditional econometric models with machine learning algorithms, resulting in a dual analytical framework that connects explanatory and predictive capabilities. The Fixed Effects model offers vigorous insights into the operational dynamics inducing profitability, while the Support Vector Machine meaningfully augments predictive accuracy, presenting a transformative viewpoint on financial analysis methodologies. Tentatively, the research shows the complex mechanisms through which total assets and complementary financial metrics, such as liquidity and leverage, impact EBITDA. Virtually, the findings equip corporate managers, investors, and policymakers with data-driven strategies to improve asset structures, manage risk, and enhance operational efficacy. By addressing methodological and analytical gaps in financial performance literature, this study sets a standard for employing hybrid econometric-machine learning frameworks to interpret complex financial phenomena.

This paper is organized as: the Literature Review investigates earlier studies on financial performance metrics and methodologies, emphasizing gaps addressed by this research. The Methodology describes the dataset, model specifications, and variables used to analyze the connection between asset and liability structures and EBITDA. The Results and Discussion section displays key findings, reasonable insights, and inferences of the econometric and

machine learning models. In conclusion, the limitations of the study and scope for future research define areas for advancement and forthcoming exploration, ensued by an inclusive conclusion reviewing the study's contributions and implication.

Literature Review

Swagatika Nanda and Ajaya Kumar Panda (2019) delved into the financial performance of manufacturing firms across several profitability levels. Their assessment underlines the importance of revenue, cost channels, and firm-specific factors. Remarkably, they decide that the influence of debt financing on profitability differs across distinctive quantiles. This reflection features the fundamental role that total liabilities play in changing performance measures such as EBITDA and Net Income. Their findings encourage a more thoughtful inspection into the financial metrics that emphasize modifications in performance across firms.

Constructing on this base, Burcu Adiloğlu and Bengü Vuran (2017) turn the focus to the discovery practices of financial metrics like EBIT and EBITDA among corporations listed on the BIST 50. Their research highlights that these metrics offer a clear viewpoint on financial performance compared to net income. By allaying the impacts of contrasting capital structures and tax rates, EBIT and EBITDA allow simpler cross-company comparisons. This underlines the prominence of total assets and total liabilities in altering a firm's stated performance, highlighting the consequence of these financial structures in your analysis of U.S. and Canadian firms.

Extending this discussion, Ana Ježovita (n.d.) examines the use of financial performance indicators in enormous Croatian units. She stresses the essential of understanding key performance indicators (KPIs) like ROA, ROE, EBIT, and EBITDA in strategic planning and decision-making. Ježovita's insights expose how these statistics can influence management bonuses and whole business outlooks. Misconceptions of these metrics might lead to inaccurate conclusions about a firm's financial health, thus accentuating the necessity to exactly measure the relationship between total assets, total liabilities, and financial performance.

In combination with this, Terence M. Yhip and Bijan M. D. Alagheband (2020) offer a complete assessment of essential financial analysis via ratio analysis. They classify financial ratios into profitability, asset consumption and efficiency, liquidity, and debt and solvency, offering significant insights into evaluating a firm's performance. Their carefulness about probable deceptive practices in financial statements, such as window dressing and deceitful reporting, emphasizes the significance of a wary appraisal of total assets and liabilities in understanding their impression on EBITDA and Net Income.

In the end, Hugo Thoursie and Lucas Fageräng (2021) discover the influence of financial metrics on company performance during the COVID-19 pandemic. Through their analysis of sectors in the Swedish market, they recognize financial ratios such as the current ratio, debt-to-equity (D/E), and return on equity (ROE) as relating to company performance among substantial market disturbances. Their findings advise that while financial metrics

do guide performance modifications, other exterior factors likely play a considerable role as well. This shows the vigorous spirit of financial analysis and features the complication of estimating total assets and liabilities, specifically in differing economic conditions.

There have been several studies on the relationship between total assets, total liabilities, and financial performance, often counting on profitability measures like EBITDA and Net Income. Nevertheless, most research tends to focus on either individual countries or specific sectors, with fewer emphasis involving U.S. and Canadian firms. Moreover, while financial ratios like Debt-to-Equity, ROA, and ROE have been broadly studied, this precise investigation into how these ratios moderate the relationship between total assets/liabilities and financial performance in the context of both U.S. and Canadian firms is a gap in the existing literature.

Methodology

Data Collection

The analysis applies a panel dataset from Compustat, having key financial metrics for U.S. and Canadian firms covering from 1950 to 2023. This dataset combines firm-level ratios and annual fundamentals, offering a complete view of the financial landscape over the decades. Prior to the analysis, the dataset goes through preprocessing to detach outliers, guaranteeing the precision and consistency of the results. This preparation aids a stout examination of the correlation between asset and liability structures and financial performance.

Model specification

Fixed Effects Model

The model explores the relationship between EBITDA and primary independent variables, while encompassing proper control variables. The model is expressed as:

$$EBITDA_{(it)} = \beta_0 + \beta_1 at_{(it)} + \beta_2 de_ratio_{(it)} + \beta_3 curr_ratio_{(it)} + \gamma_1 roa_{(it)} + \gamma_2 roe_{(it)} + \gamma_3 lt_{(it)} + \gamma_4 ni_{(it)} + \sum Year_t + \sum Industry_i + u_{(it)}$$

Random Effects Model

The model depicts both within-firm and between-firm variations, while also integrating relevant control variables. The model is expressed as:

$$EBITDA_{(it)} = \beta_0 + \beta_1 at_{(it)} + \beta_2 de_ratio_{(it)} + \beta_3 curr_ratio_{(it)} + \gamma_1 roa_{(it)} + \gamma_2 roe_{(it)} + \gamma_3 lt_{(it)} + \gamma_4 ni_{(it)} + \sum Year_t + \sum Industry_i + u_{(it)}$$

Here,

1. Core Independent Variables:

- $at_{(it)}$: Total Assets
- $de_ratio_{(it)}$: Debt-to-Equity Ratio
- $curr_ratio_{(it)}$: Current Ratio

2. Control Variables:

- $roa_{(it)}$: Return on Assets (measures operational efficiency).
- $roe_{(it)}$: Return on Equity (captures profitability compared to shareholder equity).
- $lt_{(it)}$: Long-Term Debt (shows leverage and financial risk).
- $ni_{(it)}$: Net Income

3. Fixed Effects:

- Year Effects ($\sum Year_t$): Controls for macroeconomic shocks or time-specific variations.
- Industry Effects ($\sum Industry_i$): Accounts for industry-level differences.

4. Error Term:

- Fixed Effects Model: $u_{(it)}$ captures firm-specific shocks over time.
- Random Effects Model: $u_{(it)} = v_i + \varepsilon_{(it)}$,

where:

v_i : Firm-specific random effects (time-invariant).

$\varepsilon_{(it)}$: Idiosyncratic error term (time-variant).

Data Description

Variable	Definition
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization; a measure of a firm's profitability.
at (Total Assets)	Total assets of the firm, standing for the overall size and resource base.
de_ratio	Debt-to-Equity Ratio; shows the proportion of debt used to finance the firm compared to shareholders' equity.
curr_ratio	Current Ratio; a liquidity measure showing a firm's ability to cover short-term liabilities with short-term assets.
roa	Return on Assets; measures the operational efficiency of a firm in generating profits from its assets.
roe	Return on Equity; assesses profitability compared to the equity invested by shareholders.
lt (Long-Term Debt)	Long-term debt obligations, reflecting the firm's financial leverage and risk management strategy.
ni (Net Income)	The net earnings of the firm after all expenses, taxes, and other obligations have been deducted.

Table-01. Summary statistics

Variable	Mean	Median	SD
at	363.9235597	177.85	420.3556365
curr_ratio	3.0479025	2.276	4.7802597
de_ratio	1.4615762	0.876	14.7454018
roa	0.1288911	0.138	0.1968574
roe	-0.1176347	0.112	14.7727631
lt	186.4131754	74.168	244.1276926
ni	20.1674	7.372	45.1492604

The summary statistics specify insights into the key variables included in the model. The variable Total Assets (at), a proxy for firm size, has a mean of 363.92 with a median of 177.85 and a standard deviation of 420.36, showing substantial alteration in firm sizes across the sample. Current Ratio (curr_ratio), which shows short-term liquidity, has a mean of 3.05, a median of 2.28, and a standard deviation of 4.78, advocating alterability in firms' liquidity positions. Debt-to-Equity Ratio (de_ratio), a measure of financial leverage, shows a mean of 1.46, a median of 0.88, and an elevated standard deviation of 14.75, stressing substantial differences in leverage levels. Profitability metrics such as Return on Assets (roa) have a mean of 0.13 and a standard deviation of 0.20, while Return on Equity (roe), with a mean of -0.12 and a standard deviation of 14.77, displays that some firms have momentous negative equity returns. Long-Term Debt (lt), characterizing leverage,

averages 186.41 with a median of 74.17 and a standard deviation of 244.13, showing substantial disparities in long-term obligations. In conclusion, Net Income (ni), a central profitability measure, has a mean of 20.17, a median of 7.37, and a standard deviation of 45.15, displaying an open range of profitability among firms. These statistics uncover the variety in firm characteristics and financial health within the dataset.

Table-02. Main results (regression coefficients summary)

Variable	Estimate	Std. Error	t-value	Pr(> t)
at	0.1152529	0.0021825	52.8077	<.0000 ***
de_ratio	0.0133566	0.0161587	0.8266	0.4085
curr_ratio	-0.1398702	0.0547219	-2.5560	0.0106 *
roa	27.2505035	1.5115945	18.0277	<.0000***
roe	0.0098989	0.0158984	0.6226	0.5335
lt	-0.0048844	0.0035334	-1.3824	0.1669
ni	0.5677933	0.0072855	77.9348	<.0000 ***

The outcomes of the fixed effects model offer valuable insights into the determinants of EBITDA. The coefficient for Total Assets (at) is substantially significant ($p < 0.0000$) with a positive estimate of 0.115, showing that larger firms tend to produce greater profitability, as expected. The Debt-to-Equity Ratio (de_ratio) is positive but not statistically significant ($p = 0.4085$), suggesting that leverage does not have a sturdy immediate impact on EBITDA within the sample. The Current Ratio (curr_ratio) has a negative and statistically significant effect ($p = 0.0106$), implying that extreme liquidity may inhibit profitability, theoretically reflecting ineffectiveness in resource allocation.

Among the control variables, Return on Assets (roa) shows a substantial positive effect ($p < 0.0000$), bringing to light that firms with sophisticated operational efficiency produce significantly higher EBITDA. Similarly, Net Income (ni) is strongly positive and significant ($p < 0.0000$), showing that largely profitability completely drives EBITDA. Nonetheless, Return on Equity (roe) and Long-Term Debt (lt) are not statistically significant ($p = 0.5335$ and $p = 0.1669$, respectively), implying that these factors may not have a direct impact on EBITDA in this model.

The model fit statistics reveal strong explanatory power, with an R^2 of 0.7869 and an adjusted R^2 of 0.77859, advising that around 79% of the variation in EBITDA is illuminated by the included variables. The F-statistic is vastly significant ($p < 0.0000$), implying the shared importance of the model predictors. Largely, the results highlight the size of operational efficiency and firm size in deciding profitability, while liquidity and leverage effects are nuanced and context related.

The econometric analysis revealed the following key metrics for both models:

Table-03. Econometric model findings

Metric	Fixed Effects Model	Random Effects Model
Mean Absolute Deviation	8.93	9.43
Adjusted R^2	0.77859	0.6631

These models show that asset and liability structures notably influence EBITDA performance, with the Fixed Effects model explaining a greater part of the variance in EBITDA.

The SVM model's performance was estimated using a confusion matrix, giving way the following results:

Table-04. Machine learning model findings

Metric	Value
Accuracy	89.4%
Kappa	0.7879
Sensitivity (Recall for class 0)	92.18%
Specificity (Recall for class 1)	86.61%
Positive Predictive Value (PPV)	87.32%
Negative Predictive Value (NPV)	91.72%
McNemar's Test P-Value	0.00002752.

The Support Vector Machine (SVM) model highlighted outstanding performance in predicting EBITDA classification, reaching a soaring accuracy rate of 89.4%, which emphasizes its efficacy in recognizing firms based on their financial performance. A Kappa statistic of 0.7879 further focuses on the model's consistency, contemplating sizable accord between predicted and actual outcomes. Furthermore, the model instructed convincing sensitivity (92.18%), showing its ability to decrease false negatives and appropriately recognize firms with high EBITDA performance. Combined with a specificity of 86.61%, the SVM model also proved a robust capability to classify true positives, making it a reliable tool for financial performance analysis. These metrics jointly justify the SVM model as a dependable and effective method for categorization in this context.

Table-05. Confusion matrix and statistics

Prediction	0	1
0	1143	166
1	97	1074

The SVM model appropriately spotted 1143 true negatives (TN), where both the predicted and actual classes were 0, and 1074 true positives (TP), where the predicted and actual classes were 1. Nevertheless, the model also conceded 166 false negatives (FN), where the actual class was 1 but the model predicted 0, and 97 false positives (FP), where the actual class was 0 but the model predicted 1. These results emphasize the model's strong predictive ability, with a sharp count of correct classes, while also showing areas for improvement in minimizing false negatives and false positives. This balance between true and false classifications shows the model's complete reliability in foretelling firm performance based on EBITDA.

The comparative performance of the models is summarized in the following table:

Table-06. Comparative analysis

Metric	Fixed Effects Model	Random Effects Model	SVM Classification Model
Median Absolute Deviation	8.93	9.43	Not applicable
Adjusted R ²	0.77859	0.6631	Not applicable
Accuracy	Not applicable	Not applicable	89.4%
Sensitivity (Recall for 0)	Not applicable	Not applicable	92.18%
Specificity (Recall for 1)	Not applicable	Not applicable	86.61%
Kappa	Not applicable	Not applicable	0.7879

The SVM model outclassed traditional econometric models in predictive accurateness, revealing the prospective uses of integrating machine learning techniques in financial analysis.

Table-07. *Comparative analysis of model metrics*

Metric	Fixed Effects Model	Random Effects Model
Adjusted R ²	0.77859(77.86%)	0.6631 (66.3%)
AIC (Akaike Information Criterion)	86034.34	86942.33
BIC (Bayesian Information Criterion)	86056.62	86972.04
SIC (Schwarz Information Criterion)	86062.13	86979.39
Mean Absolute Deviation (MAD)	17.84338	22.6457
Median Absolute Deviation (MAD)	8.934277	9.426578

The relative analysis of model performance metrics underlines key differences between the Fixed Effects and Random Effects Models. The fixed effects model elucidates a marginally higher percentage of variance in EBITDA with an Adjusted R² of 77.859% compared to 66.3% for the Random Effects Model. When considering model difficulty, criteria such as AIC and BIC favor the Fixed Effects Model, with much lower values (AIC: 86034.34 vs. 86942.33), showing a better total fit. Likewise, the SIC results ally with AIC and BIC, supporting the inclination for the Fixed Effects Model.

In terms of prediction accuracy, the Fixed Effects Model beats the Random Effects Model based on Mean Absolute Deviation (MAD), realizing a lower MAD (17.84338 vs. 22.6457), which suggests its predictions are precise to actual observed values. Additionally, the Fixed Effects Model explains stronger resilience to outliers, as mirrored in its Median Absolute Deviation (8.934277 vs. 9.426578). These findings cooperatively suggest that the Fixed Effects Model provides a better balance between fit, complexity, and predictive accuracy, making it a more robust choice for analyzing factors that affect EBITDA.

Robustness Check

Endogeneity Test

The endogeneity of *at* (Total Assets), a key element of EBITDA, is assessed using a Two-Stage Least Squares (2SLS) regression. The model considers *at* as endogenous and instruments it with its lagged value, *lag(at)*. Extra explanatory variables involve the Current Ratio (*curr_ratio*) and Debt-to-Equity Ratio (*de_ratio*), both regarded as exogenous. Diagnostic tests prove the suitability of this approach.

Table 08. *Two-stage least squares regression results*

Variable	Estimate	Std. Error	t-value	p-value	Significance
Intercept	-0.450	0.608	-0.740	0.459	
<i>at</i>	0.154	0.001	163.688	0.0000	***
<i>curr_ratio</i>	-0.218	0.087	-2.498	0.012	*
<i>de_ratio</i>	-0.482	0.082	-5.894	0.0000	***

Model Statistics:

- Residual Standard Error: 41 on 11781 degrees of freedom
- Multiple R²: 0.7142
- Adjusted R²: 0.7141
- Wald Test: 9174 on 3 and 11781 DF, p-value: < 0.0000

The 2SLS regression results illustrate that the variable *at* has a positive and extremely significant influence on EBITDA ($p < 0.0000$), with an estimated coefficient of 0.154. This finding shows that bigger firms tend to achieve higher profitability, steady with theoretical

expectations. Contrarywise, *curr_ratio* has a negative and statistically significant impact ($p=0.012$), showing that excessive liquidity may hinder profitability, hypothetically exhibiting ineffectiveness in resource allocation. Likewise, *de_ratio* proves a negative and highly significant effect ($p=0.0000$), highlighting the risks associated with financial leverage. The model proves strong explanatory power, with an R^2 0.7142 and an adjusted R^2 of 0.7141, showing that around 71% of the variation in EBITDA is enlightened by the predictors. The Wald test for joint significance (9174, $p<0.0000$) checks that the included variables together describe a significant ratio of the variation in EBITDA. Largely, the diagnostic tests and results provide compelling evidence for the legitimacy of the model and the size of addressing endogeneity in the analysis of profitability determinants.

2SLS Diagnostic Tests

Table 09. 2SLS diagnostic test results

Test	Statistic	Degrees of Freedom (df)	p-value
Weak Instruments Test	13.26	1, 2994	< 0.001
Wu-Hausman Test	1.17	1, 2993	0.280
Sargan Test	Not Applicable	-	-

The diagnostic tests done on the Two-Stage Least Squares (2SLS) model offer vital insights into the strength of the instruments and the potential endogeneity of Total Assets ('at'). The Weak Instruments Test proves the strength of the instrument 'lag(at)', with an F-statistic of 13.26 ($p < 0.001$). The Wu-Hausman Test suggests no compelling evidence of endogeneity for 'at' ($p = 0.280$), directing that Ordinary Least Squares (OLS) can well yield constant estimates. Since the model is accurately found, the Sargan Test for instrument validity is not relevant. These findings confirm the robustness of the 2SLS model and confirm the instrument's relevance and strength.

Table-10. The Breusch-Pagan test for heteroskedasticity results

Variable	Estimate	Significance
At	0.154	***
<i>curr_ratio</i>	-0.218	**
<i>de_ratio</i>	-0.482	***
Constant	-0.450	

Significance Levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The Breusch-Pagan test for heteroskedasticity was undertaken, yielding a statistic of 18.219 with 15 degrees of freedom ($p\text{-value} = 0.2513$). The non-significant result throws no evidence of heteroskedasticity, showing that the error terms have constant variance. Furthermore, the weak instruments diagnostics confirm that *lag(at)* is a strong and valid instrument for *at*.

Table-11. Model comparisons: robustness checks for AT

Dependent Variable: EBITDA

	No Curr Ratio (1)	No De Ratio (2)	Random Effects (3)
at	0.143*** (0.001)	0.143*** (0.001)	0.145*** (0.001)
<i>de_ratio</i>	0.012 (0.021)	-	-0.007 (0.021)
<i>curr_ratio</i>	-	-0.031 (0.070)	-0.044 (0.071)
Constant	-	-	4.462*** (1.357)

Significance Levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

This table sums up the results of robustness checks executed on the relationship between Total Assets ('at') and EBITDA. Three models are presented: (1) Excluding Current Ratio ('curr_ratio'), (2) Excluding Debt-to-Equity Ratio ('de_ratio'), and (3) A Random Effects Model. The results are presented below.

The robustness checks offer a comparative analysis of the significance and steadiness of the at total assets variable across three model specifications: (1) excluding current ratio, (2) excluding debt to equity ratio, and (3) using a random effects model. Across all models, the coefficient for at stays constantly significant at the 1% level ($p < 0.01$) and nearly identical in significance (approximately 0.143–0.145), upholding its vigorous positive relationship with EBITDA. The coefficients for the current ratio and debt to equity ratio are insignificant when held, suggesting they do not affect significantly to describing EBITDA. The Random Effects model (3) introduces a constant term (4.462), but the overall explanatory power and conclusions regarding at stay stable across models. This evenness underlines the consistency of at as a predictor of EBITDA, even when other variables are excluded, or alternative specifications are applied.

Table-12. *Sensitivity analysis (detailed model comparisons)*

Model	Coefficient (at)	Std. Error (at)	t-value (at)	p-value (at)	Coefficient (de_ratio)	p-value (de_ratio)	Coefficient (curr_ratio)	p-value (curr_ratio)	R ²	Adj. R ²
Full Model	0.14334	0.0009649	148.56	<0.001	0.01168	0.5719	-0.03016	0.6668	0.64918	0.63564
Without de_ratio	0.14334	0.0009649	148.56	<0.001	Excluded	Excluded	-0.03075	0.6607	0.64917	0.63566
Without curr_ratio	0.14335	0.0009644	148.64	<0.001	0.01182	0.5676	Excluded	Excluded	0.64918	0.63566

The sensitivity analysis was conducted by eliminating one predictor variable at a time—either current ratio or debt-to-equity ratio—from the primary model to estimate the robustness of the main variable of interest, at (total assets). In the model excluding debt-to-equity ratio, the coefficient for at was 0.14334, portending a one-unit increase in at is associated with a 0.14334-unit increase in EBITDA. This effect is highly statistically significant ($p < 0.001$), authorizing the robustness of at as a predictor. The current ratio coefficient was -0.0307, showing a little and statistically irrelevant effect on EBITDA ($p = 0.6607$). The model's explanatory power, specified by the R² value of 0.64917 (adjusted R² = 0.63566), stayed virtually unaffected compared to the full model. In the model excluding current ratio, the coefficient for at was 0.14335, once again illustrating a highly significant and consistent positive effect on EBITDA. The coefficient for debt-to-equity ratio was 0.0118, showing a trivial and statistically insignificant relationship with EBITDA ($p = 0.5676$).

The R² value was 0.64918 (adjusted R² = 0.63566), identical to the first model. These results signify that the explanatory power of the model is almost completely driven by at, as removing current ratio or debt-to-equity ratio does not affect the model's fit or the significance of at. Therefore, the sensitivity analysis confirms that at (total assets) is a robust and consistent predictor of EBITDA, while both current ratio and debt-to-equity ratio have slight and statistically insignificant effects. This reinforces that the primary driver of variation in EBITDA in this dataset is at, aligning with the focus of my research.

Table-13. *Reverse causality test results*

Granger Causality Test	F-Statistic	p-Value	Conclusion
Does EBITDA Granger-cause at?	0.8504	0.3564	No Granger causality

Causality and feedback are defined in an explicit and testable fashion (Granger, C. W. J. (1969). The Granger causality test examines whether past values of EBITDA (lagged EBITDA) enhance the prediction of at (total assets) over and above the predictive power of lagged values of at alone. Since the p-value (0.3564) is greater than the regular significance threshold (e.g., 0.05), there is no evidence to suggest that EBITDA Granger-causes at. Since the p-value > 0.05, we conclude that there is no noteworthy evidence that past values of EBITDA (lagged EBITDA) advance the prediction of at (total assets). This suggests that past values of EBITDA do not meaningfully improve the prediction of at beyond the information provided by past values of at itself.

Checking for Multicollinearity

Table-14. *VIF results*

Variable	VIF Value
at	1.019661
de_ratio	1.000519
curr_ratio	1.020154

The analysis of multicollinearity among the independent variables shows the smallest concerns, as all variance inflation factor (VIF) values are close to 1. For at (Total Assets), the VIF is 1.019661, proving a negligible contribution to multicollinearity. Likewise, the debt-to-equity ratio has a remarkably low VIF of 1.000519, further strengthening the absence of multicollinearity issues. Finally, the current ratio also shows a VIF of 1.020154, suggesting that this variable, too, does not pose multicollinearity concerns. These results authorize the autonomy of the predictors, ensuring the reliability of the regression coefficients in the model.

Results and Discussion

Key Findings

One of the main concerns of the company is the effort to achieve the desired level of profit (Purba, J. H. V., & Bimantara, D. (2020). EBITDA, or *earnings before interests, taxes, depreciation and amortization*, is a performance system of measurement positioned for many purposes including corporate valuation, managerial performance and solvency measurement (Bouwens, J., de Kok, T., & Verriest, A. (2019). This study analyzed the financial performance of U.S. and Canadian firms by evaluating the relationship between total assets (at) and EBITDA. The findings show that total assets play a critical role in driving profitability. The Fixed Effects model appeared as the most reliable econometric approach, outdoing the Random Effects model with greater adjusted R^2 values (77.86% vs. 66.31%) and lower AIC and BIC scores, being a better explanatory power and model fit.

Machine learning techniques, specifically the Support Vector Machine (SVM), proved superior predictive accuracy, achieving 89.4% accuracy with an extensive Kappa statistic of 0.7879. These results verify the efficiency of SVM in categorizing firms based on financial performance, surpassing traditional econometric models in predictive capability.

Mechanisms of Influence

The mechanism through which total assets affect EBITDA lies in their ability to support operational efficiency and revenue generation. Firms with bigger total assets are better equipped to invest in productive resources, improve efficiency, and scale operations, and at once contribute to profitability. Nevertheless, the influence of financial ratios, such as the Debt-to-Equity Ratio and Current Ratio, was found to be more nuanced. While their direct effects on EBITDA were fragile, they influence indirectly by ensuring financial stability and lowering operational risks.

Implications

The study highlights the importance of incorporating econometric and machine learning techniques to analyze financial performance. For stakeholders, the findings accentuate the significance of augmenting asset use and managing liquidity and leverage to maximize profitability. For researchers, the study links the gap between traditional and modern analytical methods, paving the way for more vibrant and predictive financial models.

Limitations of the Study

This study, while presenting constructive insights into the financial performance of U.S. and Canadian firms, has several limitations. First, the dataset, although extensive in its sequential coverage from 1950 to 2023, concentrates exclusively on firms from two countries. This geographical restriction confines the generalizability of findings, as financial dynamics can differ significantly in regions with contrasting economic conditions or regulatory environments. Furthermore, the study predominantly relies on quantitative financial data, overlooking qualitative factors such as management efficacy, market competition, or macroeconomic effects. These omitted variables might potentially have significant impacts on EBITDA but were outside the range of the present analysis. Additionally, the econometric models imagine linear relationships between variables, which may generalize complex interactions within financial systems. While machine learning models to a degree address this restriction, they also rely heavily on the quality of the data and feature engineering.

Another restriction arises from the accumulated nature of the dataset, which spans multiple industries. Sector-specific nuances, such as contrasting levels of asset efficiency or industry-specific financial structures, are not completely captured. This aggregation can dilute findings that could be more discerning within a single sectoral setting. Moreover, while the Support Vector Machine (SVM) showed enhanced predictive performance, it is intrinsically sensitive to hyperparameter adjusting and data preprocessing methods, which might curb its robustness in other datasets. The prohibition of alternate machine learning models or hybrid methodologies, such as ensemble learning techniques, depicts another limitation, as such approaches could yield even higher precision and reliability. Largely, while the study provides a sharp foundation for understanding asset-driven financial performance, these restraints suggest areas for methodological refinement and data expansion.

Scope for Further Research

Building on the restraints, future research offers several opportunities to strengthen and widen the insights provided by this study. Geologically, mounting the analysis to incorporate firms from varied regions, such as Europe, Asia, or emerging markets, would augment the comparison and relevance of the findings across several economic and regulatory contexts. Such expansion might reveal how regional differences in capital markets or governance practices affect the relationship between total assets and profitability. Furthermore, conducting sector-specific studies would offer more granular insights into how unique industry dynamics shape financial performance.

Conclusion

This study offers meaningful insights into the financial performance of U.S. and Canadian firms by emphasizing the pivotal role of total assets in driving profitability, computed through EBITDA. By keeping both traditional econometric models, such as Fixed Effects and Random Effects, together with current machine learning techniques like Support Vector Machines (SVM), the research delivers a robust framework for understanding and envisaging financial outcomes. The findings acknowledge the dire influence of asset structures on EBITDA, showing that greater firms with optimized resource allocation tend to reach superior financial performance. The Fixed Effects model appeared as the more trustworthy econometric approach, given its better fit and predictive accuracy.

Additionally, the SVM model outperformed traditional models in predictive capability, with high accuracy, sensitivity, and specificity, highlighting the value of machine learning in financial performance analysis. The combination of econometric rigor with the advanced predictive capabilities of machine learning highlights a thorough approach to assessing firm performance. This dual method not only augments understanding but also offers reasonable tools for stakeholders looking to improve financial strategies.

The analysis also highlights the nuanced roles of financial ratios, such as the Current Ratio and Debt-to-Equity Ratio, in shaping profitability. While these factors display constrained direct effects, their indirect contributions through liquidity and leverage management are critical for sustaining operational efficiency. Addressing endogeneity concerns and ensuring robustness through extensive diagnostic testing further strengthens the legitimacy of the results.

This research contributes to the literature by bridging the gap between traditional financial analysis and modern machine learning applications, offering a scalable framework for investigating firm performance across distinct sectors and regions. Future studies could expand upon these findings by discovering other variables, employing alternative algorithms, and measuring cross-industry dynamics to refine predictive models further.

The findings present actionable insights for corporate managers, investors, and policymakers, offering evidence-based guidance to increase decision-making. By using the interplay between asset structures, financial ratios, and advanced analytical techniques, firms can improve resource use, improve profitability, and ensure long-term financial sustainability.

References

- Hugo, T., and Fageräng, L. (2021). Financial metrics effect on companies' performance during COVID-19. KTH Royal Institute of Technology. Retrieved from <<https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1574217&dsid=-183>>
- Yhip, T.M., and Alagheband, B.M.D. (2020). Financial statement analysis. In *The Practice of Lending* (47–94). Springer. <https://doi.org/10.1007/978-3-030-32197-0_2>
- Tadić, I. (2022). Utjecaj kvalitete usluge na zadovoljstvo korisnika u ekonomiji dijeljenja: Primjer Ubera. Ekonomski fakultet u Splitu. Retrieved from <<https://repozitorij.efst.unist.hr/en/islandora/object/efst%3A6454/datastream/FILE0/view#page=50>>
- Kara, M., and Maden, C. (2013). The effect of corporate governance on firm performance: Evidence from Turkey. *International Journal of Business and Social Science*, 4(8), 121–129. Retrieved from <<https://dergipark.org.tr/en/download/article-file/266316>>
- Nanda, S., and Panda, A.K. (2019). A quantile regression approach to trail financial performance of manufacturing firms. *Journal of Applied Accounting Research*, 20(3), 290–310. <<https://www.emerald.com/insight/content/doi/10.1108/JAAR-06-2018-0091/full/html>>
- Chaieb, S. (2021). The impact of cash holding on debt cost. *International Journal of Economics and Financial Issues*, 11(5), 1–10. <<https://doi.org/10.32479/ijefi.11738>>
- Cao, L., and Tay, F.E.H. (2003). Financial time series forecasting using support vector machines. *Neurocomputing*, 55(1–2), 307–319, https://www.sciencedirect.com/science/article/pii/S0925231203003722?casa_token=0sHNatPyDKMAAAAA:2H0EzQtYDtWQQ0A33uz4GltePyF6msx8zQLkyBJTu6b1GUWPnnxB_TZOs61YKz_rZGlfFdSawlM
- Mukherjee, S., Osuna, E., and Girosi, F. (1997). Nonlinear prediction of chaotic time series using support vector machines. In *Proceedings of the IEEE Workshop on Neural Networks for Signal Processing* (511–520). IEEE. <https://ieeexplore.ieee.org/abstract/document/622433?casa_token=8N12XbCmLoMAAAAA:QTrwYcYXW9r3f7p824jYceLFBCQpkZmrzugVUh_9DC8J83AvwT04oBa27NCapUSGdp6zNn9ID-YhZg>
- Tay, F.E.H., and Cao, L. (2001). Application of support vector machines in financial time series forecasting. *Omega*, 29(4), 309–317. <https://www.sciencedirect.com/science/article/pii/S0305048301000263?casa_token=brB8SmgWNwIAAAAA:65RN2cdcnG7o5lcvPY5HitEs6-8GT-m6qDodPjcCa00ycZqBdWnLGpibhUugGyxyQwqlK4R9Z10>
- Ben-David, S., and Lindenbaum, M. (1997). Learning distributions by their density levels: A paradigm for learning without a teacher. *Journal of Computer and System Sciences*, 55(1), 171–182. <<https://www.sciencedirect.com/science/article/pii/S0022000097915075>>
- Stoneking, D. (1999). Improving the manufacturability of electronic designs. *IEEE Spectrum*, 36(6), 70–76. <https://ieeexplore.ieee.org/abstract/document/769272?casa_token=xjVBmyABeDEAAAAA:wzBJOteAHH4vGPK-DoXADDvU9YpBgao5W5SdehaTwr5hrlAEngUGXBFT_MZIR2M7B2Y4qqL5xpx3w>
- Joachims, T. (2002). *Learning to classify text using support vector machines*. Kluwer Academic Publishers. <https://books.google.com/books?hl=en&lr=&id=nxflBwAAQBAJ&oi=fnd&pg=PR10&ots=dBH18a_W4r&sig=KInnDt8mBvUUKrQNTTL4TPMCK0I#v=onepage&q&f=false>
- Osuna, E., Freund, R., and Girosi, F. (1997). Training support vector machines: An application to face detection. In *Proceedings of Computer Vision and Pattern Recognition* (130–136). IEEE.

- <https://ieeexplore.ieee.org/abstract/document/609310?casa_token=3abljHKf-mEAAAAA:yTQEtDsCCgFYIP1aCJ30wcMLXnmk4wLp8gvRsLbod1aUEUyec2kjsQxE4ZXqT3leUikkT5f0LUWsqw
- Burges, C.J.C., and Scholkopf, B. (1997). Improving the accuracy and speed of support vector machines. In M. Mozer, M. Jordan, and T. Petsche (Eds.), *Advances in Neural Information Processing Systems* (475–481). MIT Press.
- Cortes, C., and Vapnik, V.N. (1995). Support vector networks. *Machine Learning*, 20(3), 273–297.
- Tarassenko, L., Hayton, P., Cerneaz, N., and Brady, M. (1995). Novelty detection for the identification of masses in mammograms. In *Proceedings of the Fourth IEE International Conference on Artificial Neural Networks* (442–447). IEE.
- Shin, K.S., Lee, T.S., and Kim, H.J. (2005). An application of support vector machines in bankruptcy prediction model. *Expert Systems with Applications*, 28(1), 127–135.
- Purba, J.H.V., and Bimantara, D. (2020). The influence of asset management on financial performance, with panel data analysis. In *Proceedings of the 2nd International Seminar on Business, Economics, Social Science and Technology (ISBEST 2019)* (153–160). Atlantis Press.
- Bouwens, J., de Kok, T., and Verriest, A. (2019). The prevalence and validity of EBITDA as a performance measure. *Accounting Auditing Control*, 25(1), 55–105.
- Granger, C.W.J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, 37(3), 424–438. <https://www.jstor.org/stable/1912791?casa_token=gmn9tBn6zBckAAAAA%3A-19dORUEnZpP-y2-Dhh-A8hrcaaiaUfo0P_NTx8TEgGYzcZuWACdzXWNWbSCyPNiaGyzWjJuRc1BpqDGqVS-aiEHCw6Q8nS70XedieAbDUj9_Mv3IKA>

Energy vulnerabilities among Europeans in the Ukrainian war context

Andreea-Monica MUNTEANU

National Scientific Research Institute for Labour and Social Protection, Romania
Bucharest University of Economic Studies, Romania
andreea.munteanu@incsmmps.ro

Maria-Bianca BOLBOAȘĂ

National Scientific Research Institute for Labour and Social Protection, Romania
Bucharest University of Economic Studies, Romania
bianca.bolboasa@incsmmps.ro

Abstract. *Rising energy costs along with the Ukrainian war are widening the problems among the European population, while energy security remains one of the greatest challenges modern society encounters. This study examines how the energy crisis, exacerbated by the war in Ukraine, has disproportionately affected vulnerable groups across Europe. We use data from the Eurobarometer 514 and logistic regression to identify key factors contributing to energy poverty, such as income, household size, and regional disparities. We aim to identify the characteristics of energy-vulnerable European groups. The results indicate that low-income households, the elderly, and residents of Southern and Eastern Europe are particularly susceptible to rising energy costs. Furthermore, the study explores the broader geopolitical consequences of the war, emphasizing the urgent need for Europe to diversify its energy sources and reduce its reliance on Russian sources.*

Keywords: energy poverty, vulnerable groups, logistic regression, Ukrainian war.

JEL Classification: C35, F52, Q43.

Introduction

Energy security is known as one of the most significant challenges facing the world today, affecting both national economies and citizens' lives. Although energy poverty is lower in developed countries than in developing countries, it is mainly reflected in the difficulties of availability and accessibility (Che et al., 2021). After the adoption of Sustainable Development Goal 7 (SDG 7) and the Energy Poverty Observatory (EPOV), which promoted access to energy resources for all European states, the countries started to implement strategies against energy poverty (EnR, 2019). Zhao et al. (2022) conclude that the use of renewable energy as a substitute for traditional sources has significantly alleviated energy poverty only in European countries. In Romania, expanding renewable energies, particularly solar and hydroelectric, reduces dependence on fossil fuels and combats energy poverty. Integrating solar energy into the energy mix promotes diversification and supports the development of ecological infrastructure, which is critical for sustainable energy and economic growth (Pisică et al., 2024).

Geopolitical tensions caused by the war in Ukraine have disrupted the trend of European countries adopting renewable energy. Sanctions imposed on Russia increased the existing pressure on energy-vulnerable households after supply was reduced and electricity prices soared. The REPowerEU Plan, adopted in 2022 as part of the European Union's consumer protection efforts, sought to diversify energy sources while reducing the reliance on fossil fuel imports from Russia. Thus, the support provided by the EU to member states has been substantial, based on the severity of the crisis encountered (Moniek de Jong, 2024).

Considering the economic and social changes brought about by the armed conflict in Ukraine, this paper aims to create a profile of European citizens affected by rising electricity prices. Using data from Flash Eurobarometer 514 (2022), a series of indicators reflecting citizens' assessment of the EU's economic measures to support Ukraine during the war and the efforts to cut electricity consumption can be included in the analysis. Vulnerable groups can be characterized by demographic features such as age, region of origin, or household size, as well as by attitudes toward the war and solidarity with the Ukrainian people. Despite a growing body of literature on the energy crisis in Europe and on measures aimed at reducing energy consumption, few studies have systematically analyzed the socio-demographic profiles of vulnerable citizens in a multi-crisis context combining economic pressures, rising energy prices, and geopolitical instability. Moreover, the integration of citizens' behavioral responses and perceptions of the war in vulnerability assessments remains underexplored. This study addresses these gaps using logistic regression on recent Eurobarometer data.

The paper is organized as follows: Section 2 provides a concise literature review of energy poverty in recent years. Section 3 outlines the methodology and data employed in the research. The principal findings are detailed in Section 4, and the final section offers conclusions.

Literature Review

Energy security is one of the major challenges of the modern world. Many studies have focused on the factors that cause this phenomenon and its effects on the economy and society. The study by Kröger et al. (2023), using data from the German Socio-Economic Panel (SOEP) for 2015-2020, finds that home ownership, energy efficiency, and building type contribute to inequalities in natural gas expenditures among German citizens. According to the authors, these inequalities have been exacerbated by rising gas prices.

Rossella Bardazzi et al. (2023) employ Latent Class Analysis to explore energy poverty in five European countries (Greece, Spain, Italy, France, and Portugal), gathering data from the EU-SILC database for the period 2008-2019. The study identifies three classes of energy poverty and highlights factors such as income, housing size, and age that affect energy vulnerability. The research also illustrates how energy-poor households struggle with living conditions and heating capacity compared to energy-sufficient households, with variations across the countries analyzed. van Hove et al. (2022) reached similar conclusions about the determinants of energy poverty. The authors used data from the 2018 Enable-EU questionnaire across 11 European countries (Bulgaria, France, Germany, Hungary, Italy, Norway, Poland, Serbia, Spain, Ukraine, and the United Kingdom) to assess the risk of energy poverty using machine learning techniques. The analysis revealed universal predictors of energy poverty, such as income and housing size, in several countries, as well as specific factors, such as dwelling age, whose impact varies by country.

In Spain, Capetillo-Ordaz et al. (2024) explored the energy transition from a gender perspective. Using disaggregated demographic and socioeconomic data, the authors identified 86 energy-vulnerable zones for women and 36 for men in Madrid, most of which were concentrated in the southeastern part of the city.

The onset of the armed conflict in Ukraine further intensified the energy crisis, widening the gap between the energy security goals set by European states and the reality faced by the population. In reaction to repeated Russian attacks, the European Commission proposed a series of restrictive measures. Cui et al. (2023) examine the macroeconomic effects of power outages due to the Russia-Ukraine war, modeling three scenarios of escalating trade restrictions. Applying the GTAP-E general equilibrium model, the paper predicts price increases for regional commodities and energy (except in Russia and Ukraine), with significant effects on global supply chains and potential economic stagnation. The war in Ukraine has also led to a re-evaluation of energy transition strategies in Europe, including the postponement of coal mine closures in Germany due to the loss of access to Russian gas and an increase in natural gas extraction in Norway to compensate for the deficit, according to Antje et al. (2023).

In the 2023 public policy document, Eurodiaconia assessed public programs targeting energy poverty in Austria, the Netherlands, Serbia, and Germany. In Austria, increased energy poverty led to the introduction of financial aid for energy bills and the replacement of energy-inefficient appliances, which helped prevent disconnections and supported vulnerable households, particularly in urban areas. In 2022, the Netherlands recorded 600.000 households with energy problems. The "SchuldHulpMaatje" project addressed this

challenge by offering financial assistance through an advanced software system that helped identify high-risk areas of energy poverty and intervene effectively (Eurodiaconia, 2023).

Before the first armed attack by the Russian Federation on February 24, 2022, Ukraine introduced protection policies for the vulnerable population, offering subsidies and bill reductions. By January 1, 2021, over 3.1 million households benefited from subsidies, and 1.8 million families received bill reductions between 25% and 100%. The prohibition of heating disconnections in winter was also an example of a non-financial support mechanism. Before the war, the primary strategy to address energy poverty focused on improving the energy efficiency of vulnerable consumers' homes. Policy measures such as the Energy Poverty Mitigation Program and housing energy rehabilitation programs aimed to improve energy efficiency and solve heating problems in urban and rural areas. Ukrainian authorities promoted the replacement of outdated household appliances with energy-efficient models, the improvement of heating systems, and the adoption of cost-effective energy efficiency solutions (including energy audits) to reduce excessive energy consumption and alleviate energy poverty (Ban et al., 2021).

The outbreak of the war in Ukraine not only deepened the differences between energy-vulnerable groups but also widened disparities within the Ukrainian population. Supporting refugees from Ukraine is, therefore, a key aspect of crisis management in this context. According to the analysis conducted by Zakariás et al. (2023), most Hungarians who responded to the questionnaire (approximately 70%) were willing to accept refugees from any social group during the war. However, acceptance of refugees for a longer period was only observed among Transcarpathian Hungarians. Romani refugees from Ukraine and students from Africa and Asia were less accepted, indicating ethnic and racial prejudices. Hungarian civil society responded through various forms of aid, including material donations (23% of survey respondents) and financial donations (23%), volunteering (8%), hosting (2%), and assistance in finding a job (4%).

Women belong to one of the most vulnerable groups of refugees, as evidenced by field data from refugee reception points in Poland and Germany during the spring and summer of 2022. Women account for more than 80% of refugees and often travel with children. This reflects that migration is driven by the need for safety, which contrasts with earlier migration patterns that were predominantly male and work-oriented. Furthermore, pre-war social networks help Ukrainian refugees in Poland establish contacts with other Ukrainians (44%) or with Poles (43%) (Andrews et al., 2023).

In Ukraine, the outbreak of war led to regular power blackouts, severely restricting access to water and communications. This forced many households, mostly headed by women, to rely on wood and biomass for heating and cooking and to fetch water from rivers and streams. This situation particularly affected single mothers and women who are the sole breadwinners of the family, who make up over 70% of household heads in Ukraine. The war in Ukraine has affected energy, transport, and public security, limiting women's access to essential public services, which they rely on more than men for managing households (UN Women, 2022).

Methodology

This study aims to identify energy vulnerabilities among the European population in the current context of the energy crisis and the Russian-Ukrainian war. To define a profile for vulnerable energy consumers, we use logistic regression based on the notations imposed by Gujarati and Porter (2009).

Our dependent variable, Y , represents the degree to which rising energy prices influence customers' purchasing power. In our case, the dependent variable can take two possible values: 1 if rising energy prices impact purchasing power, and 0 otherwise (when rising energy prices do not influence purchasing power). In this case, the dependent variable follows a Bernoulli distribution.

Equation (1) presents the probability associated with an achievable event conditioned by a series of independent or explicative variables denoted by X_k , where $k = \overline{1, p}$. Usually, this probability is denoted by P , and the equation used in practice is:

$$P = E(Y = 1 | X_1, X_2, \dots, X_k) = \frac{1}{1 + e^{-(\alpha + \beta_1 * X_1 + \beta_2 * X_2 + \dots + \beta_k * X_k)}} \quad (1)$$

Another important measure usually used in practice is the odds ratio, which evaluates the possibility of a favourable event to occur.

$$\frac{P}{1 - P} = e^{\alpha + \beta_1 * X_1 + \beta_2 * X_2 + \dots + \beta_k * X_k} \quad (2)$$

The logit model is obtained after applying the natural logarithm to Equation (2), and the coefficients are estimated using the maximum likelihood method.

$$L = \ln \frac{P}{1 - P} = \alpha + \beta_1 * X_1 + \beta_2 * X_2 + \dots + \beta_k * X_k \quad (3)$$

Data

Table 1 comprises the variables utilised in this research, which are divided into independent and dependent variables according to our chosen method to define a profile that describes the vulnerabilities in the energy crisis background. More than that, we intend to identify the key characteristics of vulnerable groups in the context of energy crises and war. In line with the scope of this research, we choose our dependent variable to be reflected by the impact of increasing energy prices on the consumer's purchasing power. Also, we include multiple independent variables in our model, such as demographic variables (age, sex, income, occupation, household composition), attitudes towards the measures adopted by the European Union in the Ukrainian war context (economic sanctions, military and human support, reducing the dependency towards Russian gas and oil), European Union current economical situation, the impact of war on regenerable resources, and also the measures taken into consideration by consumers to reduce their energy and electricity bills.

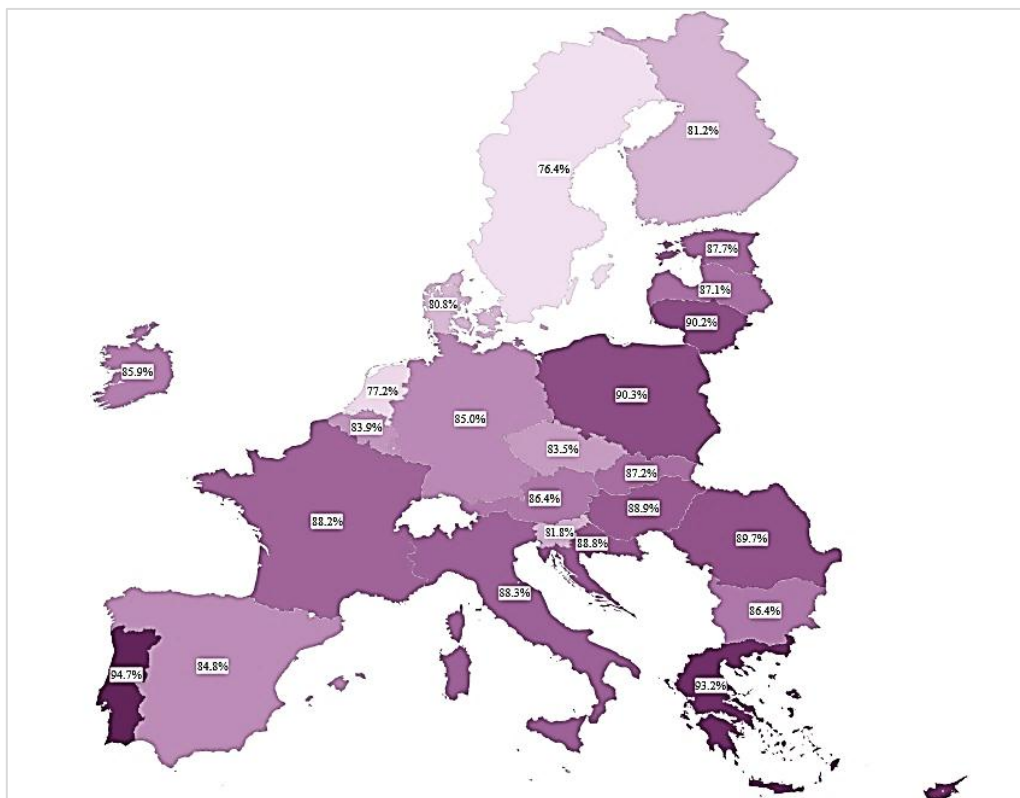
Table 1. *Variables description*

No.	Variable	Codification
Demographic variables		
1.	Sex	F – reference and M
2.	Difficulties encountered while paying bills in the last 12 months	Always & sometimes – reference and Almost never and never
3.	Age	15 – 24 – reference; 25 – 39; 40 – 54; over 55 years
4.	Occupation	Employee – reference; entrepreneur; no occupation
5.	Adults living in the household (over 15 years)	one adult – reference; 2 adults; 3 adults; more than 4 adults
6.	Provenience region	West Europe – reference; North Europe; South Europe, Central and Eastern Europe
Independent variables		
7.	Measures announced by the EU - Economic sanctions against the Russian government, companies and individuals	Disagree and Agree
8.	Measures announced by the EU - Financing the purchase and supply of military equipment to Ukraine	Disagree and Agree
9.	Measures announced by the EU - Providing humanitarian support to the people affected by the war	Disagree and Agree
10.	Economic situation of the EU	Bad and Good
11.	The EU should continue to take actions to reduce its dependency on Russian gas and oil as soon as possible	Disagree and Agree
12.	The war in Ukraine makes it more urgent for EU Member States to invest in renewable energy	Disagree and Agree
13.	The war in Ukraine makes it more urgent for EU Member States to invest in nuclear energy	Disagree and Agree
14.	The price of electricity should not depend on the price of gas	Disagree and Agree
15.	Actions to cut down the energy consumption and energy bills - Unplug electronic appliances when not in use	No and Yes
16.	Actions to cut down the energy consumption and energy bills - Reduce room temperature at home or work	No and Yes
Dependent variables		
17.	Rising energy prices have a significant impact on my purchasing power	Disagree and Agree

The Flash Eurobarometer 514 – EU’s Response to the Energy Challenges is used to identify the energy vulnerabilities among Europeans and consumers’ energy consumption behavior in the energy crisis and the Ukrainian war. The profile of energetic vulnerable consumers is defined using sixteen independent variables from Flash Eurobarometer 514, depicted in Table 1. Some variables were recoded, and irrelevant responses such as „Do not know”, along with the missing responses, were excluded from the analysis. Finally, the dataset contains 16054 observations. The sample is representative, and the geographical coverage is homogenous among the EU27 countries. The data was collected between the 23rd of November 2022 and the 30th of November 2022.

Main findings

According to Figure 1, European citizens faced difficulties caused by the increasing price of energy and electricity. The effects of increasing energy prices are manifested among Portuguese citizens (94.7% of them are affected by the price increase in the energy sector), Greek citizens (the purchasing power of 93.2% of them is impacted by the changes that appeared in the energy sector), citizens of Cyprus (93.1%), Polish citizens (90.3%) and Lithuanian citizens (90.2%). An overview of the questions investigated can be found in the Appendix.

Figure 1. *The impact of rising energy prices on purchasing power by the country of origin*

Source: Own computation in Excel using Flash Eurobarometer 514.

Table 2 summarizes the logistic regression estimates. Multiple logistic regression models containing various explicative variables were employed, but the final model was chosen according to the coefficients' significance and their economic interpretability. Also, to select the best model, we employed a robust analysis and checked the impact of adding or excluding some variables from the model. The minimal AIC value characterizes the selected model.

Over time, women faced various difficulties related to their participation and integration in the educational system or on the labour market, which was reflected directly on their incomes. Different barriers affect their well-being, such as accessing well-paid jobs or even leadership positions. There were significant differences between women and men in these areas, but gradually they decreased. In the same manner, at least in a crisis context, women are more inclined to be affected by the changes manifested by these shocks. Some examples are the energy crisis and the Ukrainian war, which are characterised by increasing energy prices. Considering these aspects, women tend to be more energy vulnerable as their purchasing power is highly influenced by rising energy prices compared to men. EPRS (2023) highlights similar characteristics of energy-vulnerable women, which are exacerbating the existing disparities between them and men.

Individuals who encountered constant or periodic difficulties while paying the energy and electricity bills in the last 12 months are more affected by the increase in energy prices compared to those who never faced financial problems related to paying bills. Specifically, these consumers are 62.2% more likely to be classified into the energy-vulnerable category, whose purchasing power is extremely impacted by the intensification of prices. Identifying energetic vulnerable customers can be assessed by considering the difficulties observed while paying their bills as a proxy for their income. Considering this, we can conclude that customers who face financial problems while paying their bills are more likely to belong to the lower-income segments. The same results were obtained by Van de Hove et al. (2022), according to which lower-income households are more prone to be energy-poor.

Rising energy prices affect all age groups except those aged 25–39. Individuals over 55 are the most affected, being 149.2% more likely to experience reduced purchasing power, followed by those aged 40–54, who are 130% more likely to be classified as energy vulnerable compared to the youngest age group.

We can observe that entrepreneurs tend to be less affected by the increase in energy and electricity prices than those employed. On the other hand, there are no significant differences between employees and people without a professional activity regarding the impact of increasing electricity prices on their purchasing power.

Household composition is a key factor in identifying possible energy vulnerabilities among European consumers. So, the purchasing power of households composed of two people over 15 years is impacted by energy price intensification. The purchasing power of households composed of more than four adults is not influenced by the price intensifications reflected in the energy and electricity sectors compared to single-adult households. Households mainly consisting of three adults are 125.8% more likely to be classified into the energy-vulnerable category than single-adult households. Similar results are reported by Bardazzi et al. (2023); according to them, the household dimension directly impacts the probability of including the households in the energy-vulnerable and energy-poor customers' categories.

Table 2. Logistic regression estimates

Variable	Coefficient	Odds ratio
Sex (F – reference)	-0.087*	0.916
Difficulties encountered while paying bills in the last 12 months (Most of the time & time to time – reference)	-0.971***	0.378
Age (15 – 24 years – reference)		
▪ 25 – 39 years	0.052	1.053
▪ 40 – 54 years	0.264***	1.302
▪ over 55 years	0.400***	1.492
Occupation (employee – reference)		
▪ Entrepreneur/Self-employed	-0.268***	0.764
▪ Without a professional activity	-0.008	0.991
Number of adults (over 15 years) living in household (one person – reference)		
▪ 2 persons	0.164***	1.178
▪ 3 persons	0.230***	1.258
▪ > 4 persons	0.138	1.149
Provenience region (West Europe – reference)		
▪ South Europe	0.463***	1.590

Variable	Coefficient	Odds ratio
▪ North Europe	-0.300***	0.740
▪ Eastern and Central Europe	0.378***	1.460
Measures announced by the EU – Economic sanctions against the Russian government, companies and individuals	-0.180**	0.834
Measures announced by the EU – Financing the purchase and supply of military equipment to Ukraine	-0.229**	0.795
Measures announced by the EU – Providing humanitarian support to the people affected by the war	0.716***	2.046
Economic situation of the EU	-0.384***	0.680
The EU should continue to take actions to reduce its dependency on Russian gas and oil as soon as possible	0.427***	1.534
The war in Ukraine makes it more urgent for EU Member States to invest in renewable energy	0.430***	1.537
The war in Ukraine makes it more urgent for EU Member States to invest in nuclear energy	0.421***	1.524
The price of electricity should not depend on the price of gas	0.999***	2.717
Actions to cut down the energy consumption and energy bills – Unplug electronic appliances when not in use	0.351***	1.421
Actions to cut down the energy consumption and energy bills – Reduce room temperature at home or work	0.228***	1.257
Intercept	-0.313***	0.731
AIC	11241	

Note: *** - 1% significance level; ** - 5% significance level; * - 10% significance level.

Source: Authors' computation in RStudio 4.1.

Another important demographic factor that strengthens the possibility of European customers being affected by energy poverty is the region of origin. The most affected regions are Southern, Central and Eastern Europe. Southern European citizens are 159% more likely to be affected by the energy price amplification than Western European citizens. Otherwise, Northern Europeans are characterized by lower chances of being influenced by price modifications in the energy and electricity sectors.

The EU's financial measures announced as a response to the Ukrainian Russian war, like economic sanctions against the Russian government, companies and citizens and financing the acquisitions and providing the necessary military equipment to Ukraine, are associated with reducing the customer's chances to be affected by the intensification of prices. On the other hand, Europeans agreeing with the human support offered by the EU to Ukrainian war victims are more prone to be vulnerable to any price changes on electricity and energy sectors.

European citizens, considering that the EU's economic situation is prosperous, tend to be less affected by the expansion of prices into the energy and electricity markets than the citizens who have a negative view of the actual situation of the European economy.

It is widely known that Russia is one of the biggest gas producers worldwide. Many European countries are dependent on Russian gas and oil. Even before the war started, many European countries started to reduce their dependency and focus on more friendly environmental sources, like renewable energy. Since the war started three years ago, EU member states have been more eager to reduce their dependency on Russian resources. In this manner, Europeans who agree with the EU initiatives on reducing dependency on Russian gas and oil are 153.4% more likely to be affected by rising energy prices, unlike the reference group that does not consider it essential that the EU should cut down their reliance on Russian resources. As mentioned, the Ukrainian war has serious implications

for the diversification of energy sources and the energy needs of EU member states' security. So, individuals considering the Ukrainian war a faster trigger to implement investments in renewable and nuclear energy manifest a considerable reduction of their purchasing power compared to those who do not consider these measures urgent and necessary. In this context, the data can be interpreted as a signal of public demand for stronger and sustained EU action on energy transition. The support expressed by energy-vulnerable citizens for renewable and nuclear investments suggests a recognition of the need to reduce dependency on volatile fossil fuel markets and to build a more resilient, sustainable energy system. This further underlines the importance of continuing and intensifying EU efforts aligned with the objectives set out in the REPowerEU plan and Sustainable Development Goal 7.

Europeans' view on the dependency that should exist or not between electricity prices and gas prices plays an important role in identifying energy vulnerabilities among customers. Europeans who agree that electricity prices should not depend on gas prices are 271% more likely to be influenced by a possible expansion of electricity prices than citizens who recognize that both prices are dependent on each other. In line with the European Commission's initiatives to reform the electricity market, this finding reinforces the demand for structural decoupling of electricity and gas prices, especially to protect consumers already experiencing high levels of energy stress. Revising the marginal pricing system to better reflect the actual cost of renewable energy generation would not only enhance fairness but also improve resilience in times of energy shocks (Fabra, 2023).

Individuals who adopt energy-saving behaviors, such as unplugging electronic devices or lowering indoor temperatures, are significantly more likely to report that rising energy prices have impacted their purchasing power. Specifically, those who unplug appliances are 142.1% more likely to feel economic strain, while those who reduce room temperatures are 125.7% more likely to experience diminished purchasing power. These results imply that these practices are not proactive behaviors reflected by environmental concern, but reactive coping mechanisms employed by energy-vulnerable households. In this regard, behavioral indicators may reflect more indirect measures of energy stress and economic hardship.

Energetic vulnerable profile includes mainly women, individuals who faced difficulties in the last 12 months while paying bills, adults over 40 years, households composed of two or three persons, Southern, Eastern and Central Europeans and consumers who take active measures to reduce their energy consumption and their bills, like unplugging the electrical devices when are not used and decreasing the temperature in rooms at home or even at work.

Conclusion

Using logistic regression and Flash Eurobarometer 514, we aimed to identify key characteristics that illustrate the vulnerabilities faced by European citizens in the context of the energy crisis and war between Ukraine and Russia. As already stated, Russia is one of the most important oil and gas producers and international exporters. The war started in 2022 between Ukraine and Russia, exacerbating the existing energy problems faced by European countries. The EU's member states started various initiatives to reduce their

reliance on Russian oil and gas resources. In this context, the existing disparities among Europeans are amplified by the increasing energy prices. At the same time, their purchasing power is also threatened, and their well-being is affected. We identified some demographic characteristics commonly distributed among European citizens. The profile of affected people includes women, individuals over 40 years, low-income households, middle-sized households and citizens of Southern, Eastern and Central Europe. Already affected citizens are taking different actions like unplugging unused electronic devices or reducing the room's temperature to reduce their consumption and bills. Addressing energy poverty in a war-driven crisis context requires not only technical solutions but also structural reforms that center on equity, inclusivity, and systemic recognition of marginalized populations. Energy transitions must be just transitions, ensuring no one is left behind — especially those already most burdened by economic and geopolitical instability.

Our findings are consistent with recent studies highlighting energy vulnerabilities among European citizens. However, the analysis should be extended by identifying behavioral coping mechanisms and integrating citizens' perceptions of the ongoing war. Some limitations are characterizing this research, like the period when the interviews were collected at an early stage of the energy crisis, results may not capture more recent adaptive behaviors or policy effects, the Eurobarometer should be retaken to reflect the latest changes in the customers' behavior; the lack of studies focused on the energy crisis and the social implications along with the identification of vulnerable groups in a multi-crisis context.

Future research directions based on this study should consider using machine learning techniques to classify customers into the vulnerable category based on their characteristics or to identify the principal factors defining the vulnerable energy group. Better results should be achieved using various classifiers, such as decision trees or even random forest techniques, which are particularly effective at capturing nonlinear relationships and complex interactions between variables.

Acknowledgment

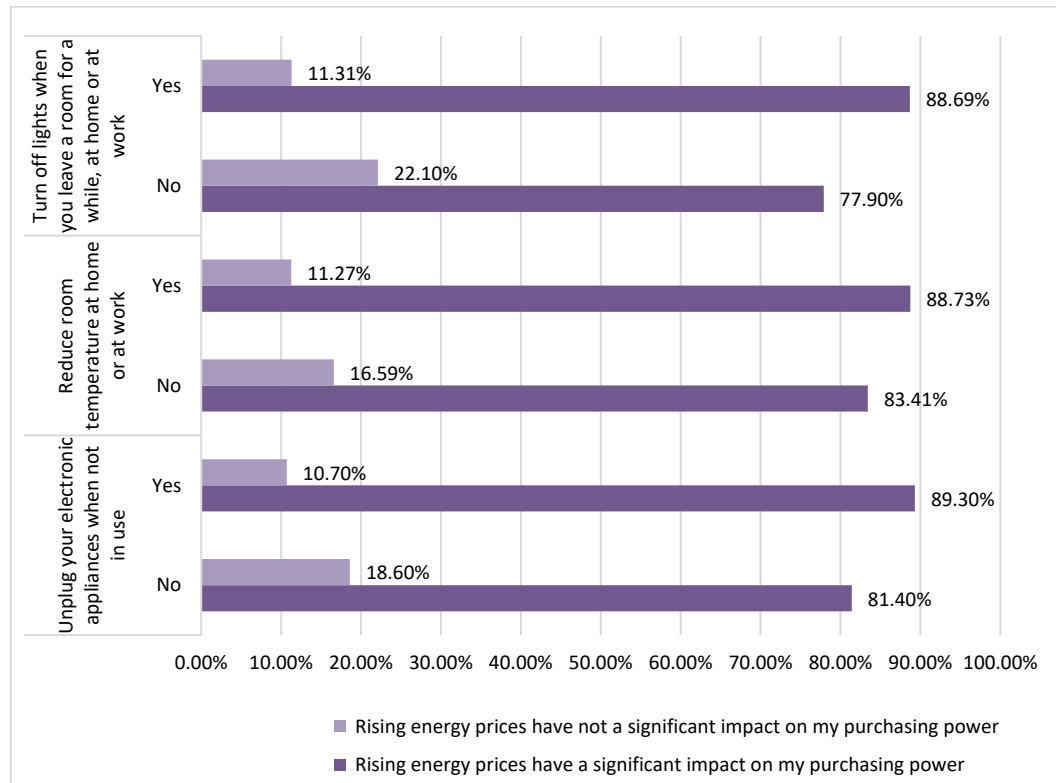
Part of this work was supported by the NUCLEU Program, funded by the Romanian Ministry of Research, Innovation, and Digitalization (Project PN 22100201).

References

- Andrews, J., Isański, J., Nowak, M., Sereda, V., Vacroux, A. and Vakhitova, H. (2023). Feminized forced migration: Ukrainian war refugees. *Women's Studies International Forum*, [online] 99, p. 102756. doi: <<https://doi.org/10.1016/j.wsif.2023.102756>>
- Antje, K., Przemysław, P., Mariusz, B. and Ilona, O.M. (2023). Calling energy inequalities into the transition agenda. *Energy Research & Social Science*, [online] 101, p. 103144. doi: <<https://doi.org/10.1016/j.erss.2023.103144>>
- Ban, M., Brajković, J., Buzarovski, S., Lončarević, Š., Maras, J., Robić, S., Stupin, K., Šantalab, D., Toš, A. and Zidar, M. (2021). *Study on Addressing Energy Poverty in the Energy Community Contracting Parties*.

- Capetillo-Ordaz, N.B., Martín-Consuegra, F., Alonso, C., Terés-Zubiaga, J. and Sesil Koutra (2024). Inclusivity in urban energy transitions: A methodological approach for mapping gendered energy vulnerability. *Energy research & social science*, 109, pp. 103426–103426. doi: <<https://doi.org/10.1016/j.erss.2024.103426>>
- Che, X., Zhu, B. and Wang, P. (2021). Assessing global energy poverty: An integrated approach. *Energy Policy*, 149, p. 112099. doi: <<https://doi.org/10.1016/j.enpol.2020.112099>>
- Cui, L., Yue, S., Nghiem, X.-H. and Duan, M. (2023). Exploring the risk and economic vulnerability of global energy supply chain interruption in the context of Russo-Ukrainian war. *Resources Policy*, [online] 81, p. 103373. doi: <<https://doi.org/10.1016/j.resourpol.2023.103373>>
- EnR (2019). Energy Poverty in the European Union. *Position paper*. European Energy Network. Available at: <<https://enr-network.org/wp-content/uploads/ENERGYPOVERTY-EnRPositionPaper-January-2019.pdf>> [Accessed 20 February 2025].
- Eurodiaconia (2023). *Energy poverty in Europe*.
- European Commission: Flash Eurobarometer 514. EU's response to the energy challenges. Survey requested by the European Commission, Directorate-General for Communication and coordinated by the Directorate-General for Communication (DG COMM "Media Monitoring and Eurobarometer" Unit). Brussels, 2022. <doi:10.2775/00780>
- Eurostat (2023). *Archive: Age of young people leaving their parental household – Statistics Explained*. [online] Europa.eu. Available at: <https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Age_of_young_people_leaving_their_parental_household&direction=next&oldid=590885> [Accessed 9 Sep. 2024].
- Fabra, N. (2023). Reforming European electricity markets: Lessons from the energy crisis. *Energy Economics*, [online] 126, p. 106963. doi: <<https://doi.org/10.1016/j.eneco.2023.106963>>
- Gujarati, D.N. and Porter, D.C. (2009). *Basic econometrics*. Boston: Mcgraw-Hill.
- Kröger, M., Longmuir, M., Neuhoﬀ, K. and Schütze, F. (2023). The price of natural gas dependency: Price shocks, inequality, and public policy. *Energy Policy*, [online] 175, p. 113472. doi: <<https://doi.org/10.1016/j.enpol.2023.113472>>
- Moniek de Jong (2024). Wind of change: the impact of REPowerEU policy reforms on gas security. *Policy studies*, pp. 1-19. doi: <<https://doi.org/10.1080/01442872.2024.2302442>>
- Pisică, A., Davidescu, A.A., Agafiței, M.D., Bolboacă, M.B. and Gheorghe, M. (2024). Transition Trajectory: VAR Projections of Romania's Shift to Renewable Energy. *Journal of Social and Economic Statistics*, 13(1). doi: <<https://doi.org/10.2478/jses-2024-0004>>
- Rossella Bardazzi, Charlier, D., Legendre, B. and Maria Grazia Pazienza (2023). Energy vulnerability in Mediterranean countries: A latent class analysis approach. *Energy economics*, 126, pp. 106883-106883. doi: <<https://doi.org/10.1016/j.eneco.2023.106883>>
- UN Women (2022). *Global Gendered Impacts of the Ukraine Crisis on Energy Access and Food Security and Nutrition*.
- van Hove, W., Dalla Longa, F. and van der Zwaan, B. (2022). Identifying predictors for energy poverty in Europe using machine learning. *Energy and Buildings*, 264, p. 112064. doi: <<https://doi.org/10.1016/j.enbuild.2022.112064>>
- Zakariás, I., Feischmidt, M., Gerő, M., Morauszki, A., Zentai, V. and Zsigmond, C. (2023). Solidarity with Displaced People from Ukraine in Hungary: Attitudes and Practices. *Journal of international migration and integration*. doi: <<https://doi.org/10.1007/s12134-023-01096-8>>
- Zhao, J., Dong, K., Dong, X. and Shahbaz, M. (2022). How renewable energy alleviate energy poverty? A global analysis. *Renewable Energy*, 186, pp. 299–311. doi: <<https://doi.org/10.1016/j.renene.2022.01.005>>

Appendix

Figure 2. Relationship between rising energy prices and energy-saving behaviors

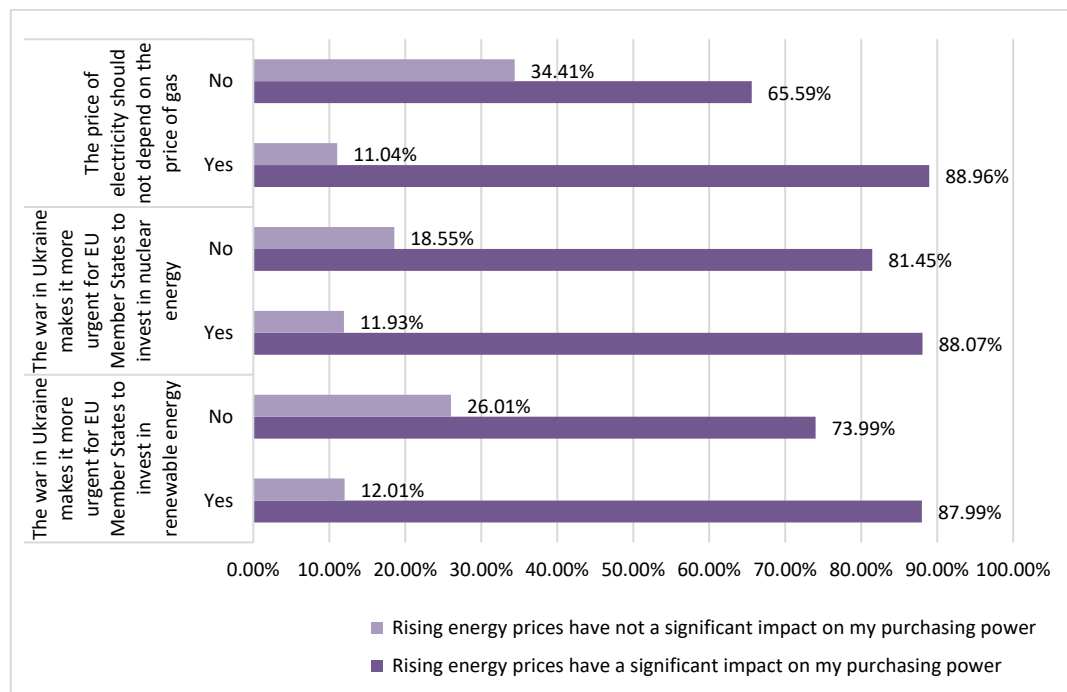
Source: Own computation in Excel using Flash Eurobarometer 514.

Table 3. The proportion of respondents who chose two energy-saving methods

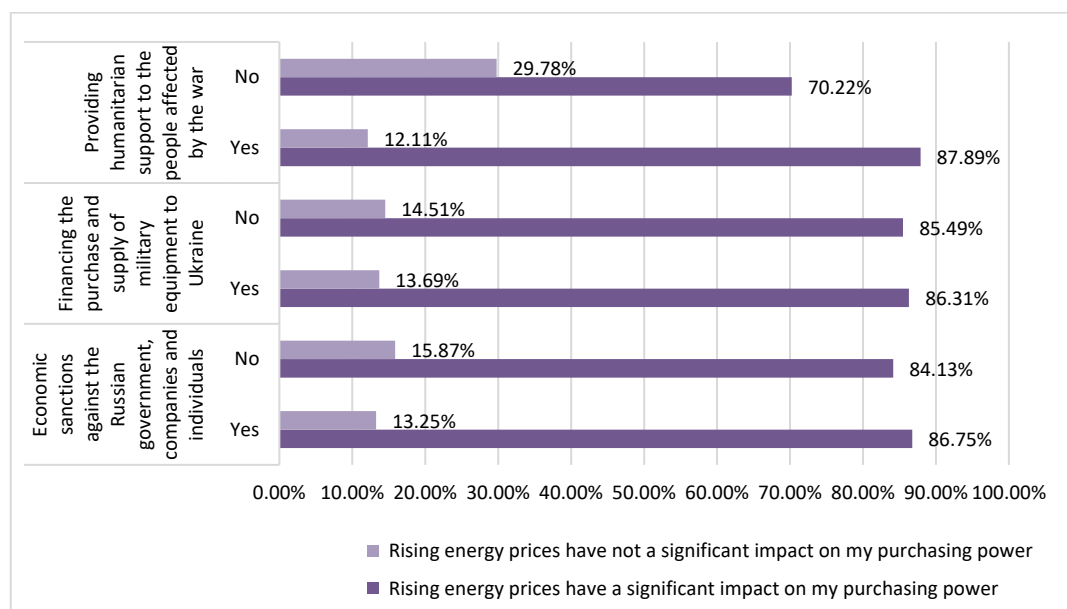
	Unplug your electronic appliances when not in use	Reduce room temperature at home or at work	Turn off lights when you leave a room for a while, at home or at work
Unplug your electronic appliances when not in use	-	36.86%	54.60%
Reduce room temperature at home or at work	36.86%	-	46.14%
Turn off lights when you leave a room for a while, at home or at work	54.60%	46.14%	-

Note: This table presents the percentage of respondents who reported using two energy-saving methods together.

Source: Own computation in Excel using Flash Eurobarometer 514.

Figure 3. *The relationship between rising prices and purchasing power in the context of the war in Ukraine*

Source: Own computation in Excel using Flash Eurobarometer 514.

Figure 4. *Relationship between rising energy prices and attitudes toward the war*

Source: Own computation in Excel using Flash Eurobarometer 514.

Empirical analysis of the relationship between FDI and economic growth in Morocco

Anas MOSSADAK

Mohammed V University, Morocco
a.mossadak@um5r.ac.ma

Abstract. *This study examines the relationship between Foreign Direct Investment (FDI) and economic growth in Morocco. A VAR model and Granger causality tests, applied to World Bank data (1970–2024), reveal unidirectional causality from FDI to growth: a 1% shock to FDI generates a cumulative 0.3% effect on GDP, confirming FDI's role as an economic growth determinant. Morocco has enhanced its attractiveness through structural reforms (Tanger Med, the Green Morocco Plan, etc.) and significant sectoral diversification. However, challenges persist: post-Covid vulnerability, reliance on traditional sectors (tourism, phosphates, light industry), and institutional shortcomings. The findings call for strengthening governance, prioritizing technology-driven FDI, and investing in education to maximize spillover effects.*

Keywords: FDI, economic growth, Morocco, VAR model, Granger causality.

JEL Classification: O1, O16.

Introduction

Foreign Direct Investment (FDI) plays an important role in the development strategies of emerging economies, particularly in an era of accelerated globalization. Recognized as a lever for economic growth due to its threefold role—technology transfer, job creation, and integration into global value chains—FDI is the subject of intense academic and policy debates. However, its impact remains ambiguous, oscillating between opportunities for modernization and risks of structural dependency, as illustrated by theoretical divergences between neoclassical approaches (Solow, 1956; Borensztein et al., 1998) and structuralist critiques (Prebisch, 1950; Frank, 1967).

Morocco serves as a compelling case study to explore this issue. Since the 1980s, the Kingdom has undergone a remarkable transition from a protectionist economy to a regional hub open to international capital, driven by ambitious reforms (free zones, mega-industrial projects) and targeted sectoral diversification (automotive, renewable energy, digitalization). While FDI inflows surged from 2.6 billion in 2000 to nearly 4 billion in 2023, their tangible contribution to national economic growth remains underexplored.

This study aims to empirically analyze the relationship between FDI and economic growth in Morocco over the period 1970–2024. Using a VAR (Vector Autoregressive) model and Granger causality test, we examine two central hypotheses: (1) Does FDI significantly stimulate Morocco's GDP? and (2) Is there reverse causality, whereby growth attracts more FDI?

The results reveal unidirectional causality from FDI to economic growth, with a cumulative 0.3% effect on GDP following a 1% shock FDI. However, this relationship is conditional on structural factors, such as institutional quality and sectoral concentration—manufacturing and technology-driven FDI demonstrating greater spillover effects than extractive industries.

This study is structured into four parts. The first and second section synthesizes the theoretical and empirical foundations of the FDI-growth nexus. The third section traces the evolution of FDI in Morocco, contextualized by economic and geopolitical reforms. Finally, the last section presents the econometric analysis and discusses its implications for public policy.

1. Theoretical Literature Review

The relationship between FDI and economic growth is a central topic in development studies. Since the pioneering work of Hymer (1960) and Dunning (1977), this relationship has been analyzed from various angles, reflecting both convergent and conflicting perspectives. This literature review synthesizes key theories, transmission mechanisms, and controversies.

Neoclassical theories posit that FDI stimulates economic growth through physical capital accumulation, technology transfer, and productivity improvements (Solow, 1956). According to this view, FDI addresses the savings gap in developing countries (Chenery & Strout's, 1966) and introduces advanced technologies, thereby reducing productivity gaps with developed nations.

Conversely, the structuralist school (Prebisch, 1950 and Singer, 1950) and dependency theory (Frank, 1967) emphasize the asymmetric effects of FDI. These frameworks argue that multinational corporations exploit host countries' resources, exacerbate sectoral imbalances (by favoring extractive industries), and create "technological dependence," limiting long-term growth spillovers.

Dunning's (1977) OLI framework (Ownership, Location, Internalization) offers a multidimensional analysis: FDI depends on firms' specific advantages (e.g., intellectual property), host-country characteristics (political stability, infrastructure), and internalization costs. This paradigm highlights that FDI's growth impact is conditioned by the host country's absorptive capacity.

Endogenous growth models (Romer, 1990; Grossman & Helpman, 1991) integrate FDI as a vector of technological diffusion. Borensztein et al. (1998) demonstrate that FDI generates positive externalities (spillovers) via workforce training, imitation by local firms, and access to global networks. However, these effects depend on human capital levels (Xu, 2000): a minimum threshold is required to internalize imported technologies.

Theoretical studies also underscore the interplay between FDI and institutions. Alfaro et al. (2004) argue that FDI fosters inclusive growth only if the host country has a developed financial system, transparent governance, and strong property rights. Similarly, trade openness (Balasubramanyam et al., 1996) and competition policies (Aitken & Harrison, 1999) amplify FDI spillovers.

The question of reverse causality remains debated: does economic growth attract FDI (via expanded markets), or vice versa? Hansen & Rand's (2006) VAR models conclude bidirectional causality, but with regional variations. Sectoral differences also matter: manufacturing and high-tech FDI yield more positive effects than extractive industries (Moran, 2011) and middle-income countries benefit more from FDI than least-developed ones due to higher absorptive capacity (Durham, 2004). Critics further warn of crowding-out effects (multinationals displacing local firms) and capital volatility (Carkovic & Levine, 2005), as well as reduced public revenues from excessive tax incentives in fiscal competition (Klemm & Van Parys, 2012).

In conclusion, the FDI-growth relationship remains complex and contingent. While neoclassical and endogenous growth theories emphasize FDI's transformative potential, structural critiques and empirical limitations remind us that its benefits are neither automatic nor universal.

2. Empirical Literature Review

FDI is supposed to stimulate growth through multiple channels: technology transfer and positive spillovers, human capital accumulation, financial development, and institutions and governance. Multinational firms introduce advanced technologies and managerial practices, fostering spillovers for local firms (Borensztein et al., 1998; Xu, 2000). FDI also incentivizes host countries to invest in education to meet skill demands (Borensztein et al., 1998; Alfaro et al., 2004). Additionally, FDI enhances credit access and market liquidity

(Alfaro et al., 2004; Hermes & Lensink, 2003). Finally, FDI drives institutional reforms (property rights protection, anti-corruption measures), creating a growth-conducive environment (Busse & Groizard, 2008; Azman-Saini et al., 2010).

Numerous studies confirm FDI's positive growth impact, particularly in developing countries (DCs). Analyzing 69 DCs, Borensztein et al. (1998) find that FDI stimulates growth only when a minimum human capital threshold exists. Alfaro et al. (2004) show FDI accelerates growth in countries with developed financial markets, enabling capital reallocation to productive sectors. A meta-analysis of 88 studies (Durham, 2004) concludes positive effects dominate, especially when FDI targets technology-intensive sectors.

However, some studies challenge this consensus. Carkovic & Levine (2005) find no significant FDI-growth link after controlling for endogeneity (high-growth countries attract more FDI). Hansen & Rand (2006), using long-term causality analysis, reveal unidirectional relationships, where growth attracts FDI, but the reverse is inconsistent. Ayanwale (2007) and Adams (2009) emphasize sectoral heterogeneity: extractive industries (oil, mining) yield fewer spillovers than manufacturing.

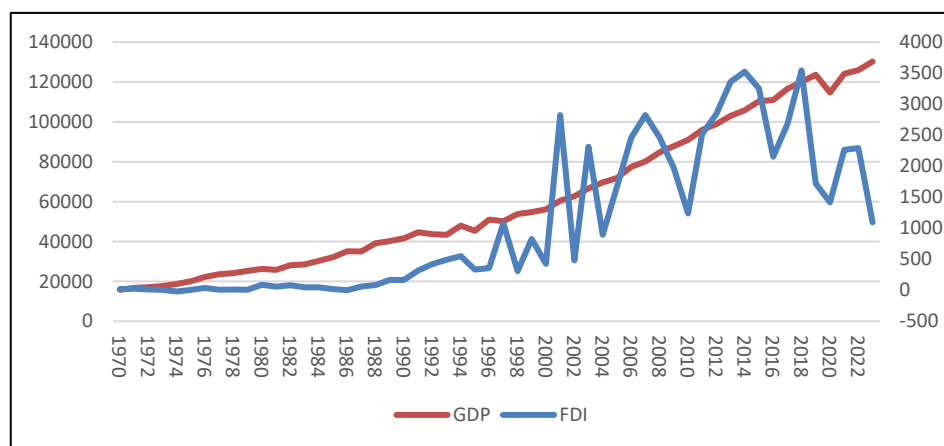
The literature underscores that FDI benefits depend on structural and institutional factors. Middle-income countries gain more from FDI than least-developed ones due to superior absorptive capacities (Blomström et al., 1994; Wang, 2020). Transparent governance and strong property rights amplify FDI spillovers (Busse & Groizard, 2008; Azman-Saini et al., 2010). Open economies, where local firms integrate into global value chains, also see stronger FDI impacts (Balasubramanyam et al., 1996; Jude & Levieuge, 2017). Targeted industrial policies (R&D subsidies, infrastructure) further enhance FDI's growth effects (Rodrik, 2004; Crespo & Fontoura, 2007).

3. Evolution of FDI in Morocco

Since the 1970s, Morocco has undergone a major economic transformation, shifting from a protectionist economy to a regional hub open to international investment. FDI has played a pivotal role in this transition, driven by structural reforms, sector-specific strategies, and gradual integration into the global economy. This section revisits five decades of evolution.

Following independence in 1956, Morocco adopted a state-led, protectionist economic model. Key sectors (energy, mining, agriculture) were state-controlled, with a focus on import substitution. FDI was limited, perceived as a threat to national sovereignty. Only a few mining (phosphates) and agro-industrial projects attracted foreign capital, notably from France. Geopolitical tensions (Cold War) and inadequate infrastructure further hindered investment.

The 1980s debt crisis pushed Morocco to sign agreements with the IMF and World Bank. The country began economic liberalization: devaluation of the dirham, subsidy reductions, and partial privatizations. FDI started flowing into tourism and textiles, incentivized by low-cost labor. However, bureaucracy and regional instability limited attractiveness.

Graph 1. *Evolution of GDP and FDI in Morocco (in Millions of US Dollars)*

Source: World Bank.

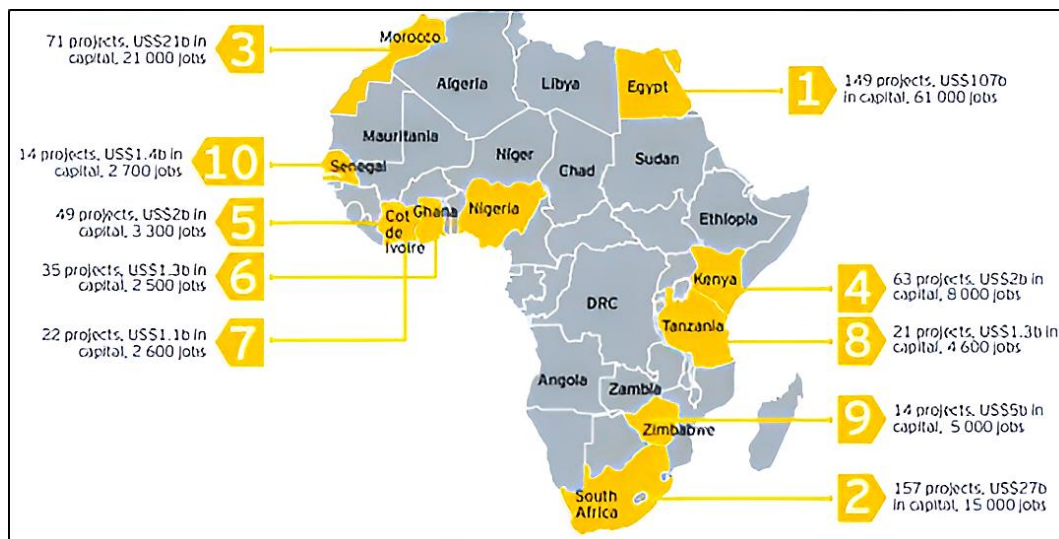
The 1990s marked a turning point with international openness. Morocco signed an association agreement with the EU (1996) and joined the WTO (1995). Privatizations accelerated (telecoms, banking), attracting firms like Vivendi and Telefónica. FDI concentrated in telecommunications, tourism, and light industry. The country became an export platform to Europe, leveraging competitive production costs.

King Mohammed VI's accession in 1999 spurred a new dynamic. The Kingdom launched mega-projects: Tanger Med (port inaugurated in 2007), Export Processing Zones (Casablanca Finance City), and sectoral plans (Emergence for industry, Green Morocco Plan for agriculture). FDI surged from 2.6 billion in 2000 to 3.8 billion in 2008. Key sectors emerged: automotive (Renault-Nissan's 2012 plant), aerospace, and renewables (Noor Solar Complex, operational by 2013). The Moroccan Investment Development Agency (AMDIE), established in 2009, streamlined investor support.

Despite the Arab Spring, Morocco maintained stability through constitutional reforms (2011). FDI diversified: automotive accounted for 34% of exports by 2019, while aerospace attracted firms like Boeing and Safran. Tourism (10% of GDP) and green energy (52% renewable target by 2030) bolstered appeal. Tanger Med became Africa's largest port, symbolizing Morocco's integration into global value chains.

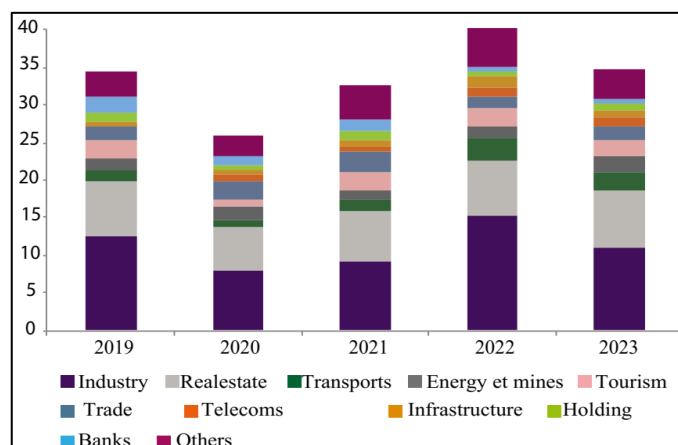
The Covid-19 pandemic and global energy crisis temporarily slowed FDI. However, Morocco pivoted to innovative niches: electric vehicles, green hydrogen (Dakhla projects), and digitalization (100,000 digital jobs target by 2025). Rejoining the African Union (2017) and ratifying the African Continental Free Trade Agreement (AfCFTA) positioned the country as a bridge between Europe and Africa. Challenges endure: administrative streamlining, skills development, and regional competition (Egypt, Tunisia).

From 1970 to 2023, Morocco transformed its economy through proactive FDI strategies. Evolving from protectionism, it has become a strategic partner for multinationals, blending political stability, bold reforms, and long-term sectoral vision. Future success hinges on balancing inclusive growth, ecological transition, and deeper African integration.

Figure 1. Top 10 of most FDI attractive countries in Africa (Billions of US Dollars) in 2023

Source: CNUCED.

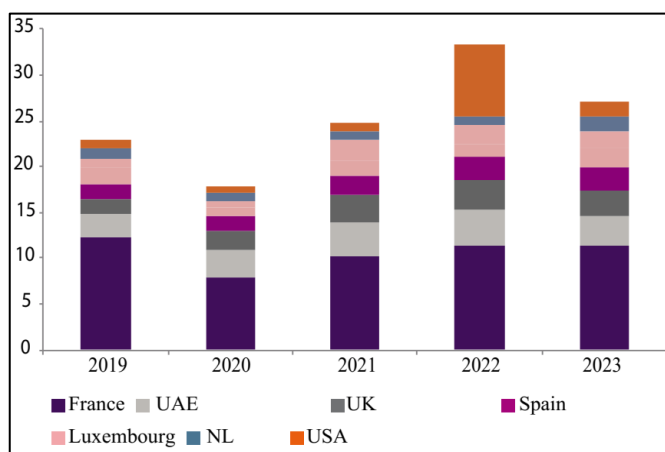
Morocco is the top 3 destination for foreign direct investment in Africa (2023). Nations such as Egypt, Nigeria, South Africa, and Kenya also feature prominently, each leveraging distinct advantages: natural resources (Nigeria's hydrocarbons, DRC's minerals), developed infrastructure (South Africa's ports, Egypt's industrial zones), or institutional stability (Rwanda). Morocco, in particular, stands out due to its open economic policies, exemplified by structural reforms (administrative streamlining, free trade zones) and flagship projects like the Tanger Med port complex. This logistics hub, combined with free trade agreements with the EU and the United States, cements Morocco's role as a bridge between Europe and Africa. These factors underpin its consistent presence in the top 10, despite heightened regional competition.

Graph 3. FDI by sectors of activity (in Billions of Moroccan Dirhams)

Source: Office des Changes

Investments in energy and mining (notably renewables and phosphate exploitation) represent a major pillar, supported by government initiatives like the Moroccan Solar Plan. The industrial sector, driven by automotive (Renault plant in Tangier) and aerospace, also demonstrates strong momentum, with an average annual growth of 8% between 2019 and 2023. Conversely, tourism and real estate, despite post-COVID recovery, remain vulnerable to external shocks, as evidenced by their collapse in 2020 (-70% for tourism). Telecommunications emerge as a resilient sector, benefiting from accelerated digitalization during the pandemic. This sectoral snapshot reflects an economy in transition, striving to balance reliance on traditional resources with technological innovation.

Graph 4. *The most contributors to FDI in Morocco (in Billions of Moroccan Dirhams)*



Source: Office des Changes

France remains the leading partner in terms of FDI, with longstanding investments in banking, industry, and energy (e.g., TotalEnergies' wind projects). The United Arab Emirates have expanded their influence through sovereign funds like ADQ, channeling significant capital into luxury real estate and infrastructure. The United States has strengthened its position via technology partnerships (Microsoft agreements, data centers) and agribusiness collaborations. Spain, despite a 2020 downturn linked to tourism dependency, is gradually reclaiming its role, particularly in energy interconnections. These trends reflect Morocco's deliberate strategy to reduce France's historical overrepresentation by fostering ties with Gulf and North American partners, balancing economic dependencies while enhancing sectoral and geopolitical resilience.

4. Estimation and results

Building on the methodology of Hansen & Rand (2006), we employ a bivariate VAR (Vector Autoregressive) model to analyze the relationship between foreign direct investment (FDI) inflows and economic growth in Morocco. Subsequently, Granger causality tests are applied to determine the direction of causality between these variables. The dataset comprises real GDP and FDI figures from 1970 to 2024, sourced from the World Bank database.

The unrestricted VAR model is specified as follows:

$$X_t = A(L)X_{t-1} + u_t$$

Where $X_t = [\Delta GDP, \Delta FDI]'$ where $A(L)$ is the lag operator and u_t is the model's error term. Before estimating the VAR model, it is necessary to test the stationarity of the GDP and FDI variables. For this purpose, we apply the Augmented Dickey-Fuller (ADF) test. The results of the test are presented below:

Table 1. *Test of stationnarity*

Null Hypothesis: D(GDP) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=10)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-10.14066	0.0000
Test critical values:		
1% level	-3.562669	
5% level	-2.918778	
10% level	-2.597285	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(FDI) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=10)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-12.64515	0.0000
Test critical values:		
1% level	-3.562669	
5% level	-2.918778	
10% level	-2.597285	

Source: Author's calculation.

The ADF test revealed that both series are stationary in first differences, indicating that they are integrated of the same order. Consequently, the VAR model is the most appropriate framework to analyze the relationship between the two variables. To determine the optimal lag order for the VAR model, we proceed with lag structure analysis using the following criteria:

Table 2. *Optimal lag order*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2204.978	NA	4.54e+36	90.08075	90.15797	90.11005
1	-2188.859	30.26451*	2.77e+36*	89.58609	89.81774*	89.67398
2	-2181.803	12.67189	2.44e+36	89.46136	89.84744	89.60784
3	-2175.975	9.991924	2.27e+36	89.38672*	89.92724	89.59179*
4	-2173.445	4.130107	2.43e+36	89.44673	90.14169	89.71040

Source: Author's calculation.

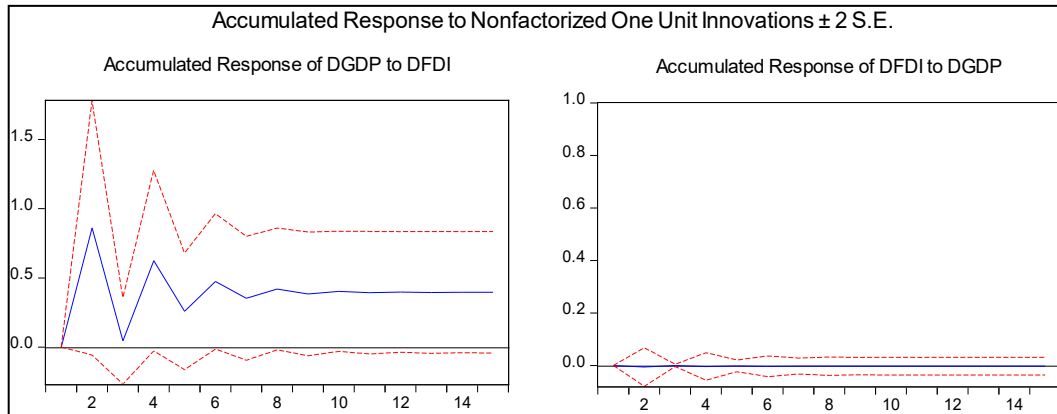
Lag order 1 minimizes the majority of selection criteria (3 out of 5). We therefore estimate a VAR(1) model to examine the relationship between GDP and FDI. The estimation results are presented below:

Table 3. *VAR estimation*

	DGDP	DFDI
DGDP(-1)	-0.402902 (0.13293) [-3.03090]	-0.006446 (0.03664) [-0.17592]
DFDI(-1)	0.861171 (0.45936) [1.87474]	-0.544576 (0.12662) [-4.30097]
C	3001.643 (435.296) [6.89564]	58.11472 (119.985) [0.48435]
R-squared	0.180231	0.287187
Adj. R-squared	0.146771	0.258093
Sum sq. resids	2.86E+08	21698053
S.E. equation	2414.179	665.4453
F-statistic	5.386481	9.870889
Log likelihood	-477.2738	-410.2635
Akaike AIC	18.47207	15.89475
Schwarz SC	18.58464	16.00732
Mean dependent	2185.248	20.63233
S.D. dependent	2613.586	772.5696
Determinant resid covariance (dof adj.)		2.28E+12
Determinant resid covariance		2.03E+12
Log likelihood		-884.3605
Akaike information criterion		34.24463
Schwarz criterion		34.46978
Number of coefficients		6

Source: Author's calculation.

The cumulative impulse response analysis reveals that foreign direct investment (FDI) exhibits a positive cumulative effect on Moroccan GDP. Specifically, a 1% increase in FDI leads to a cumulative 0.3% rise in GDP over the ten quarters following the shock. Conversely, a positive shock to GDP does not appear to have a significant positive impact on FDI inflows.

Figure 2. *Impulse response functions*

Source: author's calculation.

To strengthen our conclusions, we proceed to the Granger causality test to determine the direction of causality between FDI and GDP. This test examines whether past values of a variable X provide statistically significant information to predict the future values of another variable Y. If such predictive power exists, we conclude that X Granger causes Y.

Table 4. *Granger causality test*

Null Hypothesis:	Obs	F-Statistic	Prob.
DFDI does not Granger Cause DGDP	52	3.51465	0.0668
DGDP does not Granger Cause DFDI		0.03095	0.8611

Source: author's calculation.

The Granger causality test results confirm the conclusions drawn from the impulse response analysis. Specifically, the test indicates unidirectional causality running from FDI to GDP at a 10% significance level.

Conclusion

Foreign Direct Investment (FDI) represents a multidimensional challenge for emerging economies. This study, focused on Morocco, elucidates the complex mechanisms linking FDI to national economic dynamics. Empirical analysis, based on a VAR model and Granger causality test, confirms a significant unidirectional relationship between FDI and Moroccan GDP growth. A 1% shock to foreign capital inflows generates a cumulative 0.3% growth effect, corroborating neoclassical and endogenous growth theories (Borensztein et al., 1998; Romer, 1990).

The historical evolution of FDI in Morocco reveals a proactive strategy marked by institutional reforms (Tanger Med, Green Morocco Plan) and gradual economic diversification. However, challenges persist: post-pandemic volatility, reliance on

traditional sectors (tourism, phosphates), and gaps in vocational training hinder the structural transformation promised by FDI.

Finally, this work opens avenues for future research, including comparative analyses with other African emerging economies, integration of environmental variables (green FDI), and exploration of FDI's distributive effects on inequalities. In sum, while FDI remains an indispensable lever for Moroccan development, its sustainability hinges on balanced governance that harmonizes international competitiveness with socio-economic inclusion.

References

- Adams, S. (2009). Foreign Direct Investment, Domestic Investment, and Economic Growth in Sub-Saharan Africa. *Journal of Policy Modeling*. 31.6: 939-949.
- Aitken, B. and Harrison, A. (1999). Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela. *American Economic Review*. 89.3: 605-618.
- Alfaro, L. et al. (2004). FDI and Economic Growth: The Role of Local Financial Markets. *Journal of International Economics*. 64.1: 89-112.
- Ayanwale, A.B. (2007). FDI and Economic Growth: Evidence from Nigeria. *African Economic Research Consortium*. RP 165.
- Azman-Saini, W.N.W. et al. (2010). Foreign Direct Investment, Economic Freedom, and Economic Growth: International Evidence. *Economic Modelling*. 27.5: 1079-1089.
- Balasubramanyam, V.N. et al. (1996). Foreign Direct Investment and Growth in EP and IS Countries. *The Economic Journal*. 106.434: 92-105.
- Blomström, M. et al. (1994). Host Country Competition and Technology Transfer by Multinationals. *NBER Working Paper*. 4131.
- Borensztein, E. et al. (1998). How Does Foreign Direct Investment Affect Economic Growth? *Journal of International Economics*. 45.1: 115-135.
- Busse, M. and Groizard, J.L. (2008). Foreign Direct Investment, Regulations, and Growth. World Development. *Policy Research Working Paper*. WPS3882.
- Carkovic, M. and Levine, R. (2005). Does Foreign Direct Investment Accelerate Economic Growth? *World Bank Working Paper*.
- Chenery, H. and Strout, A. (1966). Foreign Assistance and Economic Development. *American Economic Review*. 56.4: 679-733.
- Crespo, N. and Fontoura, M.P. (2007). Determinants of FDI Spillovers: What Do We Really Know? *World Development*. 35.3: 410-425.
- Dunning, J.H. (1977). Trade, Location of Economic Activity, and the MNE: A Search for an Eclectic Approach. *Palgrave Macmillan*.
- Durham, J.B. (2004). Absorptive Capacity and the Effects of Foreign Direct Investment and Equity Foreign Portfolio Investment on Economic Growth. *European Economic Review*. 48.2: 285-306.
- Frank, A.G. (1967). Capitalism and Underdevelopment in Latin America. *Hispanic American Historical Review*. 48.3: 453-455.

- Grossman, G.M. and Helpman, E. (1991). *Innovation and Growth in the Global Economy*. MIT Press.
- Hansen, H. and Rand, J. (2006). On the Causal Links Between FDI and Growth in Developing Countries. *World Economy*. 29.1: 21-41.
- Hermes, N. and Lensink, R. (2003). Foreign Direct Investment, Financial Development, and Economic Growth. *Journal of Development Studies*. 40.1 :142-163.
- Hymer, S. (1960). *The International Operations of National Firms: A Study of Direct Foreign Investment*. MIT Press.
- Jude, C. and Levieuge, G. (2017). Growth Effect of FDI in Developing Economies: The Role of Institutional Quality. *World Economy*. 40.4: 715-742.
- Klemm, A. and Van Parys, S. (2012). Empirical Evidence on the Effects of Tax Incentives. *IMF Working Paper*. WP/09/136.
- Lucas, R.E. (1988). On the Mechanics of Economic Development. *Journal of Monetary Economics*. 22.1: 3-42.
- Moran, T.H. (2011). *Foreign Direct Investment and Development: Launching a Second Generation of Policy Research*. Peterson Institute.
- Prebisch, R. (1950). *The Economic Development of Latin America and Its Principal Problems*. CEPAL.
- Rodrik, D. (2004). Industrial Policy for the Twenty-First Century. *CEPR Discussion Paper*. 4767.
- Romer, P.M. (1990). Endogenous Technological Change. *Journal of Political Economy*. 98.5: 71-102.
- Singer, H.W. (1950). The Distribution of Gains Between Investing and Borrowing Countries. *American Economic Review*. 40.2: 473-485.
- Solow, R.M. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics*. 70.1: 65-94.
- Wang, Y. (2020). Foreign Direct Investment and Innovation in Emerging Markets. *World Development*. 12.1. 2312386.
- Xu, B. (2000). Multinational Enterprises, Technology Diffusion, and Host Country Productivity Growth. *Journal of Development Economics*. 62.2: 477-493.

Climate-driven monetary policy: a new Keynesian DSGE analysis for Ghana

Komlan Olakossan GBEGNON

Université de Kara, Togo
obiaraossan@gmail.com

Mikémina PILO

Université de Kara, Togo
pilomikemina15@gmail.com

Kounagbè Odilon Boris LOKONON

Université de Parakou, Benin
odilonboris@gmail.com

Abstract. *The objective of this research is to analyze the impact of climate change on Ghana monetary policy. To that end, World Development Indicators (WDI) and the Bank of Ghana (BoG) data are used within a New Keynesian Dynamic Stochastic General Equilibrium (NK-DSGE) framework. The results show that rising temperatures increase inflation (0.081-0.083), and reduce output (0.569-5.583%). The BoG may respond by raising the interest rates (0.448- 0.459%) to curb inflation, but growth effects vary with climate shock intensity. Findings stress the need for climate change considerations in monetary policy to balance price stability, growth and for adaptation financing.*

Keywords: climate change, monetary policy, DOLS, NK-DSGE, Ghana.

JEL Classification: Q54, E52, C32, Q58, O55.

Introduction

Climate change has emerged as one of the major challenges of the 21st century, affecting not only the environment but also the economic foundations of nations (Stern, 2007; Burke et al., 2015; NGFS, 2021). Countries such as Ghana are particularly vulnerable to the effects of climate change, despite contributing relatively little to global greenhouse gas emissions. The impacts of climate change manifest through the intensification of extreme weather events, persistent disruptions to agriculture, and unprecedented pressure on natural resources, thereby threatening macroeconomic stability and population well-being (Dell et al., 2012; FAO, 2021; IPCC, 2022; Kahn et al., 2021).

Traditionally, monetary policy has focused on ensuring price stability while supporting economic growth and smoothing business cycle fluctuations (Blanchard & Johnson, 2012; Mishkin, 2019; Woodford, 2003; Clarida et al., 1999). However, climate shocks introduce new sources of uncertainty and economic volatility, affecting investment, production, and financial stability (Kiley, 2021; Bloom, et al., 2009). The adverse consequences of climate-related stress reduce the rate of productive capital accumulation through persistent or long-term investment distortions, damage to physical and natural capital (Fankhauser & Tol, 2005). or instance, research by Deryugina and Hsiang (2014) shows that productivity declines by approximately 1.7% for every 1°C increase in the daily average temperature above 1.5°C (Deryugina & Hsiang, 2014).

The effects of climate change on productivity may remain modest in most economies if the increase in local temperatures is kept within limits (Stern, 2007). However, in the coming decades, monetary authorities will need to account for these effects, particularly if rising global temperatures generates inflationary pressures on food and other essential goods. In the short term, extreme weather events could have significant impacts on the broader economy and inflation dynamics, prompting monetary policymakers to respond appropriately depending on how output and inflation react to such shocks.

Indeed, studies such as (Lemaire, 2023) have shown that economic, monetary, and financial policies are adversely affected by climate shocks. Moreover, both academics and central bank supervisors have begun to explore the implications of climate change and climate-related risks for central banks and monetary policy (Batten et al., 2020; Carney, 2015). Although research in this field is still in its infancy (Scialom, 2022), early contributions (Dées & Weber, 2020; Cœuré & Kotz, 2021; Chen et al., 2020) have provided both qualitative and quantitative insights into how climate-related hazards can challenge monetary policy instruments and key macroeconomic aggregates. Furthermore, the Network for Greening the Financial System (NGFS, 2021) strongly recommends the systematic integration of climate-related issues into financial practices to enhance the resilience of the financial system against climate shocks. It has therefore become imperative to develop analytical frameworks capable of capturing the complex interactions between climate and economic variables (Carney, 2015).

The objective of this research is to analyze the impact of climate change on monetary policy in Ghana using a New Keynesian Dynamic Stochastic General Equilibrium (NK-DSGE) model. Specifically, the study aims to: (i) model the effects of climate shocks on key

macroeconomic variables such as inflation, gross domestic product (GDP), and the interest rate; (ii) assess the effectiveness of traditional monetary policy rules in the face of climate-induced disruptions. The NK-DSGE model is particularly well-suited for this analysis due to its ability to incorporate nominal and real rigidities, agents' rational expectations, and exogenous shocks (Walsh, 2017). It provides a dynamic assessment of economic policy in an uncertain environment, which is essential for understanding the implications of climate change for monetary policy.

Ghana represents a relevant case study for several reasons: the country is highly exposed to climate risks such as droughts, floods, and coastal erosion, all of which have significant economic repercussions (Winsemius et al., 2018). Ghana also benefits from an independent central bank and a monetary policy framework focused on price stability, offering a suitable context for analyzing necessary adjustments in response to climate shocks. Additionally, Ghana is a signatory to the Paris Agreement and has developed Nationally Determined Contributions (NDCs), reflecting its commitment to integrating climate considerations into economic policymaking.

The remainder of the paper is structured as follows: Section 2 reviews the relevant literature; Section 3 outlines the structure of the analytical model, including the key equations linking climate change and monetary policy, the model's stability condition, and the calibration parameters. Section 4 presents the simulation results and discusses the findings, and the paper concludes with Section 5, which offers concluding remarks and monetary policy implications.

Literature review

The analysis of the relationship between climate change and monetary policy has recently sparked debate in the literature regarding the role of central banks in addressing climate-related challenges (GIEC, 2021). Climate change impacts economies through various channels, including exposure to extreme weather events, dependence on climate-sensitive sectors (such as agriculture, fisheries, and tourism), the vulnerability of critical natural resources, and the capacity to implement effective climate and environmental policies. Broadly speaking, climate change affects virtually all sectors by disrupting economic activity, exerting pressure on both supply and demand, increasing production costs, altering energy prices, and diverting monetary policy from its conventional objectives (GIEC, 2021). Climate-induced pressures can reduce the supply of certain goods and services, thus contributing to price increases. Climate change may cause significant disruptions in a country's economic activities. Extreme weather events such as storms, droughts, or floods can damage infrastructure, destroy crops, disrupt supply chains, and impose substantial reconstruction costs. For instance, poor harvests can result in food shortages and higher food prices an illustration of the theory of goods scarcity.

On the supply side, climate change may also affect inflation and growth by reducing labor force participation and dampening investment (Trinnou, 2022). Climate anomalies, for example, have led to labor migration in the agricultural sector due to declining yields (Lemaire, 2023; Mendelsohn et al., 1996). This decline in production capacity can amplify

upward pressure on the general price level (Batten et al., 2020). Moreover, climate change may drive up firms' production costs. For example, businesses might need to invest in climate-resilient technologies or pay higher insurance premiums to protect themselves against climate-related risks. Furthermore, climate variability may hinder access to energy. The vulnerability of economies to climate change can also disrupt energy infrastructure, leading to increased energy and water costs within production chains (Trinnou, 2022). This may result in higher prices for goods and services that are heavily reliant on energy inputs, such as transportation, heating, or industrial production. The work of Asafu-Adjaye, et al. (2022) supports the scarcity theory, demonstrating that when energy supply declines, prices tend to rise systematically.

Climate change may also affect aggregate demand through consumer responses to rising prices, as highlighted in the scenarios presented in the IPCC's AR6 report (Masson-Delmotte et al., 2021). For instance, greater awareness of climate risks can shift consumer preferences toward more environmentally friendly goods, potentially increasing prices in those market segments. According to Barran et al. (1995), the debates on monetary policy transmission mechanisms has recently focused on the bank lending channel. Using a Vector Autoregression (VAR) model, they analyze the impact of monetary policy shocks on the U.S., Japanese, and German economies. Their estimates also allow inference of the central bank's response function. A key finding is that the transmission of monetary policy does not appear to operate primarily through bank lending. At the macroeconomic level, the credit supply response to interest rate fluctuations is insignificant. Conversely, notable responses in exchange rates and money supply support the operation of other transmission channels.

Annicchiarico and DiDio (2017) employed an Environmental-DSGE model to examine the optimal mix of environmental and monetary policies within a New Keynesian framework that incorporates pollutant emissions, abatement technologies, and environmental policy instruments. Their main findings indicate that the economy's optimal response to productivity shocks critically depends on the policy tools available to authorities, the magnitude of distortions, and the interaction between policies. Smets & Wouters (2007), used a Bayesian likelihood approach to estimate a dynamic stochastic general equilibrium (DSGE) model for the U.S. economy based on seven macroeconomic time series. The model includes various real and nominal frictions and seven structural shocks. Their results show that the DSGE model performs competitively with Bayesian VAR models in out-of-sample forecasting.

According to Chan (2020), the environmental effects of macroeconomic policies and their interaction with climate policy remain underexplored in the existing literature. His study compares the effectiveness of standard macroeconomic instruments (fiscal and monetary policy) and carbon taxation in influencing environmental dynamics to combat air pollution. An Environmental-DSGE (E-DSGE) model is employed, and results indicate that these policies can stabilize carbon emissions, though their transmission mechanisms differ. Empirical studies such as, Chen, et al. (2020); Chan, et al. (2024) have also employed the E-DSGE framework to analyze the impact of climate change on central banking operations. These models capture how monetary policy shocks influence financial conditions. Their

results show a general tightening of monetary policy in response to climate-induced volatility. Incorporating climate-related transmission channels suggests that climate change may pose long-term challenges to macroeconomic stability (Laurent, 2020). Dafermosa et al. (2018) argue that climate-related risks erode entrepreneurs' capital by driving up interest rates.

Methodology

Analytical Approach: New Keynesian Dynamic Stochastic General Equilibrium (NK-DSGE) framework

Baseline NK-DSGE framework

The baseline NK-DSGE model consists of households, firms, and a central bank. Households supply labor to firms, purchase consumption goods, and hold money and bonds. Firms hire labor, produce output, and sell differentiated products in monopolistically competitive goods markets. The monopolistic competition and price stickiness in the baseline model are respectively based on the frameworks developed by Dixit & Stiglitz (1977) and Calvo (1983). In this setting, each firm sets the price of its own goods.

Households

The representative household's preferences are defined over a composite consumption of goods C_t , held in real money balances $M_t P_1$, and the time allocated to market labor N_t . Households maximize the expected discounted utility, given by the following equation (Walsh, 2017):

$$\text{Max } U : E_t = \sum_{i=0}^{\infty} \beta^i \left[\frac{C_{t+i}^{1-\delta}}{1-\delta} + \frac{\gamma}{1-b} \left(\frac{M_{t+i}}{P_{t+i}} \right)^{1-b} - \chi \frac{N_{t+i}^{1+\eta}}{1+\eta} \right] \quad (1)$$

β where represents the discount factor, N_t denotes the number of hours worked at time t , χ is the parameter weighting the importance of leisure, δ measures the disutility of labor and η indicates the elasticity of labor supply, γ risk aversion related to leisure.

Firms

Based on the production function, profit maximization by a representative firm occurs under at least three constraints: the available technology, the dependence of output on capital K_t , labor N_t and total factor productivity Z_t , yielding constant returns to scale. Thus, the potential production function in the absence of exogenous shocks (i.e., without the occurrence of climate change) is defined by the following equation:

$$Y_{it} = Z_{it} K_{it} N_{it} \quad (2)$$

Actual output, denoted as y_t is simply the potential output adjusted for climate-related damages D_t . Incorporating these adjustments leads to a systematic reformulation of the production function, expressed as follows:

$$Y_t = D_t Z_t K_t N_t \quad (3)$$

At equilibrium, actual output is equal to consumption, according to the market-clearing hypothesis

$$Y_t = C_t \quad (4)$$

Individual consumption is specified by the following equation $c_t = C_t/N_t$, similarly K_t , capital is derived from the capital stock accumulation equation.

$$K_t = (1 - \delta)K_{t-1} + I_t \quad (5)$$

Climate module: incorporating climate change into the production function of the NK-DSGE model

Building on the theoretical foundations developed in the work of Dell et al. (2012) we specify our theoretical model in the spirit of a production function for a small open economy.

$$Y_{it} = e^{\beta C_{it}} Z_{it} K_{it}^\alpha N_{it}^\beta \quad (6)$$

$$\Delta Z_{it}/Z_{it} = g_{it} + \gamma C_{it} \quad (7)$$

$$Z_{cc_t} = \frac{y_{scc_t}}{K_t^\alpha N_t^\beta} \quad (8)$$

Y_{it} denotes real GDP, Z represents total factor productivity from capital (K) labor (N) and C is a vector of climate variables (temperature and precipitation). The functional form is expressed as follows:

$$g_{it} = g_i + (\beta + \gamma) C_{it} - \beta C_{it-1} \quad (9)$$

T_0 and P_0 denote historical temperature and precipitation levels, respectively.

$$C_{it} = \beta_1 T_{it} + \beta_2 P_{it} \quad (10)$$

Equation (10) becomes:

$$g_{it} = g_i + (\beta_1 + \gamma_1) T_{it} - \beta_1 T_{it-1} + (\beta_2 + \gamma_2) P_{it} - \beta_2 P_{it-1} \quad (11)$$

With T_0 and P_0 representing historical temperature and precipitation levels, and, g_{it} denoting the level of real GDP. The effects of rising temperature and precipitation are captured respectively by the parameters $\beta_1, \beta_2, \gamma_1$ and γ_2 .

Output Gap with Integration of the Damage Function

The output gap y_t is defined as the difference between actual output $\hat{y}_t$ and the future output level under flexible equilibrium prices y_t^f (Herber & Némec, 2022) based on the work of Dell, et al. (2012). By simplifying the capital law of motion equation, we assume that the capital depreciation rate is constant ($\delta=1$). Consequently, the level and the effect of the evolution of the damage function follow the functional form:

$$D_{RCP_s} = (1 - \Omega_{RCP_s}) \quad (12)$$

Based on the linearization of the IS curve (Walsh, 2017), the equation for the New Keynesian Phillips Curve is expressed as:

$$y_t = D_{RCP_s} \hat{y}_t - y_t^f \quad (13)$$

where $u_t = E_t y_t^f - y_t^f$ depends solely on exogenous shocks to total factor productivity (Walsh, 2017). Under the price rigidity assumption of Calvo (1983), we have:

$$y_t = \left[\left(D_{RCP_s} * E_t y_t - \left(\frac{1}{\delta} \right) (r_t - E_t \pi_t - r^*) \right) - \left(E_t y_t^f - u_t \right) \right] \quad (14)$$

$$y_t = \left[D_{RCP_s} * E_t y_t - \left(\frac{1}{\delta} \right) (r_t - E_t \pi_t - r^*) - E_t y_t^f + u_t \right] \quad (15)$$

For the sake of simplification, the expectation of potential output is given by:

$$y_t = (1 - \Omega_{RCP_s}) * E_t y_t - \left(\frac{1}{\delta} \right) (r_t - E_t \pi_t - r^*) + u \quad (16)$$

Here y_t denotes actual output, r_t is the nominal interest rate, δ is the intertemporal elasticity of substitution, $E_t \pi_t$ represents the expected future inflation, r^* is the natural rate of interest, and u symbolizes a demand shock.

$$\pi_t = \beta E_t \pi_t + k \cdot y_t + e_t, \quad (17)$$

New Keynesian Phillips Curve

The New Keynesian Phillips Curve equation represents the relationship between inflation, the output gap, and expected inflation (Bloom, et al., 2009; Rudd & Whelan, 2005; (Abbas, et al., 2016; Walsh, 2017). The equation is expressed as follows:

$$\pi_t = \beta \cdot E_t(\pi_t) + k \cdot y_t + e_t \quad (18)$$

where π_t denotes inflation, y_t the output gap, $E_t \pi_t$ the mathematical expectation of future inflation, β measures the extent to which agents incorporate future expectations into current decisions, k captures the sensitivity of inflation to variations in the output gap, and e_t represents exogenous shocks.

3.1.4.4. Taylor Rule of the Bank of Ghana

Based on the work of (Durke et al., 2024), we adopt an augmented Taylor rule, which is more suitable for a small open economy:

$$r_{CBN_t} = \varphi \pi_{CBN_t} + \sigma r_{CBN_{t-1}} + \phi y_t + \theta T X_t + v \quad (19)$$

where r_{CBN_t} is the policy interest rate in Ghana, φ and ϕ the inflation and output gap coefficients, θ the exchange rate coefficient, and $r_{CBN_{t-1}}$ the coefficient on the lagged interest rate.

Steady State and Calibration

Steady State

At the steady state, the economy is typically assumed to be unaffected by climate shocks (Trinnou, 2022). Determining the steady state involves eliminating the temporal dimension and other dynamic aspects embedded in the model. Climate-related shocks particularly those tied to temperature and precipitation that generate damages are set to zero in the NK-DSGE model. Demonstratively, in the steady state, temperature, precipitation, and damage take the following values: $\Omega=0$, which facilitates identification of the initial conditions in the NK-DSGE framework.

Calibration of the NK-DSGE model parameters

This section is devoted to calibrating the various parameters of the NK-DSGE model, drawing on the methodologies and assumptions of Trinnou (2022) and Nordhaus (2018).

Table 1. *Estimated parameter results*

N°	Parameters	Symbol	SCC	SSP1.9	SSP2.6	SSP4.5	SSP7.0	SSP8.5
1	Beta	B	0.98	0.98	0.98	0.98	0.98	0.98
2	Kappa	K	0.1	0.1	0.1	0.1	0.1	0.1
3	Oméga	Ω	-	0.397	0.383	0.423	0.437	0.923
4	Sigma	Σ	0.3	0.79	0.798	0.796	0.818	0.84
5	Psi	Ψ_i	1.5	1.5	1.5	1.5	1.5	1.5
6	Psii	Ψ_{ii}	0.5	0.5	0.5	0.5	0.5	0.5
7	Gamma	γ	-	0.1	0.1	0.1	0.1	0.1
8	rho_u	ρ_u	0.26	0.28	0.28	0.28	0.28	0.28
9	rho_v	ρ_v	0.27	0.29	0.29	0.29	0.29	0.29
10	rho_q	ρ_q	-	0.3	0.3	0.3	0.3	0.3
11	rho_e	ρ_e	0.28	0.31	0.31	0.31	0.31	0.31
12	rho_w	ρ_w	-	0.32	0.32	0.32	0.32	0.32

Source: Authors' estimates based on WDI and Bank of Ghana data, 2025.

Results and Discussion

■ Specification of the production function

Following the methodology proposed by Dell et al. (2012), we specify the production function by incorporating historical temperature and precipitation as control variables. The model is estimated using the Dynamic Ordinary Least Squares (DOLS) method in logarithmic form. To address concerns regarding stationarity, we differentiate certain variables. The functional form is expressed as follows:

$$\ln(Y_{scc}) = \ln(Z_{scc}) + \alpha \ln(K) + \beta \ln(N) + \gamma T_0 + \delta P_0 + \varepsilon \quad (20)$$

$$GDP_{scc} = Z + \alpha K + \beta N + \sum \gamma C_0 + \varepsilon \quad (21)$$

Climatic shocks are assumed to follow an AR (1) process.

Table 2. *DOLS Estimation Results*

Variables	Description	Coef.	Ecart Type	Z	P>z
Z	Total factor productivity	0.330***	0.033	9.950	0.000
K	Capital	45.143***	9.531	4.740	0.000
N	Labor	110.284***	12.580	8.770	0.000
T	Temperature	0	1.832	0.000	1.000

<i>P</i>	Precipitation	-0.002***	0.000	-18.870	0.000
----------	---------------	-----------	-------	---------	-------

* $p < .1$, ** $p < .05$, *** $p < .01$

Source: Authors, 2025.

Overall, the estimated production function aligns with theoretical expectations, confirming that GDP growth is driven by core inputs (capital and labor) and climate-related variables. Notably, a reduction in precipitation has a negative and statistically significant impact (at the 1% level) on GDP growth.

▪ Forecasting GDP in the absence of climate change using historical climate averages

In order to incorporate climate change into the output gap equation via the damage function, we first estimate the damage function parameter Ω , as outlined by Nordhaus (2018); Trinnou (2022). Using the DOLS approach, we forecast GDP in the absence of climate change using historical temperature and precipitation averages, and then project GDP under five scenarios Shared Socioeconomic Pathways (SSP) over the 2040-2059 period. The climate-adjusted GDP forecasts are derived from the baseline no-climate-change GDP and the DOLS coefficients. The results are presented in Table 4. Consistent with prior econometric studies on this topic (Dell, et al., 2012), our results underscore the adverse effects of rising temperatures under various climate scenarios on annual GDP growth.

▪ Deriving the damage function parameter Ω

This subsection presents the estimation of the Ω parameter in the damage function using the following formula:

$$|\Omega_i| = \frac{GDP_{RCP_s} - GDP_{scc}}{GDP_{scc}} \quad (22)$$

Table 3. Estimated damage function parameters Ω_{RCP_s}

Parameters	Values
$\Omega_{RCP1.6}$	0.616
$\Omega_{RCP2.6}$	0.565
$\Omega_{RCP4.5}$	0.646
$\Omega_{RCP7.0}$	0.575
$\Omega_{RCP8.5}$	0.569

Source: Authors, 2025.

Table 4. Summary of Policy Matrix Results from the Bank of Ghana (over a short- to long-term horizon)

	Climate Shock (change in climate variables)				
	Optimistic scenarios		Moderate scenarios	Pessimistic scenarios	
	SSP1-1.9	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
	1.6°C	1.7°C	2.0°C	2.1°C	2.4°C
Inflation	0.081	0.080	0.087	0.081	0.083
Policy Rate	0.448	0.446	0.481	0.453	0.459
Production	0.569	0.567	0.611	0.575	0.583
Output	0.093	0.092	0.100	0.094	0.095

Note: All values represent percentage point deviations from steady-state levels.

Source: Authors, 2025.

On the whole, simulations under different SSP scenarios show that climate change has significant effects on major macroeconomic aggregates and monetary policy instruments in Ghana. Higher temperatures are robustly related to inflationary pressures, leading to

contractionary monetary policy responses and output losses. This result accords with the accumulating evidence in the climate economics literature which suggests that climate-induced supply shocks can pose serious risks to price levels and output dynamics, especially in climate-exposed economies.

The results present an obvious pattern, as outlined in the policy matrix (Table 4):

- At 1.6°C warming, inflation trails higher by 0.081 percentage points and the Bank of Ghana increases the policy rate by 0.448 percentage points, with output retreating by 0.569 percentage points.
- At 1.7°C, an almost equivalent positive inflation shock (0.080 percentage points) leads to a similar policy rate increase of 0.446 percentage points and a 0.567 percentage point less output.
- At 2.0 °C the inflationary effect is enhanced to 0.087 percentage points which leads to a more expansionary increase of the policy rate (0.481 percentage points) and to a more contractionary contraction of output (0.611 percentage points).

These findings demonstrate the non-linear and incremental influence of increasing temperatures on macroeconomic outcomes, despite modest temperature increments. Crucially, they highlight that climate shocks in Ghana (where food prices, fuel prices and climate-sensitive sectors such as agriculture are very sensitive to thermal variability) are inflationary. Though these results are underpinned by the orthodox contractionary monetary response evident in the simulations, a more general reconsideration of the ability of monetary policy to generate responses in a weather-correlated developing economy is warranted. Tightening the policy rate to anchor inflation expectations might be a necessary response, but it would likely dampen output further, undermining efforts to adapt to the changing climate over the long run. In this vein, BoG can also contemplate contextualized and more accommodating approaches, such as aligning with fiscal authorities to keep some room to sustain accommodative policies that help investments in climate resilience especially in instances of external climate shocks.

This reasoning is also similar to that used by (Dell, et al. 2012) found that as temperatures increase, economic growth will slow especially in low-income countries. Our results support this, and suggest a reduction in consumption of about 0.560%, consistent with both a fall in household welfare and aggregate demand. Here is where preemptive and flexible central banking count. In addition, beyond traditional IT frameworks, monetary policy might, going forward, take account of explicit climate risk considerations. Things like green lending facilities, climate-adjusted interest rate peppermints, or maybe some temporary liquidity support to climate at-risk sectors. The simulations build a strong case for shifting away from reactive measures to a more forward-looking monetary policy stance, which integrates macroeconomic stabilization with long-term climate adaptation and inclusive growth.

Conclusion

Climate change is a pressing challenge, particularly for the financial sector, including central banks. This study examines the impact of climate change on monetary policy in Ghana using two main data sources: the World Development Indicators (WDI) and the

Bank of Ghana (BoG), along with key calibration parameters from the literature. The analysis is conducted using a New Keynesian Dynamic Stochastic General Equilibrium (NK-DSGE) model applied to quarterly data from Q1 2005 to Q4 2023. The parameters of the damage function were estimated using the panel-based econometric method DOLS. The results show that rising temperatures under different climate scenarios lead to an increase in the general price level (between 0.081 and 0.083 percentage point) and a reduction in output (between 0.569 and 0.583 percentage point). To counter inflationary pressures, the central bank can raise the policy rate by between 0.448 and 0.459 percentage points to stimulate economic recovery. These findings imply that monetary authorities should incorporate climate dynamics into interest rate policy in order to maintain price stability and sustain economic growth. Future research could extend these findings by conducting comparative analyses between countries operating under fixed and flexible exchange rate regimes.

References

- Abbas, S.K., Bhattacharya, P.S. and Sgro, P. (2016). The new Keynesian Phillips curve: An update on recent empirical advances. *International Review of Economics & Finance*, 43, 378-403.
- Batten, S., Sowerbutts, R. and Tanaka, M. (2020). Climate change: Macroeconomic impact and implications for monetary policy. In: DNB Occasional Studies. *De Nederlandsche Bank*, 18 (1).
- Battiston, S. et al. (2017). A climate stress-test of the financial system. *Nature Climate Change*, 7(4), 283-288.
- Blanchard, O. and Johnson, D.R. (2012). *Macroeconomics*. s.l.: (6th ed.). Pearson.
- Bloom, D.E., Canning, D. and Sevilla, J. (2009). The effect of health on economic growth: A production function approach. *World Development*, 32(1), 1-13.
- Burke, M., Hsiang, S.M. and Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature*, 527(7577), 235-239.
- Calvo, G.A. (1983). Staggered prices in a utility-maximizing framework. *Journal of monetary Economics*, 12(3), 383-398.
- Chan, H.W., Tam, K.P. and Clayton, S. (2024). Testing an integrated model of climate change anxiety. *Journal of Environmental Psychology*, 97, 102368.
- Chen, H., Sun, J., Lin, W. and Xu, H. (2020). Comparison of CMIP6 and CMIP5 models in simulating climate extremes. *Sci. Bull.*, 65(17), 1415-1418.
- Clarida, R., Galí, J. and Gertler, M. (1999). The science of monetary policy: A new Keynesian perspective. *Journal of Economic Literature*, 37(4), 1661-1707.
- Dell, Jones, and Olken (2012). Temperature shocks and economic growth: Evidence from the last half century. *American Economic Journal: Macroeconomics*, 4(3), 66-95.
- Dell, M., Jones, B.F. and Olken, B.A. (2012). Temperature shocks and economic growth: Evidence from the last half century. *American Economic Journal: Macroeconomics*, 4(3), 66-95.
- Deryugina, T. and Hsiang, S.M. (2014). Does the environment still matter? Daily temperature and income in the United States. *Review of Economics and Statistics*, 96(1), 19-33.
- Durke, O. et al. (2024). An extended Taylor rule for a small open African economy. *Scientific African*.

- Fankhauser, S. and Tol, R.S. (2005). On climate change and economic growth. *Resource and Energy Economics*, 27(1), 1-17.
- FAO (2021). *The State of Food Security and Nutrition in the World 2021: Transforming food systems for food security, improved nutrition and affordable healthy diets for all*, Rome: FAO: s.n.
- GIEC (2021). Climate Change 2021: The Physical Science Basis », Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. [ipcc.ch/report/ar6/wg1/](https://www.ipcc.ch/report/ar6/wg1/)
- Hairault, O.J. and Langot, F. (2005). F. Kydland et E. Prescott: prix Nobel d'économie 2004. *Revue d'économie politique*, 115(1), 65-83.
- Herber, P. and Némec, D. (2022). *Estimating Output Gap in the Czech Republic: DSGE Approach*. Czech Republic: Lipov'a.
- IPCC (2021). *Sixth Assessment Report. Intergovernmental Panel on Climate Change*, s.l.: s.n.
- Kahn, M.E. et al. (2021). Long-term macroeconomic effects of climate change: A cross-country analysis. *Energy Economics*, 104, 105624.
- Kiley, M.T. (2021). Macroeconomic Research and Climate Change: A Review. *Finance and Economics Discussion Series*, 2021-06.
- Laurent, A. (2020). Introduction. La transition juste. Un nouvel âge de l'économie et de l'environnement. *Revue de l'OFCE*, 1(165), 5-20.
- Lemaire (2023). *Essays on the Macroeconomic Effects of Climate Change in Developing Countries*. s.l.: (Doctoral dissertation, Université Panthéon-Sorbonne-Paris I.
- Mishkin, F.S. (2019). *The Economics of Money, Banking and Financial Markets*. 12th ed.: Pearson.
- NGFS (2022). Network for Greening the Financial System). NGFS Climate Scenarios for Central Banks and Supervisors.
- Rudd, J. and Whelan, K. (2005). New tests of the new-Keynesian Phillips curve. *Journal of Monetary Economics*, 52(6), 1167-1181.
- Schorfheide, F. (2008). DSGE model-based estimation of the New Keynesian Phillips curve. *FRB Richmond Economic Quarterly*, 94(4), 397-433.
- Scialom, L. (2022). Les banques centrales au défi de la transition écologique Éloge de la plasticité. *Revue économique*, Volume 73 (2), 219 à 242.
- Stern (2007). *The Economics of Climate Change: The Stern Review*. Cambridge University Press.
- Stern, N. (2013). The Structure of Economic Modeling of the Potential Impacts of Climate Change: Grafting Gross Underestimation of Risk onto Already Narrow Science Models. *Journal of Economic Literature*, 51(3), 838-859.
- Stern, N. and Taylor, C. (2007). *Climate change: Risk, ethics, and the Stern review*. Science, s.l.: s.n.
- Trinnou, G. (2022). Choc climatique, production et l'inflation dans l'UEMOA. *Document d'Etude et de Recherche de la BCEAO*, Issue N °CO FE B/D E R/2 022/02.
- Walsh (2017). *Monetary theory and policy*. s.l.: MIT press.
- Winsemius, H.C. et al. (2018). Disaster risk, climate change, and poverty: assessing the global exposure of poor people to floods and droughts. *Environment and Development Economics*. *Environment and Development Economics*, 23.
- Woodford, M. (2003). *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton University Press.

Appendices

A. Descriptive statistics of the data

Table 1A. *Descriptive statistics*

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
Y	GDP	280	3.304	4.883	-22.446	20.287
Z	Total factor productivity	280	0.005	0.01	-0.064	0.054
K	Gross fixed capital formation %	280	18.31	6.442	7.397	53.861
N	Hourly employment rate %	280	35.525	4.912	25.395	45.493
P	Precipitation (mm)	280	839.188	484.395	76.64	1461.55
T	Temperature en °C	280	27.797	0.801	26.28	29.38

Source: Authors, 2025.

B. Preliminary Tests

Table 1B. *Pesaran's test for spatial dependence*

Variable	CD-test	P-value	Average joint T	Mean p	Mean abs (p)
Y	4,985***	0.000	35.00	0.16	0.18
Z	4,488***	0.000	35.00	0.14	0.17
K	1,176***	0.240	35.00	0.04	0.31
N	-3,587***	0.000	35.00	-0.11	0.72
P	22,441***	0.000	35.00	0.72	0.72
T	30,588***	0.000	35.00	0.98	0.98

Note: *** Significant at the 1% level.

Table 2B. *Pesaran unit root test*

Variable	Intercept	Intercept and trend
Y	-6.092*	-6.207*
Z	-5.835*	-5.807*
K	-2.327*	-2.935*
N	-1.133*	0.989*
P	-4.556*	-5.500*
T	-4.878*	-5.533*
ΔY	-6.150*	-6.420*
ΔZ	-6.190*	-6.420*
ΔK	-5.483*	-5.703*
ΔN	-0.422*	-1.376*
ΔP	-6.190*	-
ΔT	-	-

Notes: ***, **, * significant at the 1%, 5%, and 10% level of significance, respectively. Δ is the first difference operator.

Table 3B. *Results of the spatial dependence residual test*

Tests	With fixed effects estimator		With random effects estimator	
	Statistic	P-value	Statistic	P-value
Pesaran's test of cross sectional independence	0.723	0.4698	1.794**	0.0729
Frees'test of cross sectional independence	-0.053	1.6442	-0.028	1.3750
Friedman's test of cross sectional independence	42.283***	0.000	51.779***	0.0000

Notes: indicates significance at the 5% level. For the Friedman test, only the critical values of the distribution are reported.

Table 4B. *Westerlund Cointegration Test*

Statistic test	Statistic	P-value
Variance ratio	-2.8058	0.0025

Source: Authors, 2025.

C. Simulation Results of the NK-DSGE model and computation of alternative GDP

Table 1C. *Results of the computation of alternative GDP values*

Variable	Descriptions	GDP US \$
GDP-SCC	GDP without climate change	4196
GDP-RCP1_1.9	GDP with climate change (RCP1.6)	5900
GDP-RCP1_2.6	GDP with climate change (RCP2.6)	2179
GDP-RCP3_4.5	GDP with climate change (RCP4.5)	2291
GDP-RCP4_7.0	GDP with climate change (RCP7.0)	2321
GDP-RCP5_8.5	GDP with climate change (RCP8.5)	4283

Source: Authors, 2025.

Monitoring the implementation of the Sustainable Development Goals in Romania

Maria-Daniela TUDORACHE

Bucharest University of Economic Studies, Romania
daniela.tudorache@economie.ase.ro

Ionuț JIANU

Bucharest University of Economic Studies, Romania
ionut.jianu@economie.ase.ro

Abstract. *This paper aims to assess the implementation of the Sustainable Development Goals in Romania in the context of the EU-27 membership. To achieve this, we used specific indicators for all 17 SDGs and we performed a comparative and time-series analysis to identify the current social, economic and environmental challenges that Romania is facing. Our results show that socio-economic challenges are more pressing than environmental ones, compared to other developed EU MS where the environmental challenges needs an increased focus within the policy specific processes.*

Keywords: Sustainable Development Goals, poverty, inequality, institutions, education.

JEL Classification: I25, I30, O11, Q01, Q50.

1. Introduction

The European Union emerged as a result of the need for economic recovery after the Second World War. In this case, in 1957, six countries - Belgium, France, Italy, the Netherlands and West Germany signed the Treaty of Rome, which created the European Economic Community. After establishing this community, the first objectives set in terms of development were: (i) ensuring economic and social progress by eliminating trade barriers; (ii) increasing trade relations, by promoting a common trade policy; (iii) improving working conditions and, implicitly, living conditions; (iv) respecting the United Nations principles regarding peace and international cooperation, in order to solve issues in economic, social, cultural and human field; (v) reducing regional disparities from an economic and social point of view.

Later, with the enlargement of the EU and the emergence of more global challenges, the European institutions developed and adopted the Lisbon Strategy, which stipulated that economic development must promote sustainable economic growth, and must take into account environmental protection policy. The challenges to which EU has been exposed, namely social imbalances, and ageing population, economic pressures in terms of global competition, increase the need to focus the EU policy efforts on sustainable economic growth, creating jobs, ensuring social security and better environmental protection.

In 2016, through the Paris Agreement, the EU adopted the first global climate change agreement, the UN's 2030 Agenda. In 2015, UN adopted the 2030 Agenda for Sustainable Development, which aims to support ensuring prosperity for people worldwide. This agenda includes 17 Sustainable Development Goals (SDGs), which are intended to provide an urgent response from all states through a global partnership. According to the UN, eradicating poverty, reducing inequalities, improving education and health systems, and boosting economic growth must be in line with mitigating climate change. In order to ensure sustainable development, it is necessary to achieve all SDGs simultaneously.

With the intensification of discussions at the level of working groups organized at the level of the Council of the European Union and at the level of the European Commission regarding the Paris Agreement, member states have begun to attach increasing importance to the sustainable development goals developed by the United Nations. In this context, the objective of this paper is to analyse the evolution of all SDGs (focusing on specific indicators) in Romania in the last decade.

2. Literature review

According to Acemoglu and Robinson (2012), institutions are a key factor of prosperity within countries. Institutions have the role of ensuring good governance, corruption control, regulations and a well-functioning rule of law (Alkhamery et al., 2021, Jianu et al., 2025). In this case, Nandha and Smyth (2013) demonstrated that, in 186 states, during the period 1995-2011, the quality of institutions had a significant impact on human well-being and economic development.

The reduction of poverty has become a priority, but there is no international consensus on its measurement (Sapena et al., 2018). From an economic perspective, poverty occurs when a family's income falls below a specific established threshold. Despite significant progress in eradicating poverty and promoting human well-being in recent decades, extreme poverty and inequalities are still widespread in developing countries. According to Sachs (2005), poor countries are stuck in a poverty trap from which they cannot escape without a boost from developed countries, while Easterly (2006) suggests that poverty is a cause of poor governance. Furthermore, poverty is not only a cause of lack of income, but also reflects poor health, poor education and a poor quality of life (Duflo and Banerjee, 2011; Tudorache, 2019; Tudorache, 2022).

Addressing global hunger challenges is another important objective that requires annual investments in agricultural research and development, agricultural expansion services, agricultural information systems, the expansion of irrigation and improving the literacy rate (Chichaibelu et al., 2021). Hoddinott et al. (2013) state that, in order to reduce hunger, an acceleration of yield growth, an increase in fertilizers, respectively, intervention to reduce micronutrient deficiencies (vitamin A, iodine, iron, zinc) are needed.

In terms of life expectancy and infant mortality, some progress has been recorded globally in the last two decades, the number of deaths caused by malaria being reduced to its half (World Health Organization, 2018). However, the progress has been modest and uneven, both between and within countries (Mohammed and Ghebreyesus, 2018): some countries, especially developed ones, have made progress in the field of health, while underdeveloped and developing countries still face deficiencies in their health systems. On the other hand, high prosperity around the world, changes in diet, lifestyle, along with rapid and unplanned urbanization have led to new health threats for the population. Besides that, the incidence of chronic respiratory diseases, diabetes and various forms of cancer is on an increasing trend (World Health Organization, 2017). Transformative change in cities is needed to address current and future challenges to health and sustainability (Steffen, 2018). Also, Crane et al. 2021 state that cities need international research partnerships, namely complex urban systems for sustainability and health, these being important aspects for shaping policy decisions and their implementation in urban communities.

According to UNESCO (2000), quality education occurs when the learning outcomes are measurable and recognized for all individuals. Unfortunately, there is no definition, list of criteria or a uniformly accepted curriculum that presents what quality education should include. Education is a dynamic concept that changes and evolves over time, depending on the social, economic and environmental context (UNESCO, 2005), with the ability to adapt to the labour market demands playing an important role.

Decent work is an aspirational statement about the quality of work that should be available to all who want to work. The labour market is undergoing various transformations, and working conditions are governed by market forces, which create instability and insecurity, causing increased levels of stress and anxiety for the workforce (Stiglitz, 2015; Piketty, 2014). Millions of workers around the world earn the minimum wage, a challenge that is addressed by reducing or limiting the inequality of wage distribution, respectively by

reducing the gender pay gap, since women tend to obtain lower wages than men (Belser and Rani, 2015).

The last half century has seen the emergence of the so-called concept “gender revolution”, which promoted the increase in the number of women pursuing university studies (DiPrete and Buchmann, 2013), the employment rate among women - including women with young children (Cotter et al., 2007). Moreover, equal opportunities in employment have emerged in the personnel policies of organizations (Dobbin, 2009), with women being able to occupy jobs and managerial positions that were previously occupied only by men (Weeden, 2018). In addition, wage gap have decreased significantly after 1980 in the European Union, but in other countries, such as the United States, it remained high (Blau and Kahn, 2017).

The COVID-19 pandemic has affected the progress achieved on gender equality, through the channel of the increased violence against women and through the one of increased domestic work for women. The pandemic has also highlighted the need for rapid action to address gender inequality, which remains widespread globally, even if women have played a key role in managing the health sector crisis, since the workforce in this sector is predominantly female.

Climate changes challenges are also reflected in sustainable development goals. In particular, these are reflected in temperature changes in a given region (McMichael et. al, 2006). In recent decades, the temperature has increased by 0.5 degrees Celsius due to greenhouse gas emissions (Trenbert, 2001). The increase in temperatures is associated with the melting of ice caps, the sinking of coastal areas, and floods and droughts in certain regions (Solomon et al., 2007). At global level, climate change can affect humanity, with developing countries being the most exposed to the risks (Mendelsohn et al., 2006), the effects being directly observable through the wildfires that have increased in recent times.

Atmospheric concentrations of greenhouse gas emissions have continued to rise, the period 2015-2024 being considered the warmest in history. In order to limit global warming, in accordance with the Paris Agreement, greenhouse gas emissions must reach 1990 levels by 2050. According to UN climate action reports, global emissions must be reduced by 45% below 2010 levels by 2030 to limit global warming. Fossil fuels (coal, oil, natural gas) have led to increased greenhouse gas emissions, which necessitates increased renewable energy production (Zabeltitz, 1994). The main objective of large-scale renewable energy deployment is to promote economic development, improve energy access, and mitigate climate change (Kumar and Majid, 2020). There have been improvements in access to electricity and renewable energy over the past decade, but these have been ineffective in providing affordable energy for all. In the early stages of the ecological transition, the costs appear to be quite high, especially in countries with high poverty rates, this reflecting a potential trade-off in these countries.

Additionally, human-caused damage, together with climate change, is threatening the well-being of the oceans and the water creatures (Sturesson et al., 2018). In this case, collective action and government involvement are needed to address the challenges of marine pollution (IASS, 2017). Increased interest in ocean science will lead to increased

investment in marine research to counter the damage caused by climate change (ECESA, 2017). Oceans, seas and marine resources are under threat from pollution and global warming that are disrupting ecosystems around the world. The challenges advanced by climate change create long-term repercussions, requiring investment in ocean science, environmental protection, support for small fishing communities and sustainable ocean management, especially given that approximately three billion people rely on the ocean for their livelihoods and 80% of global trade is freight transport.

Regarding the natural resources, water makes up more than two-thirds of the human body, being a vital component for any form of life. Most of the time, clean water is not accessible to human beings in particular countries or regions, this affecting the individual's health status (Khalifa and Bidaisee, 2018). There are several factors that contribute to ensuring the accessibility of clean water, including physical, demographic, geopolitical and socio-economic status (World Vision). Physically, water sources are difficult to access due to topographical factors and climatic circumstances. Demographically, location can affect the accessibility of clean water, as a result of problems related to overpopulation. Geopolitically, due to water obtained in the river flow, people downstream rely on people upstream to maintain the purity of the water. Finally, socio-economic status will have implications on the accessibility of clean water.

Forests, especially tropical forests, are known for their biological complexity, given their diverse species density and variety of biological interactions (Kricher, 1997). Deforestation and forest degradation have consequences for human well-being and survival. While efforts are being made to expand sustainable forest management and adopt biodiversity coverage, and to protect biodiversity and oceans through legislation and treaties, additional efforts are needed to protect the planet.

Moreover, responsible consumption and production are essential for a sustainable society. Human and environmental systems interact through the economic system in various ways, which has led to the emergence of several complex, intractable, conflictual and multidimensional problems that can be countered with the help of tools to manage consumption and production problems (Churchman, 1967). Therefore, sustainable production and consumption focus on different elements of the supply chain: from extractive industries to individual supply needs (Tseng et al., 2018). In this case, green supply chains and green consumerism are necessary to achieve progress in sustainable consumption and production.

Industrial companies are currently facing challenges due to globalization, rapid changes in the structure of demand and supply, and technological innovation. As a result of these changes, organizations are forced to act quickly and intelligently to changes in order to increase their competitiveness (Davenport, 2014). In addition, the integration of digital and intelligent technologies has allowed companies to find the most appropriate way to operate (Zhou, 2013). However, the volatility and uncertainty caused by technological changes are not conducive to economic development, as they create excesses and support the increase in the degree of economic division. The pandemic, together with tariff and trade tensions, have strongly affected the manufacturing industry and transportation, causing significant job losses and a decrease in the income of workers in these sectors.

3. Methodology

This paper analyses the implementation of the Sustainable Development Goals in Romania in the context of the EU-27 membership. In this respect, we selected relevant indicators (extracted from Eurostat) for the 17 SDGs, as follows:

- SDG 1 - eradication of poverty: people at risk of poverty or social exclusion (%) and in-work at-risk-of-poverty rate (%);
- SDG 2 - eliminating hunger: area under organic farming (% of utilised agricultural area) and government support for agricultural research and development (EUR per inhabitant);
- SDG 3 - ensuring good health and well-being: healthy life years at birth (years);
- SDG 4 - improving quality of education: early leavers from education and training (18-24 years) rate (%) and the percentage of population aged between 16-74 having at least basic digital skills.
- SDG 5 - ensuring gender equality: gender pay gap (difference between average gross hourly earnings of male and female employees, as % of average gross hourly earnings of men) and gender employment gap (difference between the employment rate of men and women aged 20-64, percentage points);
- SDG 6 - ensuring clean water and sanitation: people having neither a bath, nor a shower, nor indoor flushing toilet in their household (% of population) and population connected to at least secondary wastewater treatment systems (% of population);
- SDG 7 - ensuring affordable and clean energy: renewable energy (% of gross final energy consumption) and energy import dependency (% of total energy consumption);
- SDG 8 - ensuring decent work and economic growth: Real GDP per capita (EUR per capita, base year 2020) and young people neither in employment nor in education and training (NEET) rate (% of the population aged between 15-29 years);
- SDG 9 - strengthening industry, innovation and infrastructure: R&D expenditure (% of GDP);
- SDG 10 - reducing inequalities: income share of the bottom 40% of the population (% of income);
- SDG 11 - improving the sustainability of cities and communities: recycling rate of municipal waste (% of total municipal waste generated);
- SDG 12 - ensuring responsible consumption and production: circular material use rate (% of material input for domestic use);
- SDG 13 - adopting appropriate climate action measures: net greenhouse gas emissions (tonnes per capita) and average CO₂ emissions per km from new passenger cars (grams of CO₂ per km);
- SDG 14 - protecting marine areas: surface of marine protected areas (% of marine areas);
- SDG 15 - protecting land areas: surface of terrestrial protected areas (% of total land area);
- SDG 16 - promoting peace, justice and strong institutions: perceived independence of the justice system (% of the total population) and corruption perception index (0 highly corrupt to 100 absence of corruption);

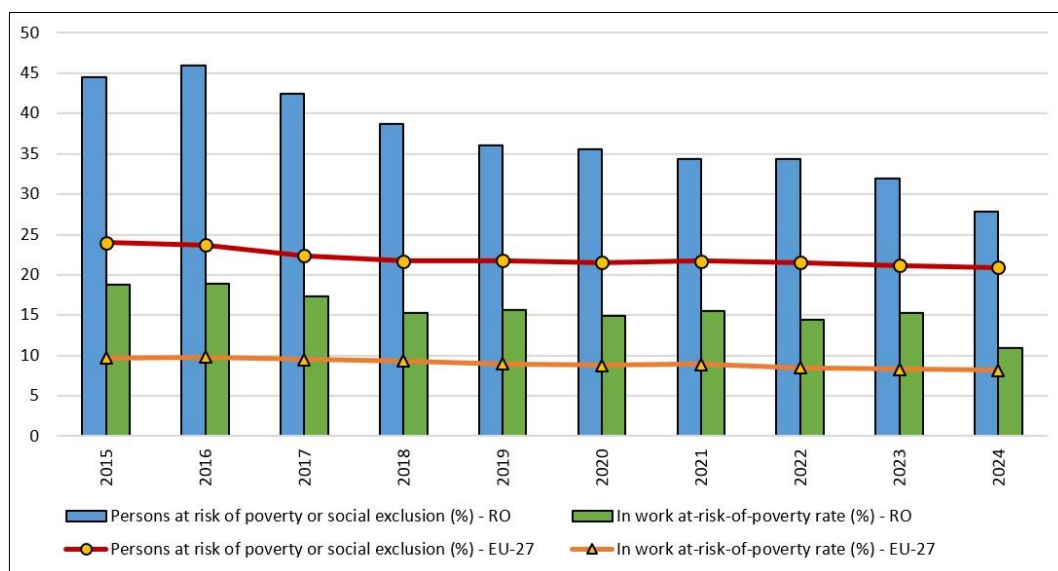
- SDG 17 - promoting partnership for the goals: official development assistance provided (% of gross national income);

However, when drafting the analysis, we followed a parsimonious approach, while not using all specific indicators and only the most relevant ones. Therefore, we did not use the order of the SDGs presented by the United Nations and Eurostat (above), since we grouped some of the selected indicators according to their links to allow their combination in specific charts. In this respect, our analysis was based on four types of chart analyses and one statistical method to measure the association between variables, as follows: (i) post-2009 crisis yearly analysis (depending on the availability of the data) for Romania using the last available year as ending point of the analysed time series; (ii) comparative analysis between Romania and other EU MS using data for the last available year; (iii) comparative analysis between Romania and other EU MS using data for the last available year and the last available year minus ten years; (iv) scatter plot analysis to examine the relationship between variables; (v) correlation coefficients to examine the association between variables. It should be noted that if some data were missing for a maximum of 3 countries (but these were available for a previous year), in these cases, we used data for the last year available (with a limit of 2 year lag).

4. Results and interpretations

In this section, we analysed specific indicators for all SDGs in the case of Romania. In *Figure 1* we analysed the people at risk of poverty or social exclusion and in work at-risk-of-poverty rate in the period 2015-2024.

Figure 1. People at risk of poverty or social exclusion rate vs. in work at-risk-of-poverty rate in Romania (2015-2024)

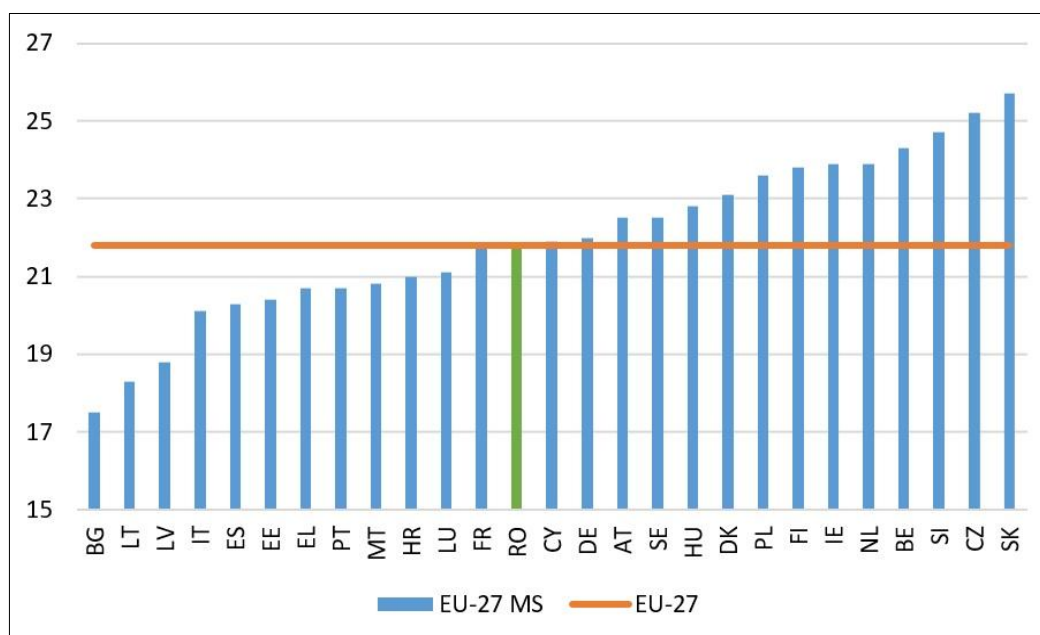


Source: Own processings in Microsoft Office Excel based on Eurostat data

Despite the fact that the people at risk of poverty or social exclusion was on a decreasing trend during the analysed period, in 2024, Romania registered the second highest poverty rate in the EU Member States (27.9%) – in first place was BG (30.3%), above the EU average (21%). Also, the social situation does not improve when examining the in work at-risk-of-poverty rate, as Romania recorded the fourth highest value of this indicator (10.9%) among EU countries, after LU (13.4%), BG (11.8%) and ES (11.2%), considering the EU rate of 8.2%. Therefore, government authorities must continue to adopt policies to reduce the poverty rate, especially in less developed regions.

The social risks are also reflected in indicators related to income inequality, another important objective that United Nations propose it as a policy priority worldwide. According to the data presented in *Figure 2*, Romania registered an average income inequality in 2024, a similar value to the one found in the case of EU.

Figure 2. Income share of the bottom 40 % of the population (2024)



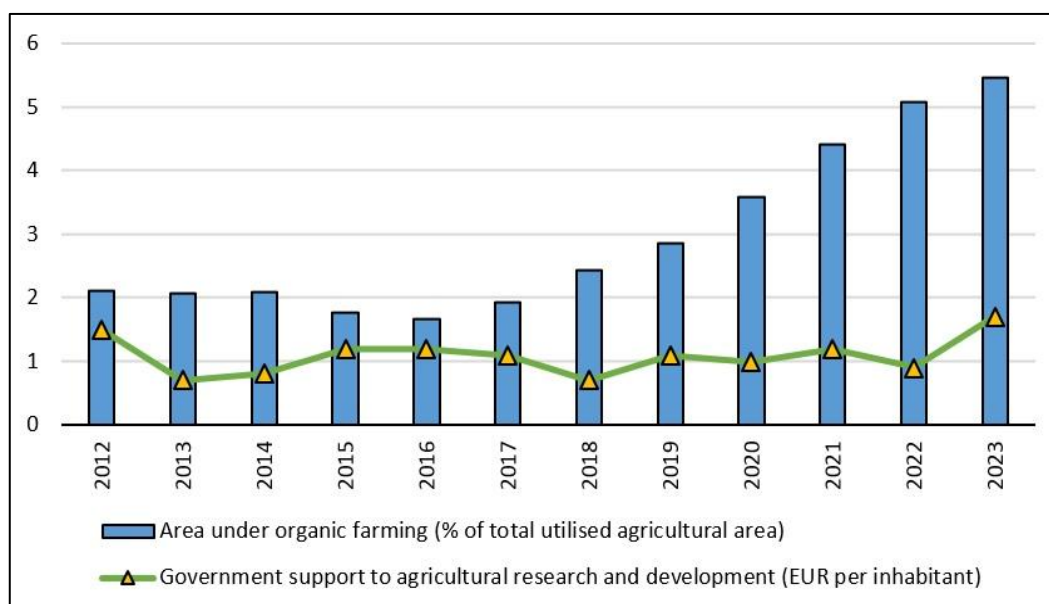
Source: Own processings in Microsoft Office Excel based on Eurostat data

In this respect, Romania registered an income share of the bottom 40% of the population of 21.8%, this being lower than the levels registered in 14 Member States (CY, DE, AT, SE, HU, DK, PL, FI, IE, NL, BE, SI, CZ and SK). However, it should be taken into account the limits of this indicator, since it does not sufficiently surprise the income gap among individuals, as the gap may be higher in the case of the bottom 10% or 20% and may be diminished when taking into account an extended overview (bottom 40%). Nevertheless, the Gini coefficient has been adjusted with 5.8 points in Romania (to a lower value) after COVID-19 crisis, which reflects a significant drop of income inequality – this confirming a reduction in this imbalance, even if this remains a serious challenge taking into account its positive association with poverty risks.

Regarding the goal of eradicating hunger, we analysed the evolution of area under organic farming and the government support to agricultural research and development. *Figure 3* shows that during the period 2012-2023 the area under organic farming increased in Romania, but still remain at a low level compared to its potential. The Member States that recorded lower values than RO (5.08%) for this indicator in 2023 was MT (0.6%), IE (2.2%), BG (2.2%), PL (3.91) and NL (4.44%). At the opposite, the countries with the highest values in 2023 were EE (23.42%), SE (19.94%) and PT (19.31%).

Also, the government support to agricultural research and development in RO was very low in 2023 (1.7 euro per inhabitant), even if it overpasses the support granted in PL (0.2 euro per inhabitant) and LU (0.8 euro per inhabitant). RO is considered a country with high agricultural potential, but government allocations remain modest throughout the analysed period, which limits its potential. In this case, funding for organic agriculture should be increased, research systems related to crop cultivation should be further developed, and irrigation should be expanded.

Figure 3. The evolution of area under organic farming (% of total utilised agricultural area) and of the government support to agricultural research and development (EUR per inhabitant) in Romania (2012-2023)

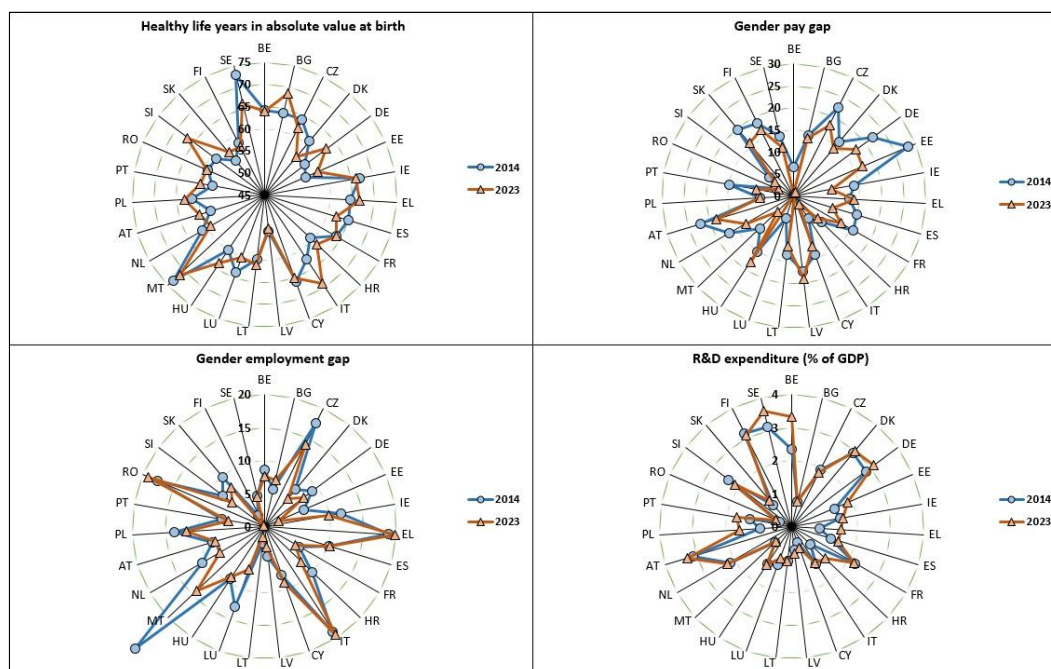


Source: Own processings in Microsoft Office Excel based on Eurostat data

Next, we selected four indicators (healthy life expectancy, gender pay and gender employment gap, and R&D expenditure as a % of GDP) to catch the progress in the implementation of three SDGs (gender equality, good health and well-being, respectively industry, innovation and infrastructure) over the period 2014-2023 in EU Member States (*Figure 4*). The data shows that the highest healthy life expectancy in 2023 has been found in MT (71.4 years), IT (69.1 years) and BG (68.6 years). Over the period 2014-2023, in the case of 14 MS, the healthy life expectancy increased (RO⁽¹⁾, LT, PL, EL, HR, SK, AT, PT, EE, HU, BG, DE, IT, SI), in 1 MS remained constant (FR), while for 12 MS it decreased

(BE, LV, IE, CY, FI, MT, CZ, NL, ES, LU, DK, SE). The graph shows that the highest increases were recorded in DE (+6 years), IT (+6.7 years) and SI (+7.9 years), while the largest drops were found in LU (-3.6 years), DK (-4.6 years) and SE (-6.7 years). However, it should be taken into account that this indicator is based on a survey, and, usually, in developed Member States, people tend to make more reports on health issues than those living in poorer countries. In this respect, when setting policy priorities and adopting new policy measures, the interpretation of this indicator should be limited to the self-perceived health and more focus should be emphasized on total life expectancy, which reflects additional challenges for Romania.

Figure 4. Healthy life expectancy, gender inequality and innovation in EU Member States



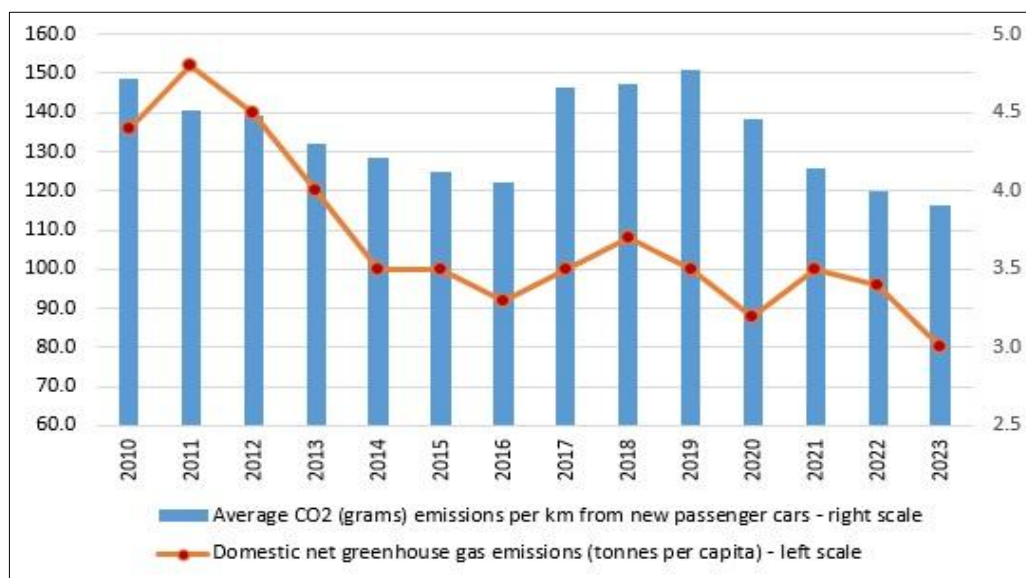
Source: Own processings in Microsoft Office Excel based on Eurostat data

With a view to gender gap, the data indicate a modest increase in gender pay inequality in the case of 4 MS (PL, EL, LV and HU), while the other MS experienced reductions in this imbalance, the largest falls being recorded in PT (-6.3pp), LU (-6.3pp) and EE (-11.2pp). In 2023, Romania registered the fourth lowest gender pay gap (3.8%) of EU, while the highest levels were reported for LV (19%), AT (18.3%) and HU (17.8%). *Figure 4* also highlights that only 6 MS (ES, IT, EL, CY, BG, RO) experienced increases in the gender employment gap, for Romania being reported the highest increase (1.6pp), while the largest falls were found in the case of EE (-4.1pp), LU (-6.1pp) and MT (-12.7pp). According to the data reported for 2023, Romania registered the third highest level of gender employment gap (19.1pp, after EL with 19.8pp and IT with 19.5pp), which highlights the need to increase the policy efforts to tackle gender inequality, including the one related to employment.

Regarding the R&D expenditure (% of GDP), Romania registered a modest increase over the period 2014-2023 of 0.16pp of GDP, while HR (+0.62pp of GDP), EL (+0.64pp of GDP) and BE (+0.96pp of GDP) experienced the highest growths of EU. At the opposite are CZ (-0.11pp of GDP), LU (-0.21pp of GDP) and SI (-0.26pp of GDP) for which has been reported the highest decreases in this indicator. Even if Romania registered a modest increase, the challenges related to low financing of R&D sector remain at a higher level, taking into account that Romania still registers the lowest share in GDP of the R&D expenditure (0.52 of GDP - 2023 data), being overpassed by MT and CY (0.64% of GDP and 0.68% of GDP - which have a competitive advantage in tourism sector) and BG (0.79% of GDP).

Another relevant goal is the one related to climate action. *Figure 5* presents the positive relationship between average CO₂ (grams) emissions per km from new passenger cars and the domestic net greenhouse gas emissions (tonnes per capita) in Romania over the period 2010-2023, this being also reflected in the mid to high Pearson correlation coefficient (49.02%). *Table 1* shows that the relationship was positive in 22 Member States, the strongest links being found in NL (80.2%), AT (72.96%) and HU (70.48%), while the highest negative correlations were calculated for FI (-15.36%), SE (-48.09%) and LV (-60.56%). This suggest that for Romania, emissions from new cars remain an important factor driving the greenhouse gas emissions, which should be adequately taken into account when designing climate strategies. However, greenhouse gas emissions in Romania remain under the levels experienced by other Member States. In this respect, even if the climate goals are pressing worldwide, Romania has enough space to promote flexible policy approaches.

Figure 5. The relationship between average CO₂ (grams) emissions per km from new passenger cars and domestic net greenhouse gas emissions (tonnes per capita) in Romania (2010-2023)



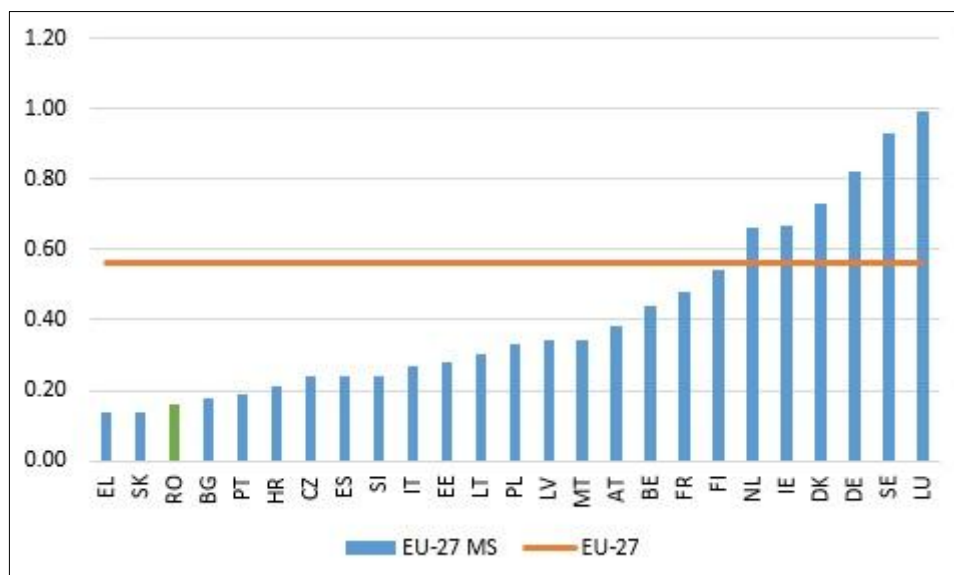
Source: Own processings in Microsoft Office Excel based on Eurostat data

Further, in Figure 6, to reflect the progress on implementing the goal entitled partnership for the goals, we analysed the official development assistance provided to developing countries. According to the Eurostat data, in 2023, Romania provided an assistance to developing countries equal to 0.16% of GNI, with 0,4pp lower than the EU value.

Table 1. Correlation between average CO₂ (grams) emissions per km from new passenger cars and domestic net greenhouse gas emissions (tonnes per capita) - 2010-2023

Correlation	Correlation
BE	57.11%
BG	-0.86%
CZ	39.65%
DK	59.32%
DE	58.19%
EE	27.76%
IE	61.09%
EL	19.08%
ES	19.40%
FR	54.97%
HR	41.40%
IT	6.93%
CY	28.33%
LV	-60.56%
LT	18.44%
LU	47.02%
HU	70.48%
MT	25.46%
NL	80.20%
AT	72.96%
PL	51.27%
PT	51.06%
RO	49.02%
SI	-10.96%
SK	32.33%
FI	-15.36%
SE	-48.09%

Source: Own processings in Microsoft Office Excel based on Eurostat data

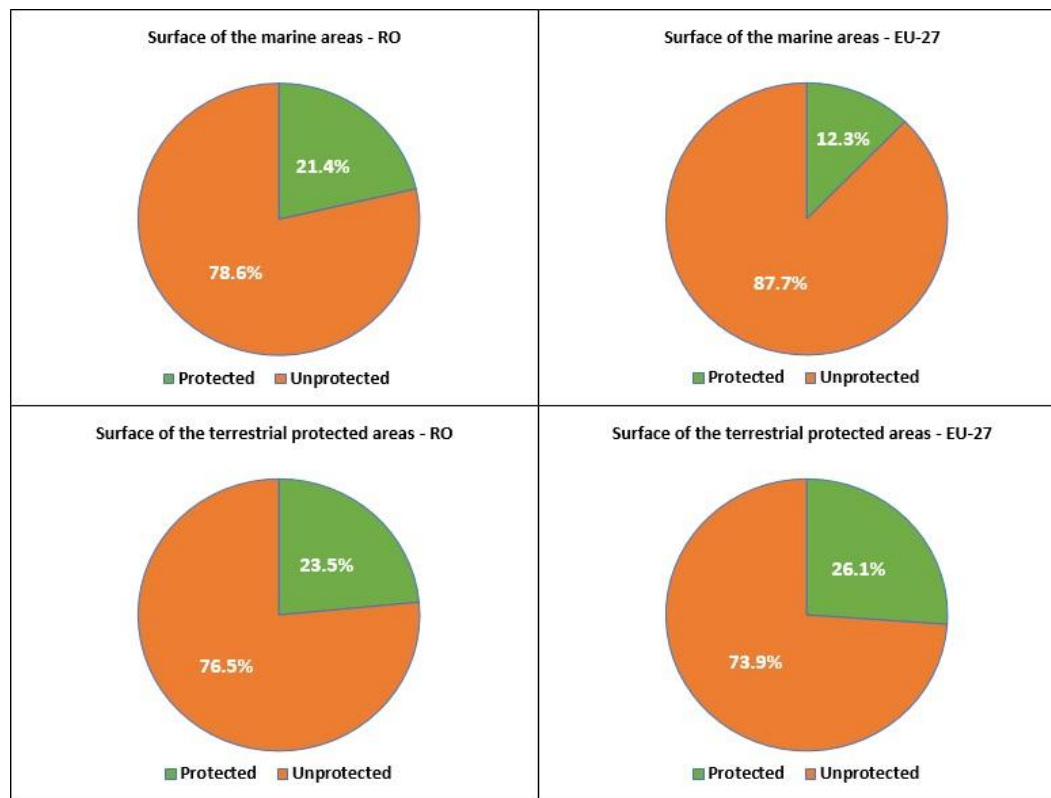
Figure 6. Official development assistance provided to developing countries (% of GNI) - 2023

Source: Own processings in Microsoft Office Excel based on Eurostat data

Although Romania is positioned under the EU value, it should be taken into account that only 6 developed EU MS registered a value over 0.56% of GNI, respectively NL (0.66%), IE (0.67%), DK (0.73%), DE (0.82%), SE (0.93%) and LU (0.99%). In this context, the data does not reflect a challenge for Romania, taking into account its development needs.

Regarding the SDGs entitled life below water and life on land, we conducted a comparison between Romania and EU-27 to examine the protected areas. In this respect, *Figure 7* indicates that 21.4% of the surface of the marine area is protected in Romania, compared to 12.3% reported for EU-27. Thus, Romania registered the seventh highest protected marine area from EU, and even if it has only 244 km of coastline, the Black Sea is ecologically valuable since it is one of the most important water areas of Europe.

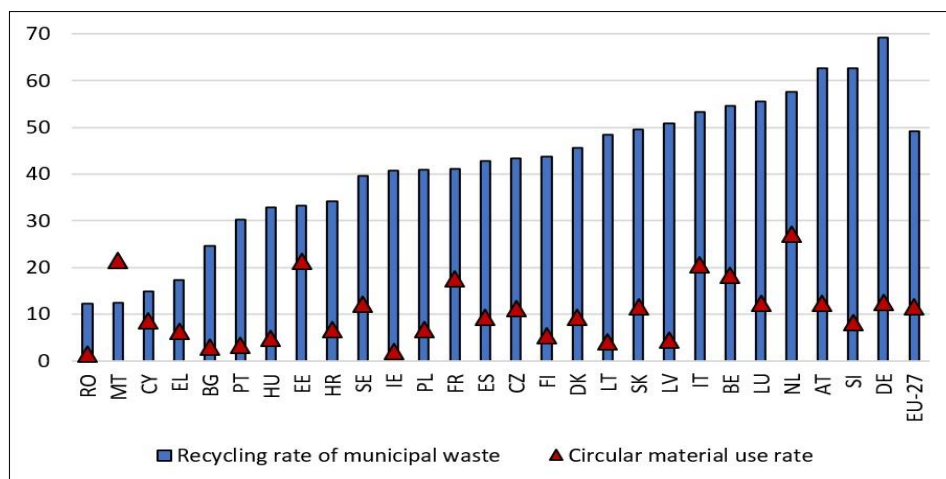
However, it should be noted that EU-27 includes five landlocked countries (AT, CZ, HU, LU, SK) which reduces the EU value, while there are also countries with a longer coastline than Romania (IT, EL, ES) for which are reported a lower surface of marine protected areas taking into account the exploitation interests and local/regional fragmentation. With a view to the terrestrial protected areas, the difference between Romania (23.5%) and European Union (26.1%) is lower, but both rates are under the quantitative target (30% - also applicable for the marine areas) set through the Green Deal that should be reached until 2030. In the context of the European commitment, further efforts are needed at national level to reach this objective until 2030, but also to completely identify the 10% areas that should be strictly protected.

Figure 7. Surface of the marine and terrestrial protected areas - RO vs. EU-27 (2022)

Source: Own processings in Microsoft Office Excel based on Eurostat data

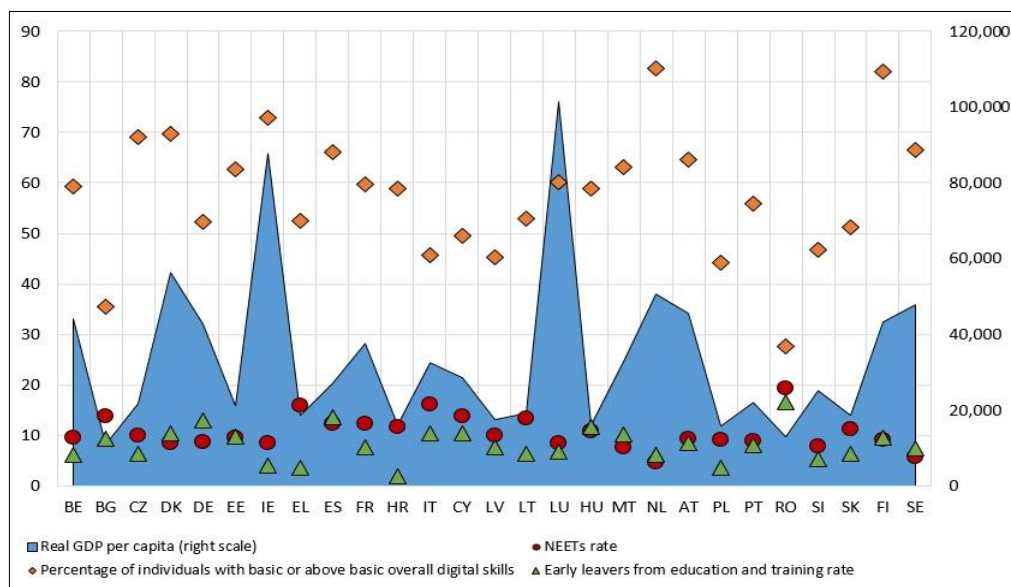
According to *Figure 8*, in 2022, the lowest value of the recycling rate of municipal has been recorded by Romania (12.3%, compared to the EU average of 49.1% - being followed by MT with 12.5% and CY with 14.8%), while the highest rates were found in AT (62.6%), SI (62.6%) and DE (69.2%). Regarding the circular materials use rate, Romania does not experience a better situation.

In 2022, RO (1.5%) registered the lowest value of this indicator, being followed by IE (2.1%) and BG (3%), while the EU average was 11.5%. The identified problems leading to low rates of recycling rate are the lack of selective waste collection containers (especially in rural areas), the lack of environmental education promoting the importance of selecting garbage. In order to reach the level of countries that consider recycling and circular economy essential, there is a need to promote investments in educating the population and those oriented to waste sorting process. In addition, the low circular material use rate may be attributable to the challenges related to poor infrastructure, dependence on primary resources and weak legislation in this area.

Figure 8. Recycling rate of municipal waste and circular material use rate in EU MS (2022)

Source: Own processings in Microsoft Office Excel based on Eurostat data

In Figure 9, we examined the EU-27 data for 2023 regarding the following indicators: real GDP per capita, percentage of individuals with basic or above basic overall digital skills, NEETs rate and early leavers from education and training rate. In this respect, according to the data, countries registering a low level of NEETs rate and early leavers from education and training rate seems to report a higher real GDP per capita, which evidences a positive relationship between economic growth and education level.

Figure 9. Economy and education quality data in EU MS (2023)

Note: the indicators expressed in % are represented on the left scale.

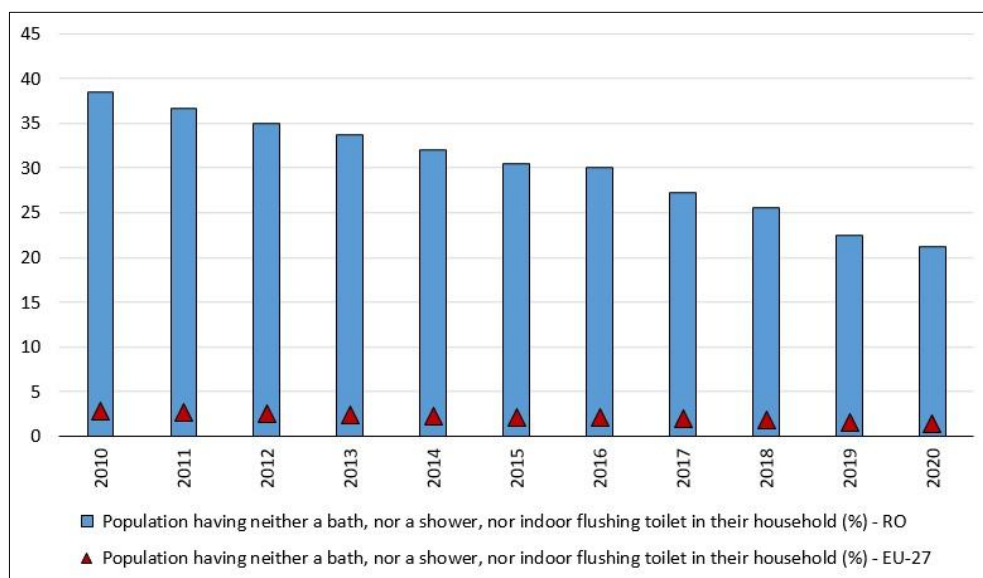
Source: Own processings in Microsoft Office Excel based on Eurostat data

People who for various reasons decide not to pursue an education or vocational qualification program will have more difficulty finding a job compared to those who have completed higher education. It should also be noted that they are exposed to income risks, compared to skilled and educated workforce.

Digital skills are also very important when discussing educational challenges. However, Romania registers the lowest rate in the EU of individuals with basic or above basic overall digital skills (27.73%) - being followed by BG (35.52%) and PL (44.3%) - well below the EU average (55.56%). Moreover, the relationship between individuals with basic or above basic overall digital skills and the NEETs rate is closely linked, as countries recording low values of the percentage of individuals with basic or above basic digital skills also register a high level of NEETs rate, a relationship strongly observed in RO, BG, EL, IT.

According to *Figure 10*, Romania is the Member State with the most households without having neither a bath, nor a shower, nor indoor flushing toilet. As can be seen, in the analysed period 2010-2020 this indicator was on a decreasing trend, but nevertheless Romania stay in the first place in the EU (21.2% in 2020 over EU average - 1.5%). This situation is worrying, and government authorities must adopt measures to support local communities in developing infrastructure within households in disadvantaged environments. Another countries from EU with high values of this indicator in 2020 were BG (7%), LV (7%) and LT (6.4%).

Figure 10. *The evolution of population having neither a bath, nor a shower, nor indoor flushing toilet in their household (%)*

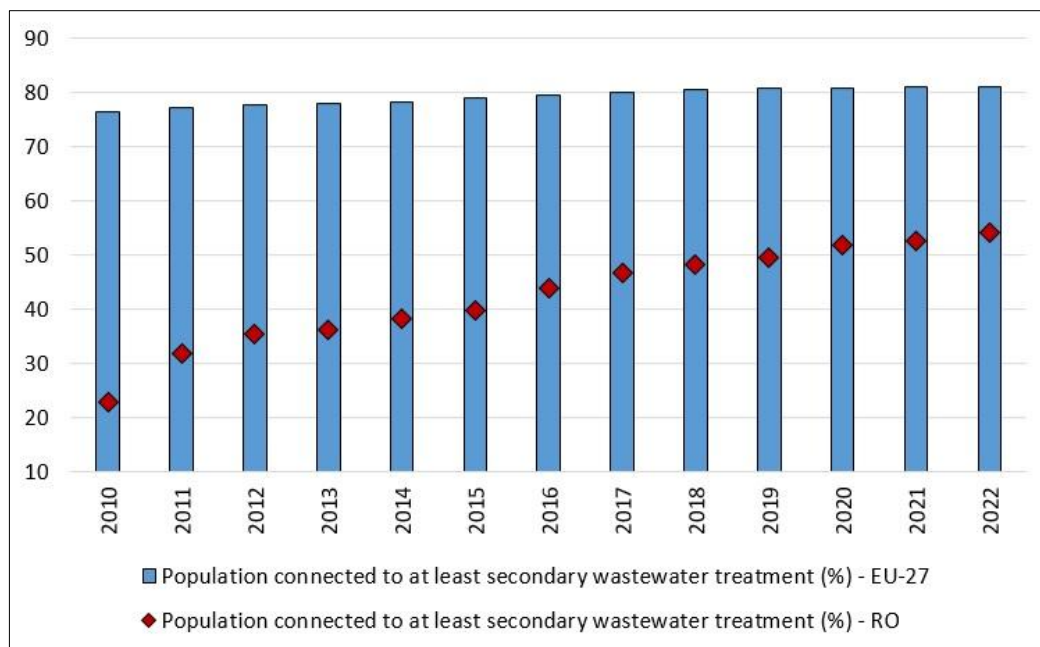


Source: *Own processings in Microsoft Office Excel based on Eurostat data*

Next, we analysed the evolution of the population connected to at least secondary wastewater treatment systems in the period 2010-2022. According to *Figure 11*, population connected to at least secondary wastewater treatment increase in Romania in the analysed

period, the highest value being recorded in 2022 - 54% (EU average 81%). Despite the progress made, Romania ranks second (with Malta in first place at 7.3), remaining well behind other countries where values exceed 99%, such as the Netherlands (99.65%) and Austria (99.15%). The low rate of population connected to at least secondary treatment systems has multiple causes: deficiency of infrastructure, disproportionate prioritization of sewage and drinking water, fragmented implementation and uneven regional distribution between urban and rural areas (almost half of the Romanian population lives in rural areas). Romania also needs to accelerate infrastructure projects regarding water treatment systems to reach EU standards and protect the environment and public health.

Figure 11. *The evolution of the population connected to at least secondary wastewater treatment systems (%)*

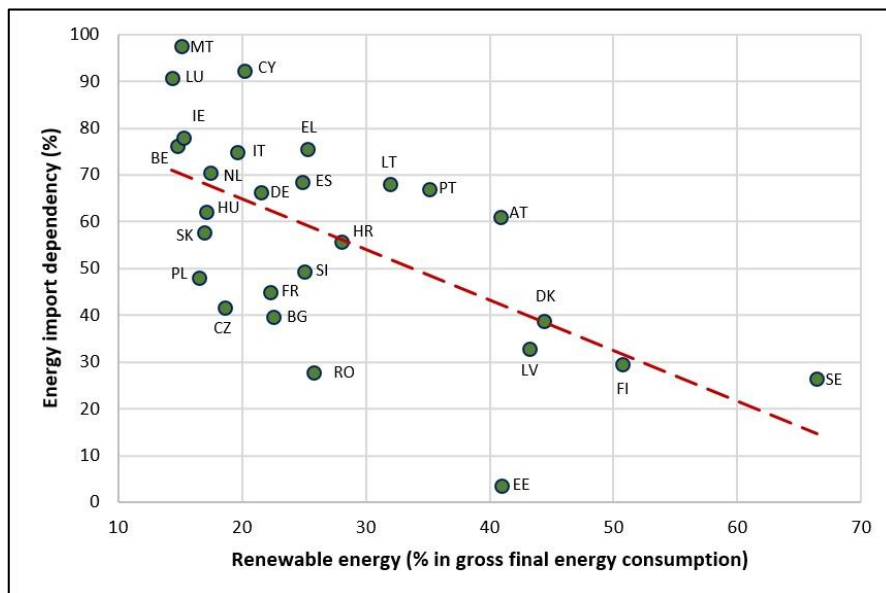


Source: *Own processings in Microsoft Office Excel based on Eurostat data*

Regarding the goal of affordable and clean energy (*Figure 12*), we found a negative relationship between the 2023 EU Member States' rankings in renewable energy and their performance in terms of energy import dependency, this being supported also by the high negative correlation coefficient (-62.37%).

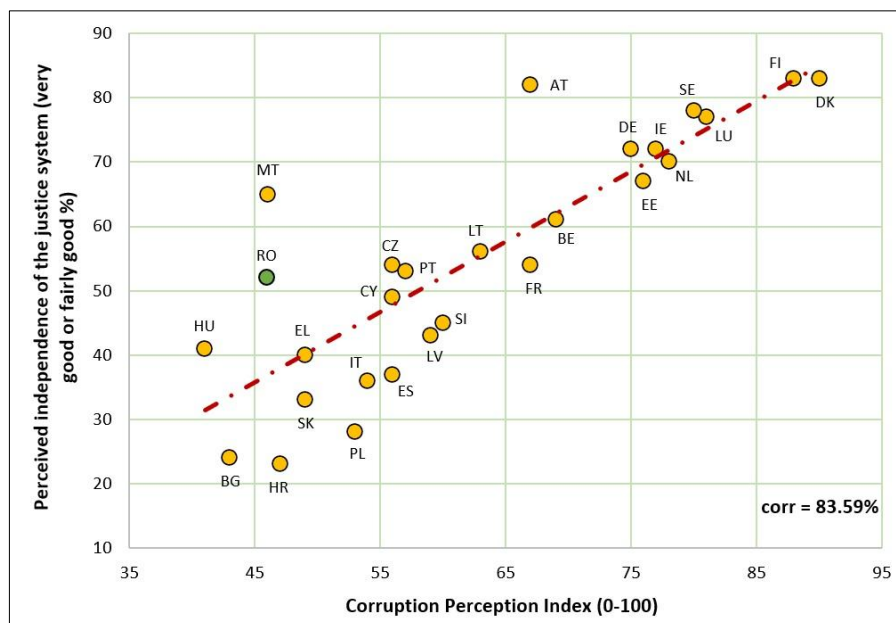
This finding highlights the importance of promoting renewable energy production, given its potential to reduce dependence on the external energy sources. According to the data, in 2023, Romania registered the third lowest energy import dependency (27.83%, compared to EU-27 dependency which is more than twice higher - 58.27%) - a lower dependency rate being found in SE (26.38%) and EE (3.47%), while in terms of renewable energy it recorded the tenth highest rate (26.78%), a higher share than the one of EU-27 (24.55%).

Figure 12. The relationship between the share of renewable energy in gross final energy consumption and energy import dependency (2023)



Source: Own processings in Microsoft Office Excel based on Eurostat data

Figure 13. The relationship between the corruption perception index and the perceived independence of the justice system (2024)



Source: Own processings in Microsoft Office Excel based on Eurostat data

The last objective examined relates to peace, justice and strong institutions (*Figure 13*). In this context, we examined the relationship between the 2024 EU Member States' rankings from the perspective of corruption perception index and their positions regarding the perceived independence of the justice system and we found a strong association (high Pearson correlation coefficient of 83.59%). This evidences the high importance of corruption perception in shaping human action, as it influences the perception on the justice system independence, but also the way people acting. Finally, the institutional pillar may provide appropriate instrumental variables for many socio-economic indicators taking into account their high association with GDP/capita and well-being indicators.

5. Conclusions

This paper shows that socio-economic challenges are more pressing than environmental ones in Romania, compared to other developed EU MS where the environmental challenges need an increased focus within the policy specific processes.

The data highlights that Romania made some progress in addressing the social challenges, but further efforts are needed taking into account social risks (also reflected in the high percentage of people being exposed to poverty or social exclusion) remain pronounced. Challenges related to education (including the ones related to high NEETs and earlyleavers rates, but also the low percentage of individuals with basic or above basic digital skills) and health systems also exerts a higher pressure on these. In addition, the rural areas in Romania remain poor, which triggers additional social risks, taking into account the high share of population not having a bath, a shower and an indoor flushing toilet in their household, but also the low rate of population connected to at least secondary wastewater treatment systems.

Even if Romania is mid-ranked regarding the renewable energy share and registers the third lowest rate of energy import dependency, our analysis confirms a strong negative relationship between EU MS positions from the perspective of these indicators (-62.37%), this confirming the important role of renewable energy in reducing the energy dependency at EU level. Nevertheless, greater efforts should be made to promote recycling behaviour and to encourage the adoption of circular economy practices through product reuse and resource efficiency. Even if the greenhouse gas emissions are low in Romania, compared to other EU MS, the policymakers should take into account when designing new policies, the mid-to-high correlation (49.02%) between the average CO₂ emissions per km from new passenger cars and domestic net greenhouse gas emissions over the period 2010-2023.

Moreover, the analysis highlights significant institutional challenges for Romania, which recommends further efforts to improve the quality of institutions taking into account their positive association with socio-economic dimension. Finally, even though Romania has reduced some economic gaps through the increase in GDP per capita, further progress can be supported by strengthening innovation capacity, including through increased - but higher quality - expenditure on research and development.

Note

⁽¹⁾ Modest increase of +0.2 years.

References

- Acemoglu, D., and Robinson, J.A. (2012). *Why nation fail: The origins of power, prosperity, and poverty*, New York; Crown Currency.
- Altikolatsi, E., Karasmanaki, E., Parissi, A. and Tsantopoulos, G. (2021). Exploring the factors affecting the recycling behavior of primary school students. *World*, Vol. 2, No. 3, 334-350.
- Belser, P. and Rani, U. (2015). *Labour Markets, Institutions and Inequality*, Cheltenham; Elgar Publishing.
- Blau, F. and Kahn, L., (2017). The gender wage gap: Extent, trends, and explanations. *Journal of Economic Literature*, Vol. 55, 789-865.
- Chichaibelu, B.B., Bekchanov, M., von Braun, J. and Torero, M. (2021). The global cost of reaching a world without hunger: Investment costs and policy action opportunities. *Food Policy*, Vol. 104, No. 102151.
- Churchman, C. (1967). Wicked problems. *Management Science*, Vol. 4. No. 14, B141-B142.
- Cotter, D., England, P. and Hermesen, J. (2007). Moms and Jobs: Trends in Mothers' Employment and Which Mothers Stay Home, *A Briefing Paper Prepared for the Council on Contemporary Families*.
- Crane, M, Lloyd, S., Haines, A., Ding, D., Hutchinson, E., Belesova, K., Davis, M., Osrin, D., Zimmermann, N., Capom, A., Wilkinson, P. and Turcu, C. (2021). Transforming cities for sustainability: A health perspective. *Environment International*, Vol. 147, No. 106366.
- Davenport, T., (2014), How strategists use "big data" to support internal business decisions, discovery and production. *Strategy & Leadership*, Vol. 42(4), 45-50.
- DiPrete, T.A. and Buchmann, C. (2013). *The rise of women. The growing gender gap in education and what it means for American school*, New York; Russell Sage Foundation.
- Dobbin, F. (2009). *Inventing Equal Opportunity*, Princeton; Princeton University Press.
- Duflo, E. and Banerjee, A. (2011). *Poor economics: A radical rethinking of the way to fight global poverty*, New York: Public Affairs.
- Easterly, W. (2006). *The white man's burden. Why the West's efforts to aid the rest have done so much ill and so little good*, New York; The Penguin Press.
- ECESA. (2017). 2017 HLPF Thematic Review of SDG 14: Conserve and Sustainably Use the Oceans, Seas and Marine Resources for Sustainable Development, *Executive Committee on Economic and Social Affairs*. <www.sdg.un.org/>
- Hoddinott, J., Rosegrant, M. and Torero, M. (2013). *Hunger and Malnutrition*, Cambridge; Cambridge University Press.
- IASS. (2017). *Achieving the Sustainable Development Goal for the Oceans*, IASS Policy Brief 1/2017.

- Jianu, I., Tudorache M.D. and Simion, C.S. (2025). Assessing the Impact of Institutions on Social Development, *Proceedings of 19th International Conference on Business Excellence 2025*, 907-915.
- Khalifa, M. and Bidaisee, S. (2018). The Importance of Clean Water. *Scholar Journal of Applied Science and Research*, Vol. 1, No. 7, 17-20.
- Kricher, J. (1997). *A Neotropical Companion*, Princeton; Princeton University Press.
- Kumar, C.R. and Majid, M.A. (2020). Renewable energy for sustainable development in India: current status, future prospects, challenges, employment, and investment opportunities. *Energy, Sustainability and Society*, Vol. 10, No. 2.
- McMichael, A.J., Woodruff, R.E. and Hales, S. (2006). Climate change and human health: Present and future risks. *Lancet*, Vol. 367, 859-869.
- Mendelsohn, R., Dinar, A. and Williams, L. (2006). The distributional impact of climate change on rich and poor countries. *Environment and Development Economics*, Vol. 11, 159-178.
- Mohammed, A.J. and Ghebreyesus, T.A. (2018). Healthy living, well-being and sustainable development goals. *Bull World Health Organ*, Vol. 96, No. 9, 590-590A.
- Nandha, M. and Smyth, R. (2013). Quality of Governance and Human Development, *SSRN*, Available at; <https://doi.org/10.2139/ssrn.2360898>.
- Piketty, T. (2014). *Capitalul în secolul XXI*, București; Litera.
- Sachs, J.D. (2005). *The end of poverty. Economic Possibilities of Our Time*, New York; The Penguin Press.
- Sapena, J., Almenar, V., Apetrei, A., Escriva, M., and Gil, M. (2018). Some reflections on poverty eradication, true development and sustainability within CST. *Journal of Innovation & Knowledge*, Vol. 3, No. 2, 90-92.
- Solomon, S., Qin, D., Manning, M., Marquis, M., Averyt, K. and Tignor, M.M. (2007). *Climate Change 2007 - The Physical Science Basis: Working Group I Contribution to the Fourth Assessment Report of the IPCC*, Cambridge; Cambridge University Press.
- Steffen, W. (2018). Trajectories of the earth system in the Anthropocene. *The Proceedings of the National Academy of Sciences*, Vol. 115, No. 33, 8252-8259.
- Stiglitz, J. (2015). *The Great Divide: Unequal Societies and What We Can Do About Them*, New York; W.W. Norton & Co.
- Stureson, A., Weitz, N. and Persson, A. (2018). *SDG 14: Life Below Water. A Review of Research Needs. Technical annex to the Formas report Forskning för Agenda 2030*, Stockholm: Stockholm Environment Institute.
- Trenberth, K.E. (2001). Climate variability and global warming. *Science*, Vol. 293, 48-49.
- Tudorache, M.D. (2019). Poverty rate determinants in the Central and Eastern Europe member states, *Theoretical and Applied Economics*, Vol. 26, No. 4, 163-180.
- Tudorache, M.D. (2022). Poverty in Romania: an analysis at regional level, *Theoretical and Applied Economics*, Vol. 29, No. 631, 81-88.
- United Nations. (2017). Development Issues No. 9: Low growth with limited policy options? Secular Stagnation – Causes, Consequences and Cures. *Economic Analysis*, Department of Economic and Social Affairs.
- United Nations Educational, Scientific and Cultural, Organization (UNESCO). (2000). The Dakar Framework for Action: Education for All: meeting our collective commitments (including six regional frameworks for action), *World Education Forum, Dakar, UNESDOC Programme and Meeting Document*.
- United Nations Educational, Scientific and Cultural, Organization (UNESCO). (2005). Contributing

- to a more sustainable future: Quality education, life skills and education for sustainable development, *UNESDOC Programme and Meeting Document*.
- Weeden, K.A., Newhart, M. and Gelbgiser, D. (2018). Occupational Segregation, *Stanford Inequality and Poverty Center paper*, Stanford.
- Zabeltitz, C. (1994). Effective use of renewable energies for greenhouse heating. *Renewable Energy*, Vol. 5, 479-485.
- Zhou, J. (2013). Digitalization and Intelligentization of manufacturing industry. *Advances in Manufacturing*, Vol. 1, 1-7.
- Eurostat, <www.ec.europa.eu/eurostat>
- United Nations, <www.sdg.un.org/goals>
- World Vision, <www.worldvision.org.nz/>

Insurance and sustainable structural transformation: Does renewable energy matter?

Geneviève Christel KAMDOUM MAPA

University of Bamenda, Bamenda, Cameroon

Cmapakamdoum@yahoo.com

Younchawou NGOUWOU

University of Dschang, Dschang Cameroon

yngouwouo@gmail.com

Emmanuel NSO FILS

Omar Bongo University, Libreville, Gabon

nsofils2002@yahoo.fr

Abstract. *The existing body of research examining the interplay between finance and development predominantly concentrates on the banking sector and capital markets, often overlooking the significant potential of the insurance sector. To address this gap, this paper investigates the impact of the insurance sector on sustainable structural transformation, specifically emphasizing the mediating role of renewable energy adoption. Employing panel data from 40 African countries spanning the period 2000-2019 and utilizing Panel Corrected Standard Error (PCSE) and Feasible Generalized Least Square (FGLS) estimation techniques, the findings indicate a positive and statistically significant relationship between insurance sector development and sustainable structural transformation. Further, the disaggregation of insurance into life and non-life insurance reveals that both sub-sectors contribute positively, with non-life insurance exhibiting a more substantial effect. Crucially, the analysis establishes renewable energy as a key transmission mechanism through which the insurance sector influences sustainable structural transformation. These results suggest that policymakers should strategically leverage the savings generated by the insurance sector to foster and fund initiatives that promote a transition towards sustainable development pathways.*

Keywords: insurance sector, sustainable structural transformation, renewable energy.

JEL Classification: G22, G32, Q42.

1. Introduction

The prevailing global paradigm of sustainable development is widely considered a crucial framework for addressing the multifaceted challenges confronting both developed and developing nations. A defining characteristic of many Southern countries is their constrained access to the financial resources necessary to fuel their development ambitions. The adoption of renewable energy stands as a key objective within the Sustainable Development Goals (SDG 7), and the pivotal role of energy efficiency in combating climate change was underscored at COP 21.

Despite concerted global efforts to accelerate the growth of renewable energy, a significant impediment remains: the challenge of securing adequate financing (IEA, 2021). Compounding this issue is the often-low return on investment associated with clean energy projects (Taghizadeh-Hesary & Yoshino, 2020). Indeed, research by Del Gaudio (2022) suggests that green loans can potentially reduce bank profitability and elevate default risk. However, contrasting findings from Zyadin et al. (2014) highlight the substantial commercial potential inherent in renewable energies, thus advocating for increased investment. Despite this potential, recent data from the International Energy Agency (IEA, 2021) indicate that renewable energy sources still constitute less than 30% of global energy production. Overall, Alharbi et al. (2023) emphasize the compelling role of renewable energy as a solution to climate change.

The expansion of renewable energy necessitates the integration of innovative technologies. Existing literature has established the significant role of the financial sector in fostering innovation (Cornaggia et al., 2015; Hsu et al., 2014). Capital mobilized by the insurance sector can contribute to advancements in renewable energy technologies through several mechanisms. Firstly, an efficient financial sector can lower the financing costs associated with new technologies through effective resource allocation. Secondly, the insurance sector can facilitate the diversification of investor risks, enabling companies to leverage external funds to mitigate the inherent risks of innovation (Cornaggia et al., 2015). Finally, the increasing urgency of climate action is driving investors towards greater social responsibility, prioritizing sustainable investments (Krueger et al., 2020).

Prior scholarly work indicates that shifting economies away from basic farming and raw material exploitation toward industrial and service-based frameworks is crucial for boosting economic expansion and increasing output potential (Botta et al., 2023; Page, 2015). Specifically, factory-based production provides benefits like increased wealth, cost efficiencies through large-scale operations, and advancements in technology, making it a favored pathway for improving how efficiently things are made (Page, 2015). Additionally, factory output creates substantial indirect positive impacts on the service industry through interconnected activities, encouraging external benefits in technological advancement, workforce skill improvement, and knowledge acquisition, all essential for bettering overall competitive standing (Page, 2015). The core of reshaping industrial structures involves moving production resources from less efficient to more efficient and resource-conscious areas, driven by the best possible distribution and organization of these resources across different economic activities (Lin & Zhou, 2021). Nevertheless, conventional factory-led output can severely harm the environment.

In response, some African nations, such as South Africa, have implemented carbon taxes to incentivize companies to adopt greener inputs, such as renewable energy, which possess the potential to significantly reduce greenhouse gas (GHG) emissions. The South African government has adopted various supply-side interventions as instruments of green industrial policy. For instance, a carbon tax was introduced in 2019 at a rate of R120 per ton of carbon dioxide equivalent (tCO₂e), subsequently increasing to R190 per tCO₂e from January 1, 2022 (National Treasury, 2024). The National Treasury aims for a carbon tax of US\$ 30 per tCO₂e by 2030, which remains below the International Monetary Fund's target of US\$ 50 per tCO₂e for emerging markets (SARB, 2023; Gaspar & Parry, 2021). Notably, South Africa's carbon tax covers a substantial portion (80%) of the country's emissions. In contrast to carbon-emitting energy sources, clean power from sunlight, wind, and water produces electricity without direct greenhouse gas emissions during its use. The widespread integration of sustainable technologies is fueling the expansion of environmentally sound manufacturing industries. Similarly, monetary progress can act as a driver in converting conventional industrial setups into advanced, intelligent industries, fostering industrial modernization as a means to stimulate economic advancement (Nian & Dong, 2022).

Numerous investigations have underscored the influence of financial progress on economic restructuring. Research conducted by Xue et al. (2024) suggests that the evolution of digital finance facilitates the updating of industrial frameworks. Likewise, Dong et al. (2024) highlight the role of financial technology in reshaping economic structures. Wang et al. (2023) emphasize the significant part played by environmentally conscious finance in enabling economic transformation, and Yang et al. (2023) establish a connection between financial development and the sophisticated evolution of the manufacturing sector. Nevertheless, existing research appears to have largely ignored the insurance industry when examining the link between financial growth and economic restructuring.

The African insurance industry is expanding rapidly, with increased participation from corporations, individuals, and governing bodies across life, non-life, and reinsurance markets. In 2019, insurance premiums in Africa were valued at USD 68.15 billion. The largest markets are concentrated in South Africa, Kenya, Egypt, Nigeria, Algeria, Angola, and Tunisia, collectively representing 83% of all African premiums in 2019. Data from the Federation of African National Insurance Companies (FANAF, 2023) indicates that the African insurance market accounted for only about 1% of total global premiums in 2022, compared to 43% in the Americas, 28% in Asia, and 27% in Europe. Despite often being less prominent within broader financial service sectors in Africa, the long-term growth and financial capacity of the insurance industry could arguably be vital for overall economic expansion and, particularly, economic restructuring.

This study makes three main contributions. Firstly, it seeks to fill the existing void in the analysis of the relationship between the financial sector and economic restructuring by specifically analyzing the role of the insurance industry. The insurance sector offers essential safeguards against capital investments and credit, and by extending investment timelines, it can increase the readiness of banks and investors to assume risks. It serves as a catalyst for economic and structural diversification by redirecting financial resources

from less productive sectors to more productive activities and by increasing access to financing. Consequently, enhancing the efficiency of financial resource allocation is crucial for driving broader economic efficiency and economic restructuring (Beck et al., 2011). Secondly, this study utilizes a contemporary and comprehensive measure for sustainable economic restructuring, the "Sustainable and Inclusive Structural Transformation Index," developed by Lin et al. (2019). Finally, this research aims to elucidate the function of renewable energy in the relationship between insurance and sustainable economic restructuring, a dimension largely overlooked in prior research. The mobilization of funds from the insurance sector could significantly contribute to the advancement of renewable energy technologies, ultimately facilitating the substitution of fossil fuels in companies' production processes and promoting sustainable economic restructuring.

The subsequent sections of this paper are structured as follows: Section 2 provides a succinct overview of the relevant scholarly work, Section 3 details the methodological framework, Section 4 presents the empirical findings, and Section 5 concludes with a discussion of the results and their implications for policy.

2. Literature Review

This section is structured into two sub-sections: the theoretical foundation (2.1) and empirical evidence (2.2)

2.1. Theoretical literature

Economic restructuring involves a fluid redistribution of productive endeavors, generally moving from farming to factory production and subsequently to service industries, marked by related changes in the proportional contribution of each sector to total production, job creation, and spending patterns (Pineli et al., 2021; Tyler et al., 2017). Monetary progress is broadly acknowledged as a vital element in facilitating this evolutionary change (Levine, 1999). Based on the principles of financial deregulation, eliminating restrictions on monetary systems is believed to encourage effectiveness and economic expansion (Naceur, 2016). Such deregulation can stimulate increased rivalry, greater novelty in financial instruments, and improved availability of funding, all of which can substantially aid economic restructuring. The conceptual links between monetary progress and economic restructuring are complex and have been investigated from various theoretical standpoints.

2.1.1 The Role of financial development in facilitating structural transformation

A well-developed financial system acts as a catalyst for structural transformation by optimizing resource allocation, encouraging capital accumulation, and driving technological innovation. Efficient financial markets direct funds towards their most productive applications, empowering firms to invest in advanced technologies and scale their operations (Levine, 1999). This function is especially critical for the expansion of the manufacturing and service sectors, which generally demand more substantial capital investments compared to agriculture.

2.1.2 Resource allocation and investment

An advanced financial system underpins structural transformation by enabling the efficient allocation of capital across diverse economic sectors (Levine, 1999). Financial institutions, encompassing banks and capital markets, play a pivotal role in information gathering, project evaluation, and the channeling of funds towards the most promising investment opportunities. This process is fundamental to structural change, facilitating the movement of resources from lower-productivity agricultural activities towards higher-productivity industrial and service sectors (Bustos et al., 2020). Furthermore, financial development fosters capital accumulation, a prerequisite for funding investments in nascent industries and advanced technologies (Levine, 1999). The expansion of credit markets empowers firms to secure loans for investment purposes, while the growth of equity markets provides avenues for raising capital through the issuance of shares.

2.1.3 Innovation and technological adoption

In developing economies, firms frequently encounter financial limitations that hinder their capacity to invest in research and development (R&D) and implement new technologies. A robust financial system can alleviate these constraints by offering firms access to the necessary funding for innovation (Pradhan et al., 2016). Supporting this, Liu and Liu (2021) demonstrated that financial development contributes to a reduction in carbon emission intensity through the promotion of technological innovation.

The body of theoretical literature robustly supports the premise that financial development is instrumental in facilitating structural transformation. By optimizing resource allocation, encouraging capital accumulation, fostering innovation, and effectively managing risk, well-functioning financial systems empower economies to transition from agrarian-based structures towards industrial and service-oriented models.

2.2. Empirical literature

The empirical literature on the relationship between financial development and structural transformation is organized around two key aspects: the direct and indirect effects.

2.2.1 The direct effect

Investigations centered on the Sub-Saharan African region (SSA) have explored how monetary progress influences economic restructuring, frequently within the context of integrated financial systems. These analyses commonly suggest that monetary progress encourages economic shifts by increasing the worth added by both factory production and farming. Nevertheless, its effect on the service industry might be less pronounced, and the noticed outcomes may be more interconnected than separate (Alagidede et al., 2020). As an example, Ustarz and Fanta (2021) discovered a beneficial effect of monetary progress on service and farming industries in SSA, but pointed out that a certain level of monetary progress is needed to positively affect the factory sector. Likewise, Lo and Ramde (2019) determined that monetary progress supports long-run economic restructuring within the Franc Zone.

Looking beyond Africa, research in other areas provides pertinent understandings. Li et al. (2021) studied the interaction between ecological rules and monetary progress on environmentally friendly overall production efficiency in China's Yangtze River Delta (YRD) area. Yang et al. (2023) examined data from 283 Chinese urban centers to evaluate how monetary progress affects carbon releases, while taking into account the improvement of industrial frameworks. Their results indicate a distinct positive impact of monetary progress on both carbon releases and the advancement of industrial frameworks. While a straightforward connection between monetary progress and economic restructuring is often seen, an indirect connection influenced by elements like the uptake of sustainable energy sources merits further investigation.

2.2.2 Indirect effect

The exploration of the indirect relationship between financial development and structural transformation is organized into two key areas. The first (section 2.2.2.1) examines the established links between financial development and renewable energy adoption, while the second (section 2.2.2.2) presents evidence on the nexus between renewable energy and structural transformation.

2.2.2.1 Financial development and renewable energy

Heightened worldwide worry about climatic shifts and the pressing need for enduring power options has placed the connection between monetary progress and sustainable energy at the forefront of both scholarly inquiry and governmental policy creation. A growing collection of academic work points to a favorable link between monetary progress and the embrace of sustainable energy.

Monetary progress can spur the utilization of sustainable energy by easing the acquisition of funds for relevant undertakings (Qamruzzaman, 2024). Monetary organizations are increasingly presenting varied financial tools, including loans and equities, specifically crafted to bolster the implementation of sustainable energy technologies. This ease of funding is especially vital for high-cost sustainable energy ventures like extensive solar and wind power plants. Furthermore, monetary progress can lessen the perceived hazards tied to sustainable energy investments, thereby making them more appealing to investors (Taghizadeh-Hesary & Yoshino, 2020). Effective monetary systems can also steer resources toward exploration and innovation, encouraging technological leaps and lowering the costs of sustainable energy technologies. Such novelty is crucial for enhancing the competitive advantage of sustainable energy sources compared to traditional fossil fuels. Moreover, monetary progress can boost the effectiveness of sustainable energy markets by offering transparent price indicators, decreasing transaction expenses, and fostering vigorous competition (Sun et al., 2023).

Beyond funding ventures, monetary progress can also encourage the uptake of sustainable energy by individual consumers and businesses. Access to borrowing and other monetary services empowers households and firms to invest in sustainable energy systems, such as solar panels and energy-efficient appliances. Moreover, monetary progress underpins the expansion of sustainable energy industries by supplying essential working capital, trade financing, and other vital monetary services. A broad investigation encompassing 103

economies revealed a notable beneficial effect of monetary progress, particularly via banking institutions, on sustainable energy consumption (Sun et al., 2023). Further analysis underscored the impact of market depth, accessibility, and efficiency in both stock and bond markets on sustainable energy consumption (Sun et al., 2023).

The idea of ecological finance, encompassing monetary investments with clear environmental advantages, is increasingly recognized as a key driver for the sustainable energy sector. Ecological bonds, ecological loans, and other specialized ecological financial products serve to channel capital toward sustainable energy projects and promote wider ecological advancement objectives (Subramaniam & Loganathan, 2024), who also found that ecological finance propels sustainable energy growth in Singapore. In a related vein, Ye et al. (2022) scrutinized the influence of diverse aspects of monetary progress, including credit, equities, and securities, alongside corporate social responsibility (CSR) reporting, on sustainable energy investment in a developing economy, finding that CSR efforts positively shape sustainable energy adoption. Similarly, Iqbal and Fikri (2024) emphasize the capacity of Islamic finance, guided by Sharia principles, to fund sustainable energy projects across 30 nations with a presence of Islamic banks, suggesting that Sharia-compliant investors can play a significant role in financing clean technologies and promoting ecological advancement.

2.2.2.2 Renewable energy and sustainable structural transformation

Worldwide energy systems are undergoing a deep change, spurred by increasing worries about climatic shifts, the crucial need for secure energy supplies, and the pursuit of lasting economic progress (Yang et al., 2024). This shift involves a basic move away from fossil-based power towards sustainable energy forms, such as sunlight, wind, water power, and plant-based fuels, with major effects across different parts of the economy (Li et al., 2021). This analysis of existing research explores the varied effects of adopting sustainable energy on economic reshaping, covering changes in productive activities, the makeup of industries, technological progress, and societal betterment. Economic reshaping is defined as a basic change in how an economy is structured, typically involving moving resources from traditional areas like farming to manufacturing and service provision (Wei et al., 2022).

The growth and implementation of sustainable energy technologies act as a trigger for expansion in various economic sectors, including factory output, building, and services. For example, making key parts for sustainable energy systems, like solar panels and wind generators, creates new industries and job opportunities. Similarly, the building and setting up of sustainable energy plants greatly adds to economic growth. Furthermore, the ongoing upkeep and running of these plants require specialized services, further boosting the service sector (Liu et al., 2019), who showed that sustainable energy better encourages the improvement of China's industrial structure compared to coal-based energy. According to Maria et al. (2023), a basic economic reshaping is vital to stop the rise in global temperatures and advance lasting progress through a move to a low-carbon system. Overall, current research suggests that sustainable energy plays a key part in driving economic reshaping and creating a more lasting and fair future. By embracing sustainable energy and pushing technological innovation, nations can achieve their climate goals and ease

economic restructuring (Shan et al., 2021). Despite these significant advantages, the move to sustainable energy also brings considerable challenges, notably including financial obstacles.

This review points out three main gaps in the current research. Firstly, the established link between monetary progress and economic reshaping has largely ignored the possible role of the insurance industry in easing financial hurdles faced by businesses. Secondly, earlier studies on economic reshaping have not yet used the more complete and lasting measures now available for this factor. However, Lin et al. (2019) developed the "Sustainable and Inclusive Structural Transformation Index," which evaluates a nation's economic performance by considering environmental sustainability and social inclusion alongside economic reshaping. Finally, the research examining the connection between monetary progress and economic reshaping has not adequately highlighted the mediating role of sustainable energy. Yet, the growth of the sustainable energy sector significantly affects economic progress, particularly through intermediate industries such as electrical machinery production, transportation, warehousing, and various service industries. These identified gaps form the basic starting point for this study, leading to the development of the following hypotheses:

H₁: The insurance sector promotes sustainable structural transformation

H₂: Renewable energy is a channel through which the insurance sector fosters the structural transformation.

3. Data and methodology

3.1. Data

This study employs panel data covering 40 African countries over the period spanning 2000 to 2019. Data pertaining to insurance activities were sourced from the Global Financial Development database. Macroeconomic variables were collected from the World Development Indicators. The sustainable structural transformation indicator was obtained from the research of Lin et al. (2019). The selection of the study period and countries was determined by data availability. A comprehensive description of the data is presented in Tables 1 and 2, and the specific list of countries included in the analysis is provided in Table A in the Appendix. Table 1 provides a summary of the model variables using key indicators. As illustrated in this table, the distribution of total insurance activity across the African countries in our sample exhibits considerable heterogeneity. (Variation coefficient = $\frac{\text{Standard deviation}}{\text{Mean}} = \frac{2.339}{1.459} = 1.60 > 0.33$). Table 2 presents the results of the correlation analysis. As shown in this table, a positive relationship exists between total insurance activity and sustainable structural transformation. This positive association is further substantiated by the graphical representation in Figure 1. The implication of this finding is that countries with more developed insurance markets tend to accumulate sufficient resources to facilitate their transition towards sustainable structural transformation.

Table 1. *Descriptive Statistics*

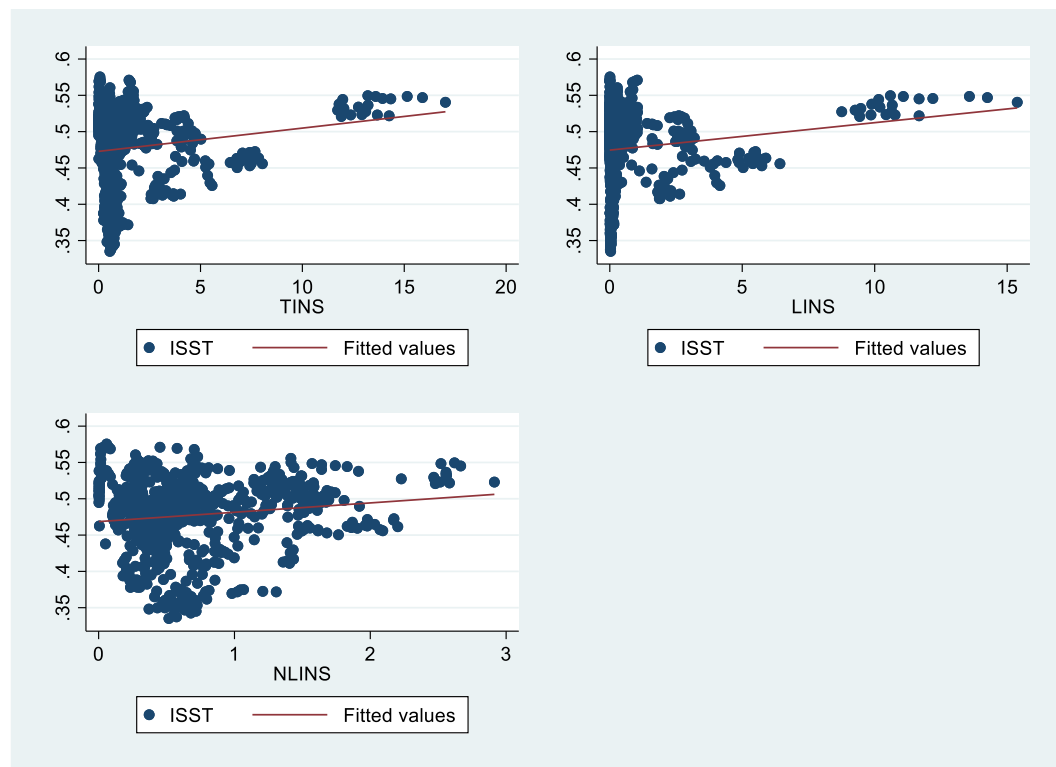
	N	Mean	SD	Median	Min	Max
ISST	800	.478	0.049	.488	.335	.575
TINS	800	1.459	2.339	.707	.002	17.023
LINS	800	.781	1.962	.143	0	15.381
NLINS	800	.698	0.522	.537	.002	2.914
Renewable	800	62.273	29.375	75.55	.1	98.3
Domcred	800	23.276	25.228	14.419	.002	142.422
Debtstocks	772	50.272	42.418	37.651	2.551	366.033
Mineralrents	800	1.243	2.826	.059	0	24.834

Source: Authors.

Table 2. *Correlation matrix*

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) ISST	1.000					
(2) TINS	0.185	1.000				
(3) Renewable	-0.019	-0.449	1.000			
(4) Domcred	0.156	0.784	-0.674	1.000		
(5) Debtstocks	0.134	-0.086	0.122	-0.046	1.000	
(6) Mineralrents	0.183	-0.064	0.004	-0.009	-0.049	1.000

Source: Authors.

Figure 1. *Insurance and sustainable structural transformation*

Source: Authors.

The dependent variable in this study is sustainable structural transformation, which we measure using the Sustainable and Inclusive Structural Transformation Index (ISST) developed by Lin et al. (2019). This index assesses the degree to which a country has cultivated a modern economy grounded in industry or services while simultaneously safeguarding the environment and promoting gender inclusivity. A key distinction of the SIST is its methodology, which, in line with New Structural Economics, accounts for variations in development levels across countries. The index evaluates a nation's performance relative to its available resources, employing multiple imputation techniques to address data limitations. This allows for comparative analysis across a broad spectrum of indicators for nearly 200 countries over a 25-year period. The ISST comprises several indicators categorized into three principal components: structural transformation, environmental sustainability, and social inclusiveness. Each indicator is transformed using a conditional cumulative density function to ensure equitable comparisons between countries at comparable stages of development.

Our primary independent variable of interest is insurance. For our baseline analyses, we utilize total insurance penetration as our measure. To ensure the robustness of our findings, we further differentiate between life and non-life insurance penetration. Insurance penetration is defined as the ratio of total insurance premium volume to GDP, serving as an indicator of the significance of insurance activity relative to the overall size of the economy. This measure is widely adopted in the existing literature (Arena, 2008; Bayar et al., 2021; Horvey et al., 2023).

The control variables included in our analysis are selected based on established literature concerning the determinants of structural transformation. Specifically, we incorporate the following variables: mineral resources (measured as the ratio of total mineral resource rents to GDP), external debt (captured by the percentage of external debt stock in GDP), domestic credit (measured as domestic credit extended by banks to the private sector as a percentage of GDP), and renewable energy (measured as the percentage of renewable energy consumption in total final energy consumption). Prior research on structural transformation has identified several key determinants. For instance, Huang et al. (2023) found a positive correlation between resource rents and structural transformation in developing countries. Similarly, Fogang and Tchitchoua (2020) demonstrated a non-linear relationship between external debt and structural transformation. Regarding renewable energy, Tian et al. (2024) established its role in promoting sustainable development. Finally, Kromtit (2022) showed a positive association between financial development and structural transformation.

3.2. Estimation strategy

The objective of this paper is to study the effect of insurance sector on the sustainable structural transformation in Africa. Our model specification is based on the study conducted by Tong et al. (2020). The econometric specification of our model is structured as follow:

$$ISST_{it} = \gamma_0 + \gamma_1 Tins_{it} + \gamma_2 Renew_{it} + \gamma_3 Domcred_{it} + \gamma_4 Debt_{it} + \gamma_5 Mineral_{it} + u_i + v_t + e_{it} \quad (1)$$

Where u_i is the unobserved country-specific effect, v_t is the time-specific effect and e_{it} is the error term. INS, Renew, Domcred, Debt, Mineral respectively represent the insurance activity, renewable energy, domestic credit, external debt, and mineral resources. Given that Insurance activities might influence the sustainable structural transformation through renewable energy, we defined the interaction variable between insurance and renewable energy (Tins*Renewable). This variable is included in equation (1) to form equation (2).

$$ISST_{it} = \gamma_0 + \gamma_1 Tins_{it} + \gamma_2 Renew_{it} + \gamma_3 Domcred_{it} + \gamma_4 Debt_{it} + \gamma_5 Mineral_{it} + \gamma_6 (Tins * Renewable)_{it} + u_i + v_t + e_{it} \quad (2)$$

Since our sample includes a larger N (40) compared to T (20), the automatic choice for robustness is the Panel Corrected Standard Error (PCSE). The PCSE models are both heteroskedasticity and simultaneously correlated across panels, with or without autocorrelation. However, since the empirical literature has found the two estimators to be mostly identical with common attributes, except when the number of time periods is twice the number of cross sections, (Reed & Ye, 2011), we also present the results of the FGLS method as an alternative measure to check the robustness of our findings. For, a popular Prais-Winsten estimation with the Panel Corrected Standard Error (PCSE), suggested by Beck and Katz (1995), has been performed to offer efficiency and consistency. Nevertheless, a related technique that would also achieve the same goal of overcoming group heteroskedasticity, time-invariant cross-sectional dependence as well as serial correlations is the Feasible Generalized Least Squares (FGLS) estimator previously proposed by Parks (1967). In fact, Monte Carlo simulations revealed that the FGLS and PCSE estimators are robust to three econometric problems: autocorrelation, heteroskedasticity, and panel correlation (Bai et al. 2021). However, as reported by Reed and Ye (2011), the FGLS estimator has been found to significantly underestimate standard errors in finite samples and cannot be used when the number of cross sections (N) is greater than the number of periods (T). In such circumstances, Beck and Katz (1995) proposed the PCSE estimator, which is a modification of the full GLS-Parks estimator that preserves the Prais-Winsten weighting of the observations for autocorrelation, but uses a sandwich estimator to incorporate the cross-sectional dependence when calculating the standard errors.

4. Results

This section is organized into three key parts. The first presents the main findings and their interpretation. The second explores the results while considering potential heterogeneity across the sample. Finally, the third part examines the role of renewable energy as a mediating factor in the relationship between insurance activities and sustainable structural transformation.

4.1. Main Results

Table 3 presents the results of the Panel Corrected Standard Error (PCSE) estimation, illustrating the effect of insurance activities on sustainable structural transformation. The findings in this table indicate that total insurance positively influences sustainable structural

transformation in African countries (columns 1 and 4). Decomposing total insurance into its life and non-life components confirms this initial result, with non-life insurance exhibiting a more substantial impact (Columns 2-3, 5-6). This outcome aligns with the premise that financial development fosters capital accumulation, which is crucial for funding investments in emerging industries and technologies (Levine, 1999). The expansion of credit markets enables firms to access borrowing for investment purposes. Indeed, the finance industry plays a significant role in long-term growth by influencing savings rates, investment decisions, and technological innovations (Levine, 2005). Consequently, improved resource allocation can spur innovation and facilitate the transition of economies from agriculture to industry and services, while simultaneously reducing carbon emission intensity through technological advancements (Liu & Liu, 2021). This result is consistent with the findings of Lo and Ramde (2019), who observed that financial development promotes long-run structural transformation in the Franc Zone, and the work of Jiang et al. (2020), which established a positive contribution of financial development to industrial structure upgrading in China.

Regarding renewable energy, the results indicate a positive and significant effect on sustainable structural transformation (Columns 4-6). The development of renewable energy can stimulate growth across various sectors, including manufacturing and services. For example, renewable energy technologies such as wind turbines and solar panels lead to the creation of new industries and employment opportunities, ultimately contributing to economic growth. As noted by Liu et al. (2019), renewable energy is more effective in promoting the upgrading of China's industrial structure compared to coal energy. Furthermore, Shan et al. (2021) demonstrated that by adopting renewable energy and fostering innovation, countries can achieve their climate goals and promote economic restructuring. The relatively modest effect of renewable energy on sustainable structural transformation in our African sample might reflect the current limited allocation of significant budgets towards clean energy development in these countries. Nevertheless, the positive relationship observed between these two variables should inform policymakers about the potential positive impacts of prioritizing clean energy development. Similarly, external debt also shows a positive influence on sustainable structural transformation. The relatively low impact of foreign debt presented in Table 3 could be attributed to the possibility that African countries' debt is not primarily directed towards promoting technological innovation, and even less so towards combating climate change.

Concerning mineral resources, their positive and significant impact on sustainable structural transformation can be explained by the fact that their exploitation can provide raw materials for the industrial sector. Moreover, the export of certain mineral resources generates foreign currency for exporting countries, which can be utilized to finance the transition from agriculture to industry and services. This finding contradicts the resource curse hypothesis identified by Nkemgha et al. (2022), who argued that natural resources constitute a hindrance to African industrialization. Similar results were obtained using Feasible Generalized Least Square (FGLS) and Pooled Ordinary Least Squares (OLS) estimations, as detailed in Table 4.

Table 3. *Effect of Insurance on sustainable structural transformation (PCSE)*

	1	2	3	4	5	6
Variables	ISST	ISST	ISST	ISST	ISST	ISST
TINS	0.00321*** (0.000290)			0.00426*** (0.000561)		
NLINS		0.0129*** (0.00196)			0.0163*** (0.00529)	
LINS			0.00378*** (0.000356)			0.00420*** (0.000590)
Renewable				0.000176*** (2.17e-05)	0.000217*** (2.12e-05)	0.000176*** (2.35e-05)
Domcred				0.000174*** (5.18e-05)	0.000249*** (9.31e-05)	0.000237*** (5.05e-05)
Debtstocks				0.000175*** (4.10e-05)	0.000158*** (4.22e-05)	0.000175*** (4.10e-05)
Mineralrents				0.00347*** (0.000418)	0.00372*** (0.000497)	0.00335*** (0.000403)
Constant	0.473*** (0.000539)	0.469*** (0.00139)	0.475*** (0.000439)	0.445*** (0.00301)	0.436*** (0.00306)	0.447*** (0.00323)
Obs	800	800	800	772	772	772
R-squared	0.023	0.019	0.023	0.104	0.101	0.102
Number of I	40	40	40	39	39	39
Prob(Chi2)	0.00	0.00	0.00	0.00	0.00	0.00

Source: Authors

Table 4. *Effect of insurance on sustainable structural transformation (FGLS and Pooled OLS)*

	FGLS	FGLS	FGLS	Pooled OLS	Pooled OLS	Pooled OLS
VARIABLES	ISST	ISST	ISST	ISST	ISST	ISST
TINS	0.00426*** (0.00126)			0.00426*** (0.000761)		
NLINS		0.0163*** (0.00555)			0.0163* (0.00796)	
LINS			0.00420*** (0.00138)			0.00420*** (0.00111)
Renewable	0.000176** (7.87e-05)	0.000217*** (7.75e-05)	0.000176** (7.91e-05)	0.000176*** (3.07e-05)	0.000217*** (2.17e-05)	0.000176*** (3.63e-05)
Domcred	0.000174 (0.000135)	0.000249* (0.000128)	0.000237* (0.000129)	0.000174*** (6.01e-05)	0.000249 (0.000168)	0.000237*** (7.27e-05)
Debtstocks	0.000175*** (3.99e-05)	0.000158*** (3.98e-05)	0.000175*** (4.01e-05)	0.000175*** (5.46e-05)	0.000158** (5.66e-05)	0.000175*** (5.38e-05)
Mineralrents	0.00347*** (0.000585)	0.00372*** (0.000603)	0.00335*** (0.000583)	0.00347*** (0.000511)	0.00372*** (0.000515)	0.00335*** (0.000491)
Constant	0.445*** (0.00687)	0.436*** (0.00700)	0.447*** (0.00702)	0.445*** (0.00248)	0.436*** (0.00347)	0.447*** (0.00299)
Observations	772	772	772	772	772	772
R-squared				0.104	0.101	0.102
Number of I	39	39	39	39	39	39
Prob (Chi2)	0.00	0.00	0.00			
Prob(F-stat)				0.00	0.00	0.00

Source: Authors.

4.2. Accounting for heterogeneity

South Africa holds a dominant position in the African insurance market, accounting for approximately 68.2% of the continent's total insurance premiums. Given this significant share, it is pertinent to highlight the distinction between the results obtained from the full sample and those derived from a sample excluding South Africa. Table 5 presents the

analysis of the effect of insurance on sustainable structural transformation for the sample excluding South Africa. The findings indicate that both total insurance and non-life insurance exert a positive influence on sustainable structural transformation in this subsample. However, life insurance shows an insignificant effect. This outcome can be attributed to the composition of South Africa's insurance market, where non-life insurance constitutes roughly 80% of the total premiums, while life insurance accounts for only 20%. These statistics suggest that while the non-life insurance market is largely driven by South Africa, the life insurance market has a more distributed presence across other African countries.

Table 5. *Regression without South Africa*

Variables	1 ISST	2 ISST	3 ISST
TINS	0.00417** (0.00174)		
NLINS		0.0170*** (0.00506)	
LINS			0.00276 (0.00231)
RENEWABLE	0.000168*** (2.63e-05)	0.000156*** (2.65e-05)	0.000166*** (2.61e-05)
Domcred	0.000149** (5.82e-05)	2.61e-05 (8.41e-05)	0.000236*** (5.24e-05)
Debtstocks	0.000177*** (4.12e-05)	0.000170*** (4.21e-05)	0.000176*** (4.06e-05)
Mineralrents	0.00348*** (0.000395)	0.00376*** (0.000507)	0.00333*** (0.000383)
Constant	0.446*** (0.00319)	0.443*** (0.00376)	0.448*** (0.00307)
Observations	752	752	752
R-squared	0.073	0.079	0.069
Number of I	38	38	38
Prob (Chi2)	0	0	0

Source: Authors.

4.3. The role of renewable energy in the insurance-sustainable structural transformation nexus

Table 6 demonstrates an indirect relationship between the insurance sector and sustainable structural transformation, mediated by renewable energy. This finding establishes renewable energy as a key transmission mechanism through which the insurance sector fosters sustainable structural transformation in Africa. This result can be explained by the potential of savings generated by the insurance sector to facilitate loans and investments in the development of renewable energy technologies. Such access to finance is particularly crucial for capital-intensive renewable energy projects like solar and wind farms. Furthermore, financial development can mitigate the risks associated with renewable energy investments, thereby enhancing their appeal to investors (Taghizadeh-Hesary & Yoshino, 2020). Consequently, advancements in renewable energy technologies are expected to stimulate growth across various sectors, including manufacturing, construction,

and services. For example, the production of solar panels, wind turbines, and other renewable energy systems creates new industries and employment opportunities. As highlighted by Liu et al. (2019), renewable energy more effectively promotes the upgrading of the industrial structure in China compared to coal energy.

Table 6. *The role of renewable energy on the relationship insurance and sustainable structural transformation*

Variables	1 ISST	2 ISST	3 ISST	4 ISST	5 ISST	6 ISST
TINS	0.00321*** (0.000290)	0.00382*** (0.000314)	0.00176*** (0.000638)	0.00352*** (0.000599)	0.00426*** (0.000561)	0.00172** (0.000792)
Renewable		0.000104*** (1.51e-05)	0.000208*** (2.66e-05)	0.000186*** (2.25e-05)	0.000176*** (2.17e-05)	0.000131*** (2.19e-05)
Domcred			0.000309*** (7.03e-05)	0.000229*** (5.55e-05)	0.000174*** (5.18e-05)	0.000278*** (5.85e-05)
Debtstocks				0.000160*** (4.76e-05)	0.000175*** (4.10e-05)	0.000173*** (4.20e-05)
Mineralrents					0.00347*** (0.000418)	0.00359*** (0.000428)
TINS*Renewable						0.000120*** (3.57e-05)
Constant	0.473*** (0.000539)	0.465*** (0.00127)	0.455*** (0.00254)	0.449*** (0.00304)	0.445*** (0.00301)	0.443*** (0.00321)
Observations	800	800	800	772	772	772
R-squared	0.023	0.026	0.032	0.063	0.104	0.110
Number of I	40	40	40	39	39	39
Prob(Chi2)	0	0	0	0	0	0

Source: Authors.

5. Conclusion

Africa's green transition represents a significant challenge for the continent. However, the delayed industrialization process could offer African nations a unique opportunity to "leapfrog" traditional development pathways and directly pursue sustainable structural transformation. Guided by this perspective, this study aimed to investigate the impact of the insurance sector on sustainable structural transformation, with a particular focus on the mediating role of renewable energy. Employing Panel Corrected Standard Error (PCSE) and Feasible Generalized Least Square (FGLS) methods on a sample of 40 African countries spanning the period 2000-2019, our findings establish that the insurance sector indeed promotes sustainable structural transformation. Furthermore, the disaggregation of insurance into life and non-life categories reinforces this conclusion, with non-life insurance exhibiting a more pronounced effect. Crucially, our results also reveal that renewable energy serves as a key transmission mechanism through which the insurance sector fosters sustainable structural transformation. Consequently, policymakers should strategically leverage the savings generated by the insurance sector to implement programs that steer the continent towards sustainable development. Moreover, African governments should actively promote the development and adoption of green solutions by alleviating financial constraints on environmentally friendly technologies and projects through incentives such as green subsidies for technology development and adoption.

References

- Alagidede, I.P., Ibrahim, M., and Sare, Y.A. (2020). Structural transformation in the presence of trade and financial integration in sub-Saharan Africa. *Central Bank Review*, 20(1), 21-31.
- Alharbi, S.S., Al Mamun, M., Boubaker, S., and Rizvi, S.K.A. (2023). Green finance and renewable energy: A worldwide evidence. *Energy Economics*, 118, 106499.
- Arena, M. (2008). Does insurance market activity promote economic growth? A cross-country study for industrialized and developing countries. *Journal of risk and Insurance*, 75(4), 921-946.
- Bai, J., Cho, S.H., and Liao, Y. (2021). Feasible generalized least squares for panel data with cross-sectional and serial correlations. *Empirical Economics*, 60, 309-326.
- Bayar, Y., Gavriltea, M.D., and Danuletiu, D.C. (2021). Does the insurance sector really matter for economic growth? Evidence from Central and Eastern European countries. *Journal of Business Economics and Management*, 22(3), 695-713.
- Beck, N., and Katz, J.N. (1995). What to do (and not to do) with time series cross-section data. *American Political Science Review*, 89, 634-647.
- Bustos, P., Garber, G., and Ponticelli, J. (2020). Capital accumulation and structural transformation. *The Quarterly Journal of Economics*, 135(2), 1037-1094.
- Cornaggia, J., Mao, Y., Tian, X., and Wolfe, B. (2015). Does banking competition affect innovation? *Journal of financial economics*, 115(1), 189-209.
- Del Gaudio, B.L., Previtali, D., Sampagnaro, G., Verdoliva, V., and Vigne, S. (2022). Syndicated green lending and lead bank performance. *Journal of international financial management & accounting*, 33(3), 412-427.
- Fogang, D.D.M., and Tchitchoua, J. (2020). Analyzing the impact of external debt on industrialization: the African franc zone case. *African Journal of Applied Statistics*, 7(1), 885-914.
- Gaspar, V., and Parry, I. (2021). A proposal to scale up global carbon pricing. *IMFBlog*, June, 18.
- Horvey, S.S., Osei, D.B., and Alagidede, I.P. (2023). Insurance Penetration and Inclusive Growth in Sub-Saharan Africa: Evidence from Panel Linear and Nonlinear Analysis. *International Economic Journal*, 37(4), 618-645.
- Hsu, P.H., Tian, X., and Xu, Y. (2014). Financial development and innovation: Cross-country evidence. *Journal of financial economics*, 112(1), 116-135.
- Huang, Q., Xie, V.W., and You, W. (2023). Resource rents, urbanization, and structural transformation. *Urbanization, and Structural Transformation*. STEG
- International Energy Agency, 2021, 1 December. Renewable Electricity Growth is Accelerating Faster than ever Worldwide, Supporting the Emergence of the New Global Energy Economy. [Press release]. Retrieved from. <https://www.iea.org/news/renewable-electricity-growth-is-accelerating-faster-than-ever-worldwide-supporting-the-emergence-of-the-new-global-energy-economy>.
- Iqbal, M.S., and Fikri, D.S.M. (2024). Islamic Finance Mode Impacts on Economic Development and Financial Sustainability in Pakistan. *Hamdard Islamicus*, 47(4).
- Jiang, M., Luo, S., and Zhou, G. (2020). Financial development, OFDI spillovers and upgrading of industrial structure. *Technological Forecasting and Social Change*, 155, 119974.
- Kromtit, M. (2022). Financial development, growth strategies and structural transformation (Doctoral dissertation, University of Glasgow).
- Krueger, Philipp, Zacharias Sautner, and Laura T. Starks (2020). The importance of climate risks for institutional investors. *The Review of financial studies* 33.3: 1067-1111.

- Levine, R. (1997). Financial development and economic growth: views and agenda. *Journal of economic literature*, 35(2), 688-726.
- Li, J., Tang, D., Tenkorang, A.P., and Shi, Z. (2021). Research on environmental regulation and green total factor productivity in Yangtze River Delta: From the perspective of financial development. *International Journal of Environmental Research and Public Health*, 18(23), 12453.
- Li, S., Meng, J., Zheng, H., Zhang, N., Huo, J., Li, Y., and Guan, D. (2021). The driving forces behind the change in energy consumption in developing countries. *Environmental Research Letters*, 16(5), 054002.
- Li, Songran and Shao, Qinglong. (2023). *How do financial development and environmental policy stringency affect renewable energy innovation? The Porter Hypothesis and beyond*. Elsevier BV.
- Lin, J.Y., Monga, C., and Standaert, S. (2019). The inclusive sustainable transformation index. *Social Indicators Research*, 143, 47-80.
- Liu, J., Li, J., and Yao, X. (2019). The economic effects of the development of the renewable energy industry in China. *Energies*, 12(9), 1808.
- Liu, X., and Liu, X. (2021). Can financial development curb carbon emissions? Empirical test based on spatial perspective. *Sustainability*, 13(21), 11912.
- Lo, S.B., and Ramde, F. (2019). Développement financier et transformation structurelle des pays africains de la zone Franc: une approche panel-VAR. *Revue Interventions économiques. Papers in Political Economy*, (61).
- Maria, M.R., Ballini, R., and Souza, R.F. (2023). Evolution of green finance: a bibliometric analysis through complex networks and machine learning. *Sustainability*, 15(2), 967.
- Naceur, M.S.B. (2016). *Financial Development, Inequality and Poverty*. International Monetary Fund.
- National Treasury (2024). 2024 Budget Review Revenue Trends and Tax Proposals-National Budget2024. Available at: <<https://www.treasury.gov.za/documents/national%20budget/2024/review/Chapter%204.pdf>>
- Nkemgha, G., Engone Mve, S., Balouki Mikala, H., and Tékam, H. (2022). Linking natural resource dependence and industrialization in sub-Saharan African countries. *International Review of Applied Economics*, 36(2), 245-263.
- Parks, R.W. (1967). Efficient estimation of a system of regression equations when disturbances are both serially and contemporaneously correlated. *Journal of the American Statistical Association*, 62, 500-509.
- Pineli, A., Narula, R., and Belderbos, R. (2021). FDI, multinationals and structural change in developing countries. In *New Perspectives on Structural Change: Causes and Consequences of Structural Change in the Global Economy* (pp. 494-523). Oxford University Press.
- Pradhan, R.P., Arvin, M.B., Hall, J.H., and Nair, M. (2016). Innovation, financial development and economic growth in Eurozone countries. *Applied economics letters*, 23(16), 1141-1144.
- Qamruzzaman, M. (2024). Nexus between foreign direct investment, gross capital formation, financial development and renewable energy consumption: evidence from panel data estimation. *GSC Advanced Research and Reviews*, 18(1), 182-200.
- Reed, W.R., and Ye, H. (2011). Which panel data estimator should i use? *Applied Economics*, 43(8), 985-1000. <<https://doi.org/10.1080/00036840802600087>>
- Shan, S., Genç, S.Y., Kamran, H.W., and Dinca, G. (2021). Role of green technology innovation and renewable energy in carbon neutrality: A sustainable investigation from Turkey. *Journal of environmental management*, 294, 113004.

- Subramaniam, Y., and Loganathan, N. (2024). Does green finance affect renewable energy development in Singapore? *Journal of Asian Business and Economic Studies*, 31(3), 162-174.
- Sun, Z., Zhang, X., and Gao, Y. (2023). The impact of financial development on renewable energy consumption: A multidimensional analysis based on global panel data. *International journal of environmental research and public health*, 20(4), 3124.
- Taghizadeh-Hesary, F., and Yoshino, N. (2020). Sustainable solutions for green financing and investment in renewable energy projects. *Energies*, 13(4), 788.
- Tian, J., Culley, S.A., Maier, H.R., and Zecchin, A.C. (2024). Is renewable energy sustainable? Potential relationships between renewable energy production and the Sustainable Development Goals. *Climate Action*, 3(1), 35.
- Tong, H., Wang, Y., and Xu, J. (2020). Green transformation in China: Structures of endowment, investment, and employment. *Structural Change and Economic Dynamics*, 54, 173-185.
- Tyler, P., Evenhuis, E., Martin, R., Sunley, P., and Gardiner, B. (2017). Growing apart? Structural transformation and the uneven development of British cities. *Cambridge Journal of Regions, Economy and Society*, 10(3), 425-454.
- Ustarz, Y., and Fanta, A.B. (2021). Financial development and economic growth in sub-Saharan Africa: A sectoral perspective. *Cogent Economics & Finance*, 9(1), 1934976.
- Wei, Q., Guo, A., Wei, L., and Ni, W. (2022). Analysis of the mechanism of renewable energy on energy-saving and environmental protection industry: Empirical evidence from four countries. *Energy Reports*, 8, 205-217.
- Yang, G., Zha, D., Cao, D., and Zhang, G. (2024). Time for a change: Rethinking the global renewable energy transition from the Sustainable Development Goals and the Paris Climate Agreement. *The Innovation*, 5(2).
- Yang, W.J., Tan, M.Z., Chu, S.H., and Chen, Z. (2023). Carbon emission and financial development under the “double carbon” goal: Considering the upgrade of industrial structure. *Frontiers in Environmental Science*, 10, 1091537.
- Ye, J., Al-Fadly, A., Quang Huy, P., Quang Ngo, T., Phi Hung, D. D., and Hoang Tien, N. (2022). The nexus among green financial development and renewable energy: investment in the wake of the Covid-19 pandemic. *Economic research-Ekonomska istraživanja*, 35(1), 5650-5675.
- Zyadin, A., Puhakka, A., Ahponen, P., and Pelkonen, P. (2014). Secondary school teachers' knowledge, perceptions, and attitudes toward renewable energy in Jordan. *Renewable Energy*, 62, 341-348.

Appendix

Table A. List of countries

Algeria	Central Africa Republic	Gambia	Mauritania	Senegal
Angola	Chad	Ghana	Mauritius	Sierra Leone
Benin	Democratic Republic of Congo	Guinea	Morocco	South Africa
Botswana	Congo	Kenya	Mozambique	Tanzania
Burkina Faso	Cote d ivoire	Lesotho	Namibia	Togo
Burundi	Egypt	Madagascar	Niger	Tunisia
Cabo Verde	Ethiopia	Malawi	Nigeria	Uganda
Cameroon	Gabon	Mali	Rwanda	Zambia

Natural resources and the price of freedom. A concise analysis of Ukraine's natural resources and who wins more from their direct exploitation?

Raluca Iuliana GEORGESCU

Bodislav & Associates, Romania

raluca.georgescu@infinitemgroup.com

Dumitru Alexandru BODISLAV

Bucharest University of Economic Studies, Romania

alex.bodislav@ase.ro

Abstract. *This article investigates the intricate relationship between natural resources and national freedom, focusing on Ukraine as a resource-rich yet geopolitically vulnerable state. It analyses the economic, political, environmental, and strategic dimensions of resource management and their implications for sovereignty, sustainability, and international security. Ukraine's reserves of iron ore, titanium, uranium, coal, and fertile agricultural land are assessed in terms of economic viability, environmental risks, and their role in global supply chains. The study further explores how Russia, the European Union, and the United States benefit differently from Ukraine's natural resources in the context of ongoing conflict, sanctions, and shifting alliances. While Ukraine possesses immense potential to become a key agricultural and mineral exporter and an energy-independent nation, political instability, war, and governance deficiencies have limited its capacity to capitalize on these advantages. The paper concludes that sustainable management, institutional reform, and integration into European and global markets are essential for Ukraine to transform its resource endowment into long-term freedom and prosperity.*

Keywords: Ukraine, natural resources, economic independence, resource governance, geopolitical economy, energy security sustainable development.

JEL Classification: Q34, Q35, F51, O13, P48.

1. Introduction

Freedom is often considered as one of the most prized values of human civilization; nonetheless, it involves an immense cost. Nations and societies bear costs for their independence, security, and self-determination, with natural resources being an important component in this equation. The interplay between natural resources and the cost of freedom is complex, covering economic stability, political authority, environmental management, and geopolitical struggles (Smith, 2019).

2. The economic foundations of freedom

An essential component of a country's economic force are its natural resources. Wealth can be created by nations with abundant resources, such as minerals, oil, gas, and fertile land, supplying them with the financial resources they need to maintain and ensure their independence and freedom (Ross, 2012). A robust economy enables a country to invest in education, establish infrastructure, and grow sectors that provide wealth and jobs. In turn, economic independence makes it more difficult for outside forces to manage, easily manipulate or control a country. An abundance in resources, however, does not guarantee freedom. The way a country manages its resources determines whether they operate as a foundation for long-term independence or a source of economic instability. Economic collapse brought on by poor management, corruption, and an excessive reliance on one resource can leave a country open to both internal conflict and external pressures (Acemoglu & Robinson, 2012). Therefore, the preservation of freedom requires responsible resource management.

Political and Social Consequences

The management of natural resources has traditionally influenced political power relations both inside nations and globally. Resource-rich nations often experience internal disputes on resource allocation, resulting in conflicts, corruption, and even authoritarian rule (Collier, 2007). In certain instances, ruling elites dominate resource wealth, suppressing democratic liberties and raising inequality. This is seen in countries where oil wealth has facilitated the establishment of dictatorial regimes that are limiting political freedoms for the general population (Ross, 2012).

Nations that adopt transparent governance and fair allocation of resources can leverage their wealth to promote political freedom. Public investment in education, healthcare, and infrastructure can empower individuals, resulting in a more involved and independent society (Acemoglu & Robinson, 2012). The management of natural resources reflects the prevailing political structure and profoundly impacts the degree of freedom inside a society.

Long-Term Freedom and Environmental Sustainability

As natural resources support political and economic stability, long-term freedom is put at risk by their depletion and improper management. Overuse of resources can result in

climate change, biodiversity loss, and environmental deterioration, all of which can make it more difficult for a country to maintain its independence (Diamond, 2005). For example, national stability depends on the security of food and water, and if these resources are not managed well, they may cause a reliance on outside assistance, which could weaken national sovereignty (Brown, 2011).

Sustainable resource management guarantees a habitable and prosperous environment for future generations. Long-term independence depends on making investments in conservation efforts, renewable energy, and responsible resource extraction (Sachs, 2008). Respecting and protecting its natural resources ensure a country's current political and economic standing as well as the freedom of future generations.

The Cost of Resource Dependence and Geopolitical Struggles

Countries with natural resources often find themselves at the epicentre of geopolitical struggles. Foreign powers can target countries with abundant resources to seize control of valuable commodities. Wars have been fought for access to minerals, oil, and strategic waterways throughout history (Klare, 2012). Competition for resources can result in economic sanctions, military disputes, and foreign interventions, all of which put a country's sovereignty at risk.

Furthermore, countries that lack fundamental and essential resources are forced to import, leaving them open to changes in prices and political influence from resource-rich countries (Yergin, 2011). For instance, a nation's capacity to make independent foreign policy decisions may be restricted by its energy dependence. In a world where power dynamics are often dictated by resource control, diversifying energy sources and securing trade agreements are essential tactics for preserving freedom.

3. Ukraine's Natural Resources: Economic Viability and Sustainable Exploitation

Ukraine is one of the greatest resource-rich countries in Europe, possessing extensive agricultural land, significant energy resources, vast mineral reserves, and substantial freshwater bodies. The country's historical and economic development has been significantly influenced by these natural resources. Nevertheless, the sustainability of their exploitation continues to be a significant concern because of ineffective management practices, high extraction costs, and environmental risks. The challenge is to optimize the economic potential of these resources while minimizing impact on the environment and avoiding financial barriers that could impede development.

This article offers a comprehensive examination of Ukraine's most valuable natural resources, including their economic importance, environmental impact, and the feasibility of their sustainable utilization. We will evaluate the responsible use of Ukraine's natural resources by exploring modern extraction methods, regulatory frameworks, and investment strategies.

Major Natural Resources in Ukraine

Ukraine is a worldwide leader in the production of mineral resources, possessing substantial reserves of uranium, manganese, titanium, and iron ore. These minerals are essential for both domestic industries and international markets, as follows:

- **Iron Ore:** The Kryvyi Rih Basin is the primary location of some of the largest iron ore deposits in the world - Ukraine. The country's reserves surpass 30 billion tonnes, placing it among the top ten iron ore exporters (USGS, 2021). The country's metallurgical sector has historically been significantly impacted by the extraction of iron ore, which has contributed to steel production and exports.
- **Manganese:** Ukraine's manganese reserves, particularly in the Nikopol and Veliko-Tokmak regions, rank among the largest in Europe and are a critical component of steel production.
- **Titanium:** The aerospace, military, and medical industries rely on the country's extensive titanium deposits. Ukraine is one of the five largest titanium producers in the world (European Commission, 2021).
- **Uranium:** Ukraine has the potential to decrease its dependence on imported nuclear fuel due to its substantial uranium deposits. However, most of its uranium mining industry necessitates modernization and investment (World Nuclear Association, 2021).

Economic and Environmental Factors

Deforestation, soil erosion, and water contamination from tailings and heavy metal runoff are among the severe environmental challenges that mining in Ukraine presents. Modern techniques, including environmentally conscious extraction methods, improved waste management systems, and land rehabilitation projects, must be implemented to reduce these risks (European Environment Agency, 2020). An increase in technological collaboration and foreign investment is essential for the modernization of mining infrastructure and the reduction of costs.

Agricultural Resources

Ukraine is often referred to as the "breadbasket of Europe" because of its extensive, fertile chernozem soil, which occupies approximately 25% of the country's land area. This soil is exceptionally fertile, enabling the production of wheat, corn, sunflower, and barley on a large scale:

- **Grain Production:** Ukraine is a global leader in the export of corn and wheat. Wheat is a significant contributor to the country's GDP, as the favourable climate and fertile soil facilitate high crop yields.
- **Sunflower and Oilseeds:** Ukraine is the world's largest producer of sunflower oil, an essential commodity in global vegetable oil markets.
- **Organic Farming Potential:** Ukraine can expand its sustainable agricultural sector in response to the growing global demand for organic produce.

Despite the immense potential, intensive farming has resulted in the overuse of pesticides and fertilizers, the degradation of soil, and the loss of biodiversity (FAO, 2020). Sustainable

agricultural practices, including precision farming, conservation tillage, crop rotation, and reduced chemical inputs, can contribute to the preservation of soil fertility and long-term productive agriculture. By investing in agricultural technology, such as AI-driven monitoring systems and precision irrigation, it is possible to reduce costs and optimize the use of water and fertilizer.

Energy Resources

Ukraine possesses substantial energy resources, such as coal, natural gas, oil, and renewable energy potential. Yet, complete energy independence has been stalled by aging infrastructure and geopolitical factors.

Ukraine has substantial potential for domestic energy production, as evidenced by its over 37 billion tonnes of coal reserves, which are primarily located in the Donetsk and Lviv-Volyn basins (BP Statistical Review, 2021). Still, coal mining is an environmentally hazardous activity that contributes to the pollution of air and water. Shale Gas and Natural Gas: The Dnipro-Donetsk Basin is home to extensive, untapped shale gas reserves in Ukraine. The potential for these reserves to be developed is to improve energy security and decrease reliance on Russian gas imports. Ukraine's southern and central regions are particularly high in solar and wind energy potential. IRENA (2021) reports that the government has implemented policies to encourage and attract investments in green energy projects. Greenhouse gas emissions, air pollution, and land degradation are the consequences of conventional fossil fuel extraction. It is imperative to make the shift to renewable energy sources, including solar and wind, to ensure long-term sustainability. Upgraded energy infrastructure, government incentives, and foreign investment are essential for this transition (World Bank, 2021).

Timber and Forests

About 15% of Ukraine's landmass is covered by forests, with the Carpathian region being home to substantial timber resources. These forests provide support and sustenance for the timber industry, carbon sequestration, and biodiversity.

Ukraine's forests are at risk due to illegal logging and deforestation. These issues can be addressed through the implementation of sustainable forestry practices, afforestation projects, and more strict regulatory enforcement. The preservation of forest ecosystems can be achieved by promoting the development of non-timber forest products, including medicinal plants, and eco-tourism (State Forestry Agency of Ukraine, 2022).

Water Resources

Ukraine has a vast network of rivers, including the Dnieper, Dniester, and Southern Bug, which are critical to agriculture, industry, and energy production. Water quality is at risk due to industrial pollution and climate change. Investing in sustainable irrigation systems and modern wastewater treatment plants has the potential to improve water security and efficiency (World Bank, 2021).

Cost Considerations and Economic Viability

Several factors determine the feasibility of sustainable resource exploitation:

- **Modern Technologies Investment:** Sustainable extraction methods often require substantial initial investments, but they generate lasting economic and environmental advantages and benefits.
- **Government Policies and Regulations:** Effective policies, such as tax incentives for sustainable projects, can help to promote environmentally responsible resource utilization.
- **Ukraine has the potential to attract foreign direct investment (FDI) in the mining, agriculture, and renewable energy sectors to reduce costs and improve efficiency.**
- **Infrastructure Development:** To optimize resource distribution and reduce operational expenses, it is imperative to prioritize the development of modern energy and transportation infrastructure.

4. Who Wins More?

Ukraine has been a strategic economic and geopolitical centre in Eastern Europe for an extended period. Nevertheless, this affluence has also rendered Ukraine a battleground for influence, particularly among the United States (US), the European Union (EU), and Russia. However, the nation's economic potential has been substantially diminished by persistent political instability and military conflicts, even though its resources are essential to global energy security, industrial production, and food supply chains.

Ukraine is one of the largest holders of natural gas reserves in Europe, with an estimated 1.1 trillion cubic meters (BP Statistical Review, 2022). Ukraine has historically served as a critical transit centre for Russian gas exports to the European Union. Until 2014, most of the Russian gas that was intended for European markets was transported through Ukrainian pipelines, which resulted in substantial transit fees and granted Ukraine strategic leverage. Nevertheless, the landscape has been significantly altered by the ongoing conflict with Russia and the annexation of Crimea. Underinvestment and political instability have resulted in the underdevelopment of Ukraine's gas fields, which are predominantly situated in the Dnipro-Donetsk region. Despite the existence of substantial reserves, the nation continues to depend on imports to satisfy domestic demand. The European Union has been instrumental in promoting Ukraine's energy independence by offering financial and technical support to modernize its gas infrastructure and integrate it into the European energy market. The United States has indirectly benefited from Ukraine's transition away from Russian energy dependence from a geopolitical perspective. In their pursuit of alternatives to Russian gas, European nations have increasingly looked to American liquefied natural gas (LNG) as a substitute. While Ukraine continues to depend on external supplies, its strategic location and underground gas storage facilities remain essential for the energy security of Europe.

The Donetsk and Luhansk regions contain the majority of Ukraine's estimated 3.9 billion tonnes of coal reserves (IEA, 2023). Until the 2014 outbreak of conflict, Ukraine was one of the top coal producers in Europe due to these reserves. Nevertheless, a significant portion of this coal production has been under Russian control since the conflict began. The loss of coal mines in the eastern region has compelled Ukraine to increase its dependence on imports, including those from Russia, which paradoxically benefits from Ukraine's diminished energy independence. Simultaneously, the EU and the United States have experienced less direct benefits, as their economies are transitioning to renewable energy. War damage and environmental concerns confound extraction efforts, rendering the long-term future of Ukraine's coal industry uncertain.

Ukraine's oil reserves are estimated to be 395 million barrels, which is relatively modest. Although this is insufficient to establish Ukraine as a global oil player, its strategic location and refining infrastructure render it a critical transit centre for European energy supplies. Political risks and infrastructural challenges have hampered foreign investment in Ukraine's efforts to increase domestic oil production over the years. The energy sector of Ukraine has indirectly benefited the United States and the European Union by reducing their dependence on Russian imports and promoting energy diversification strategies. Nevertheless, Ukraine has encountered limitations in its ability to completely capitalize on its oil resources because of inconsistent energy policies and poor infrastructure.

Ukraine is the scene of some of the world's most valuable iron ore deposits, with reserves estimated to be 30 billion tonnes (World Mining Data, 2023). Major mining operations are concentrated in Kryvyi Rih, Kremenchuk, and Poltava, and Ukraine is among the top global producers due to these vast reserves. Ukraine has historically supplied substantial quantities of iron ore to European industries, which is a critical component of steel production. Ukraine's ore exports provide substantial support to the EU's construction and manufacturing sectors. Previously, Russia had significant stakes in Ukrainian mining operations, but due to geopolitical tensions and sanctions, it no longer has access to these resources.

Ukraine has the fourth highest global reserve of titanium, a valuable resource for aerospace, defence, and high-tech industries (USGS, 2023). Ukraine's titanium reserves have become increasingly strategic as the US and EU aim to decrease their reliance on Chinese titanium supplies. Given its significance in the production of aircraft and advanced military technologies, the United States has demonstrated a particular interest in ensuring a consistent supply of Ukrainian titanium. Significant deposits of uranium and manganese, which are necessary for nuclear energy and steel production, are also found in Ukraine. Ukraine's economic potential is made even stronger by these resources, but their full potential has been constrained by political instability. Ukraine is a major agricultural powerhouse in addition to its wealth in minerals and energy. The nation ranks among the top producers and exporters of sunflower oil, corn, and wheat all over the world. It represents 12% of global wheat exports and 16% of corn exports (FAO, 2023). Due to its reliance on Ukrainian grain for food security, the EU benefits most from Ukrainian

agricultural exports. Nevertheless, Russia has made an organized effort to disrupt Ukraine's agricultural sector by seizing farmland in occupied territories, blockading ports, and targeting export routes. While the US competes with Ukraine in grain exports, it also indirectly benefits from the stability of the global market.

The question of who benefits the most from Ukraine's resources arises considering the ongoing conflict and the strategic role of Ukraine in supplying energy, minerals, and food.

Russia's Gains and Losses

Throughout history, Russia has exercised substantial economic leverage over Ukraine's resources. Russia benefited on Ukraine's coal, natural gas transit routes, and agricultural exports prior to the 2014 annexation of Crimea and the 2022 invasion.

Gains: Russia has seized control of portions of Ukraine's resource-rich Donbas region, which is home to most of the country's coal reserves. Given the sanctions imposed on Russian energy products, the occupation of these regions enables Russia to utilize coal for domestic consumption and export. Furthermore, Russia has enhanced its global leverage by positioning itself as an alternative supplier to regions experiencing shortages by disrupting Ukraine's capacity to export natural gas and grain.

Losses: Sanctions and international isolation have resulted in substantial economic losses for Russia, despite its territorial expansion. The EU, which was previously a significant market for Russian and Ukrainian coal, has implemented significant trade restrictions. Additionally, Russia's influence over the energy security of the region is diminished by Ukraine's transition to European energy integration. However, the war has also resulted in long-term diplomatic and economic repercussions that impede Russia's ability to engage in foreign trade and investment.

Economic and Strategic Benefits of the European Union

The EU is one of the largest beneficiaries of Ukraine's resource wealth. For an extended period, Ukraine has been the primary source of raw materials for Europe, including energy transit, agricultural products, and iron ore.

Gains: Ukraine's position as a major grain supplier is crucial for European food security. The EU stabilizes food prices within its member states by importing substantial quantities of Ukrainian wheat, corn, and sunflower oil. Furthermore, Ukraine's iron ore exports are essential for the European steel industry, as they provide support to the construction and manufacturing sectors. Following the Russian invasion, Europe strengthened its ties with Ukraine's energy sector. Ukrainian natural gas storage facilities are essential for the EU, as they reduce its dependence on Russian gas. European investments that could potentially replace fossil fuel imports from Russia have also been attracted to Ukraine's potential for renewable energy development, particularly wind and solar power.

Losses: Supporting Ukraine comes with significant financial costs. Ukraine has required substantial economic and military assistance from the European Union to maintain its

defence and economy. Furthermore, the ongoing conflict disrupts trade routes, resulting in temporary food and energy shortages that affect European markets.

The United States: Economic Gains and Strategic Leverage

Despite its geographical distance, the United States has established itself as a significant player in the competition for Ukraine's resources. The primary objectives of the United States are to enhance its position in global energy markets, secure alternative resource supplies, and limit Russian influence.

Gains: Exports of liquefied natural gas (LNG) to Europe have been one of the United States' most significant advantages. American LNG has stepped in to fill the gap as the EU seeks alternatives to Russian energy, thereby increasing US energy revenues and geopolitical influence. Additionally, Ukraine's titanium and other critical mineral reserves are of strategic significance to the aerospace and defence industries of the United States. By securing access to these resources, Ukraine becomes a valuable partner in the security of supply chains for advanced technologies, thereby reducing reliance on China.

Losses: The US has provided billions of dollars in financial and military assistance to Ukraine. Although this establishes enduring strategic partnerships, it faces a substantial economic burden. Furthermore, American agricultural exporters engage in competition with Ukraine in global markets, which results in certain economic conflicts of interest.

A Crisis in a Resource-Rich Country: Ukraine

Ukraine has been unable to take full advantage on its natural resources because of political instability and war, despite its immense natural wealth. Despite the potential to become a leading agricultural and mineral exporter and an energy-independent powerhouse, the country has been unable to fully capitalize on these advantages due to the ongoing conflict.

Gains: Due to the world-wide significance of its resources, Ukraine receives substantial foreign aid and investment. Ukraine's economy is still receiving assistance from the EU and the US in the form of infrastructure projects and energy sector modernization. Furthermore, Ukraine is establishing itself as a long-term alternative supplier of energy resources, agricultural goods, and minerals as it transitions from its dependence on Russian energy.

Losses: Ukraine experiences the most substantial losses in the form of territorial occupation and destruction. The war has resulted in the relocation or closure of numerous industries, disrupted exports, and damaged infrastructure. The economic potential of Ukraine is restricted, and post-war reconstruction efforts are delayed due to the inability to fully control and extract its resources.

The natural resources of Ukraine provide economic and strategic advantages to each major power—Russia, the EU, and the US—to varying degrees. In the short term, Russia benefits from the occupation of coal-rich regions and the disruption of Ukraine's exports. However, these advantages are undermined by long-term sanctions and diplomatic isolation. The EU is the most immediate economic beneficiary, as it relies on Ukrainian food and mineral

exports to maintain market stability. The United States, on the other hand, maintains geopolitical influence by exporting LNG and gaining access to critical minerals. Ukraine's potential is immense; however, it is constrained by political instability and war. The future of Ukraine's resource exploitation will be contingent upon its capacity to regain control, secure sustainable investment, and develop industries that are not subject to external geopolitical pressures.

5. Governance of Ukraine and its reform

In recent years, Ukraine has experienced unprecedented challenges, particularly because of the ongoing war, which has disrupted its economy, infrastructure, and societal structure. Nevertheless, to reconstruct and develop in a sustainable and resilient manner, the country must prioritize strategic policies and investments. These include the following: investing in human capital, assuring environmental sustainability, building economic development, rebuilding infrastructure, and strengthening governance.

Institutional reform, infrastructure reconstruction and governance

Effective development in Ukraine necessitates solid institutions and effective governance. Corruption has been a persistent issue that has slowed economic progress and public trust (Transparency International, 2022). It is necessary to prioritize the modernization of government institutions, improving the level of transparency, and the reinforcement of the rule of law. The expansion of e-government platforms and the digitization of public services have the potential to improve efficiency and minimize corruption. The European Commission (2023) has also suggested that the integration of Ukraine into European institutions and adherence to EU legal frameworks can promote a more strengthened democratic governance.

The infrastructure of Ukraine, which covers roads, bridges, energy systems, and industrial facilities, has been significantly impacted by the war (World Bank, 2023). Resilient and sustainable infrastructure development must be the primary focus of post-war reconstruction. This refers to the implementation of modern, energy-efficient technologies and improving the level of connectivity between the country and European markets. Investment in transportation infrastructure, including high-speed rail and modernized highways, will boost economic growth and trade. Additionally, the development of digital infrastructure, such as the expansion of broadband and the implementation of 5G networks, will lead to technological iUkraine's economy has traditionally been based on heavy industry, agriculture, and raw material exports. Diversification is indispensable for guaranteeing economic stability over the long term. The country should prioritize the development of value-added industries, including renewable energy, IT services, and high-tech manufacturing (OECD, 2023). Promoting a business-friendly environment and encouraging foreign direct investment (FDI) will speed up economic growth. Also, the investment in small and medium-sized enterprises (SMEs) has the potential to promote employment creation and entrepreneurship, thereby reducing reliance on traditional industries.

Food security, agricultural modernization, green transition and energy independence

To optimize sustainability and productivity, the agricultural sector requires modernization (FAO, 2023). Soil health and crop yields can be improved by implementing precision agriculture, optimizing irrigation systems, and reducing dependence on chemical inputs. Increasing profitability can be achieved by developing value-added food processing industries and expanding access to global markets. It will also be essential to implement sustainable agricultural practices to minimize the effects of climate change and guarantee long-term food security innovation and business opportunities.

The energy security of Ukraine is a significant concern due to its dependence on energy imports and fossil resources. The transition to renewable energy sources, including hydropower, solar, and wind, should be the primary focus of post-war development (IRENA, 2023). Expanding domestic energy production and investing in smart grids can enhance energy security and sustainability. In addition, the implementation of energy efficiency measures in both buildings and industries can result in a decrease in overall consumption and a saving in costs. A green transition is consistent with the environmental standards of the European Union and has the potential to attract international investment in sustainable projects.

Climate resilience, environmental sustainability, human capital development and education

Ukraine is confronted with substantial environmental obstacles, such as soil degradation, industrial pollution, and deforestation (UNEP, 2023). All aspects of development must be integrated with environmental sustainability during post-war reconstruction. Improving waste management systems, promoting reforestation projects, and enforcing stricter environmental standards will all contribute to a healthier ecosystem. Resilience to climate change will be improved through the implementation of climate adaptation strategies, including drought-resistant agriculture and flood protection. Sustainable growth will be encouraged by investing in circular economy practices and green technologies.

Ukraine's future prosperity is reliant upon the availability of a workforce that is exceedingly effective. To satisfy the requirements of a modern economy, the education system must be reformed to prioritize STEM (science, technology, engineering, and mathematics) education and vocational training (UNESCO, 2023). The workforce will be adequately prepared for economic transformation by increasing access to professional development programs and higher education. In addition, it will be essential to address brain drain by establishing incentives for skilled professionals to remain in Ukraine to encourage long-term development.

Human capital development, education, and healthcare system improvement

Ukraine's future prosperity is reliant upon the availability of a workforce that is exceedingly effective. To satisfy the requirements of a modern economy, the education system must be reformed to prioritize STEM (science, technology, engineering, and mathematics)

education and vocational training (UNESCO, 2023). The workforce will be adequately prepared for economic transformation by increasing access to professional development programs and higher education. In addition, it will be essential to address brain drain by establishing incentives for skilled professionals to remain in Ukraine to encourage long-term development.

The healthcare system of Ukraine has been massively burdened by the war, which has revealed deficiencies in medical infrastructure and accessibility (WHO, 2023). Improved medical supply chains, expanded healthcare access in rural areas, and the reconstruction of hospitals should be the primary objectives of post-war development. Improvement of public health initiatives, such as mental health support and disease prevention programs, will support a healthier population. Telemedicine and electronic health records are examples of digital healthcare solutions that can improve the quality of patient care and increase efficiency.

6. Conclusion

Social inclusion and support for vulnerable populations must be the primary focus of Ukraine's recovery. It is essential to address the needs of internally displaced persons (IDPs), war veterans, and affected communities to achieve long-term stability (UNHCR, 2023). Policies that encourage economic reintegration, community reconstruction, and social cohesion will contribute to the development of national unity. A fair and equal recovery process can be achieved by reinforcing social safety nets, which incorporate affordable housing and employment programs.

Ukraine's future development is tied upon its geopolitical position. The economic and security benefits will be achieved by solidifying alliances with the European Union, NATO, and international financial institutions (NATO, 2023). Infrastructure funding, technological collaboration, and trade expansion can be assisted through international partnerships. By leveraging global support and ensuring an effective diplomatic presence, Ukraine will improve its international standing.

The future of Ukraine is highly promising; despite the significant obstacles it has encountered. The country stands ready for a resilient recovery, as it is dedicated to infrastructure modernization, governance reform, and economic diversification. Ukraine's population has exhibited extraordinary determination and perseverance. The nation can establish a prosperous and prosper future by encouraging innovation, investing in human capital, and adopting sustainable practices. Ukraine will be able to successfully integrate into the global economy by establishing strategic partnerships with international allies, which will further support economic stability and security. The road ahead is difficult, but with perseverance and visionary leadership, Ukraine may emerge from its trials stronger, more united, and ready for a prosperous future.

References

- Acemoglu, D., and Robinson, J.A. (2012). *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*. Crown Publishing Group.
- Bodislav, D.A. (2011). The Birth of the Regulated Company in the Macroeconomic Environment, *Theoretical and Applied Economics*, vol. 18, no. 6(55), 129-140.
- Bodislav, D.A. (2016). *Business intelligence for decision making in economics, chapter in Artificial Intelligence in Financial Markets*, London: Palgrave-Macmillan, 125-158.
- Bodislav, D.A., and Georgescu, R.I. (2023). A Sustainable and Resilient Socio-Economic Paradigm through Corporate Governance Intervention, *Theoretical and Applied Economics*, vol. 30, no. 4(637), 77-82.
- BP Statistical Review (2022). World Energy Outlook. FAO (2023). Food Security Report. IEA (2023). Ukraine Energy Overview. USGS (2023). Mineral Commodity Summaries. World Mining Data (2023). Global Mining Report.
- BP Statistical Review. (2021). *Energy Outlook: Ukraine's Coal and Gas Reserves*. BP.
- Brown, L.R. (2011). *World on the Edge: How to Prevent Environmental and Economic Collapse*. W.W. Norton & Company.
- Collier, P. (2007). *The Bottom Billion: Why the Poorest Countries Are Failing and What Can Be Done About It*. Oxford University Press.
- Diamond, J. (2005). *Collapse: How Societies Choose to Fail or Succeed*. Penguin Books.
- European Commission. (2021). Critical Raw Materials in the EU.
- European Commission. (2023). Ukraine's Integration into the EU Economy.
- European Environment Agency. (2020). Sustainable Mining and Environmental Protection.
- FAO. (2020). Soil Fertility Management in Ukraine.
- FAO. (2023). Sustainable Agriculture Development in Ukraine.
- Georgescu, R.I. (2020). *Strategii de valorificare a resurselor naturale în contextul globalizării*, Bucharest: Universitara Publishing.
- Georgescu, R.I. (2023). Modern leadership in business organisations during economic disruption, *Theoretical and Applied Economics*, vol. 30, no. 2(635), 73-82.
- IRENA. (2021). Ukraine's Renewable Energy Potential.
- IRENA. (2023). Renewable Energy Transition in Ukraine.
- Klare, M.T. (2012). *The Race for What's Left: The Global Scramble for the World's Last Resources*. Metropolitan Books.
- NATO. (2023). Ukraine's Geopolitical Strategy and Security Partnerships.
- OECD. (2023). Economic Recovery and Diversification Strategies for Ukraine.
- Ross, M.L. (2012). *The Oil Curse: How Petroleum Wealth Shapes the Development of Nations*. Princeton University Press.
- Sachs, J. (2008). *Common Wealth: Economics for a Crowded Planet*. Penguin Press.
- Smith, J. (2019). *Natural Resources and Sovereignty: A Global Perspective*. Cambridge University Press.
- State Forestry Agency of Ukraine. (2022). Sustainable Forestry Management Plans.
- Transparency International. (2022). Corruption Perceptions Index.
- UNEP. (2023). Environmental Challenges and Solutions for Ukraine.
- UNESCO. (2023). Education Reform and Workforce Development in Ukraine.

- UNHCR. (2023). Support for Displaced Populations in Ukraine.
- USGS. (2021). Ukraine's Iron Ore and Mineral Reserves.
- WHO. (2023). Post-War Healthcare System Strengthening in Ukraine.
- World Bank. (2021). Water Management and Sustainable Development in Ukraine.
- World Bank. (2023). Ukraine's Infrastructure Reconstruction and Economic Growth.
- Yergin, D. (2011). *The Quest: Energy, Security, and the Remaking of the Modern World*. Penguin Books.

Assessing the macroeconomic impact of fiscal deficit in India: evidence from ARDL approach

Prakhar PANDEY

Kumaun University, India
Prakhar.eco@gmail.com

Rajnish PANDE

Kumaun University, India
hodeconomics@kumainital.ac.in

Abstract. *This paper examines the dynamic interaction between economic growth in India and fiscal deficit data between the years 1970 and 2021 through the use of the Autoregressive Distributed Lag (ARDL) bounds testing method. Based on the theoretical framework of the Neoclassical school of thought, the paper will seek to learn whether fiscal deficit is either a stimulus to long-term growth or a limiting factor. Surprisingly, empirical findings have indicated that fiscal deficit as a percentage of GDP negatively influences the long-run growth at a statistically significant level. This favours the crowding-out theory that where a government borrows too much, it can force out any private investment by reducing economic growth.*

Gross capital formation, broad money supply, and trade openness in the short run however, demonstrate several mixed and varying effects on growth, representing the intricacies of the interactions of various variables in the macroeconomic setting. The model assumes that diagnostic tests involving no serial correlation, homoscedasticity, and normal residuals are met; hence, estimates are reliable.

The results show the essence of prudent fiscal management. To achieve inclusive and stable growth in India, policymakers ought to focus on measures that imply decreasing structural deficits, increasing the quality of public spending, and striking a compromise between temporary economic demands and long-term sustainability.

Keywords: fiscal deficit, economic growth, ARDL, public finance.

JEL Classification: E62, H62, C32, O40.

1. Introduction

In the field of economics, the relationship between the budget deficit and economic growth continues to be a significant topic of investigation. This is especially true in developing nations such as India, which are confronted with the twin challenge of speeding economic growth while simultaneously maintaining economic stability. A policy instrument that has been the subject of debate for a long time is the fiscal deficit, which occurs when the government spends more money than it gets in. Keynesians are of the opinion that in times of economic slack, it is important to run budget deficits in order to stimulate general demand and jumpstart economic development. On the other hand, the monetarist and neoclassical schools of economic thought argue that long-term fiscal imbalances can result in inflation, higher interest rates, a buildup of debt that is not sustainable, and a lack of private investment, all of which can be detrimental to the economy in the long run.

In the context of this discussion, India is a highly intriguing example. Since the 1970s, India's public finances have been plagued by a structural imbalance in its fiscal budget. Deficit financing has been utilized by governments in order to accomplish developmental objectives, to sustain expenditure in the social sector, and to deal with shocks to the macroeconomic system. In contrast, the consequences of irresponsible fiscal policy over the long term were increasingly apparent in the late 1980s and early 1990s, which ultimately led to the crisis in the balance of payments that occurred in 1991. After then, India started rolling out macroeconomic and fiscal changes in response to the situation. The commitment to fiscal restraint was strengthened even further with the passage of the Fiscal Restraint and Budget Management Act (FRBM Act) in the year 2003. Despite these measures, there are still instances of budgetary slips occurring, particularly during times of global crisis such as the Global Financial Crisis (2008) and the COVID-19 pandemic. In light of this, it is imperative that we reconsider the long-term trade-offs that exist between fiscal activism and macroeconomic stability.

There is still no agreement among researchers on this specific topic in empirical research. Several studies have shown that fiscal deficits can help the economy grow, especially when they are used to pay for public investments or as a tool for countercyclical operations. Other studies have shown that the effects of fiscal deficits can be either bad or not straight, depending on how they are paid for, how well the money is spent, and the state of the economy as a whole. This difference shows how important it is to do research that is based on strong empirical frameworks and is specific to the situation at hand.

With this in mind, the goal of this study is to look into how India's fiscal deficit affects economic growth in the short and long terms, starting in 1970–71 and ending in 2021–22. Pesaran and Shin (1999) came up with the Autoregressive Distributed Lag (ARDL) Bounds Testing method as a way to test for cointegration. This method works very well when you are looking at time series variables that are integrated at more than one level. The large amount of data not only makes the estimate look more accurate, but it also shows how big changes in structure, shocks from outside the economy, and changes in policy have had a big effect on the economy over time. The empirical model includes important

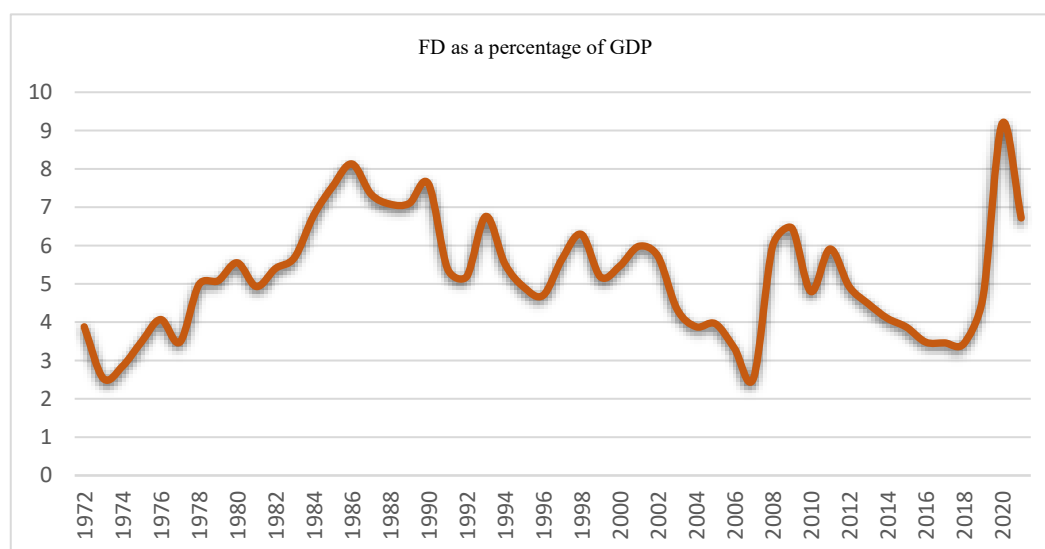
macroeconomic control variables like gross capital creation, inflation, the currency rate, trade openness, and total revenue, in addition to the gross domestic product and the budget deficit. We now have a full picture of how India's tax policy affects economic growth.

This paper is structured as follows. The following subsection 1.1 highlights the trends and patterns in India's fiscal deficit since 1970. Section 2 is divided into two parts: the first discusses the theoretical background of fiscal deficit-growth linkages, and the second presents a review of relevant empirical literature. Section 3 outlines the model specification and estimation strategy. Section 4 discusses the results obtained from the ARDL framework. Section 5 concludes the study with policy implications and directions for future research.

1.1. Fiscal Deficit in India

As shown in Figure 1, the fiscal deficit (FD) of India, as a percent of GDP has had a greatly cyclical, policy-driven trend over the last 50 years, as both a reflection of underlying structural economic issues and developments in the fiscal system. Between the mid-1970s and the mid-1980s, FDs varied between 3 and 4 percent of GDP, which pointed to a moderate degree of imbalance which accords with the inward-looking developmental model adopted in India. The 1980s, nevertheless, are a major change: fiscal deficits steadily grew, reaching over 8 percent of GDP by the middle of the 1980s. This increase was mainly attributed to the increasing levels of expenditure by the people, unproductive subsidies as well stagnancy in revenues, with low levels of productivity in addition to lack of tax buoyancy (Rangarajan & Srivastava 2005). The instability that followed macroeconomically formed part of the conditions that led to the crisis of the balance of payments in the year 1991 and thus it revealed the insecurity of the fiscal architecture of India.

Figure 1. *Fiscal Deficit as a Percentage of GDP (1970–2021)*



Source: RBI, 2022.

Subsequently, a serious effort at fiscal consolidation was witnessed during the post-1991 regime of liberalizations. During the mid-1990s, the deficit-to-GDP ratio was reduced to about 5 percent with receipts of disinvestment and with restructuring of subsidies and incomplete revenue reforms. The trend did, however, soon reverse itself when populist spending and slippages in fiscal control, which began during the coalition years, resulted in a revival of fiscal imbalances at the end of the 1990s (Chakraborty & Dash, 2017). In the light of institutional protection, the FRBM Act originated in 2003, which had a purpose of legally binding the central government by providing the consolidated fiscal objectives and cutting down the revenue deficits. Figure 1 shows the visible effects of the Act since the fiscal deficit has decreased significantly (below 3 % of GDP) between the period since 2007-08 thus indicating short-run effectiveness of rule-based fiscal discipline and better management of the government finances (Government of India, 2004; RBI, 2010).

The current spell of fiscal restraint, however, economics was brought to a screeching halt by the 2008 world financial crisis, which made it necessary to reactionary fiscal stimulus comprising of tax cuts and heightened capital spending. As a result the fiscal deficit leaped to more than 6 percent of GDP highlighting the conflict between the fiscal regulations and the economic necessities. Though the government again expressed its intentions to give the FRBM framework a priority, the corresponding periods of time (2011–2019) saw only incomplete consolidation, with the fiscal space being constrained by structural revenue constraints, particularly, following the implementation of the Goods and Services Tax (GST), and increasing expenditure demands. According to Patnaik and Pandey (2019), the fiscal deficit of India after the crisis showed not only sensitivity to the macroeconomic shock but also to the fiscal behavior of sub-nations and the flow of federal transfers.

The largest and most spectacular surge in the fiscal deficit came in 2020-2021, as the COVID-19 pandemic forced the government to implement massive, never-before-seen fiscal expansions in terms of direct transfers, food subsidies, and health spending. It contributed to a fiscal deficit of approximately 9.5 percent of GDP, which was the highest of post-reform history (IMF, 2021; RBI, 2021). Not only did this event put pressure on India's debt dynamics, but the event triggered debates again on the relevance and flexibility of fiscal rules. Fiscal frameworks of the future, as the 15th Finance Commission (2021) has pointed out, need to include escape clauses and medium-term debt anchors, as they help make room in fiscal policymaking between fiscal discipline and the finance-friendly effects of public investment.

Therefore, looking at the historical dynamics of the fiscal deficit in India, shown in Figure 1, there is one piece of history repeating over time, and that is one of fiscal profligacy and subsequent corrections through institutional measures. Although such measures as those provided by FRBM Act do help to suggest the period of consolidation, sustainable fiscal performance in India still depends on enhancing the efficiency of taxation, quality of expenditure, and institutional credibility. And as is well observed by Mohanty (2012), in a developing economy such as India, the task at hand is not only to bring deficits down but to make sure that fiscal policy bears a positive relevance to macroeconomic stability and inclusive growth.

2. Review of literature

2.1. Theoretical Perspectives on Fiscal Deficit and Economic Growth

Understanding the relationship between fiscal deficits and economic growth continues to be a central concern in economic theory and policy. Numerous theoretical frameworks have offered different interpretations of how government borrowing influences macroeconomic performance. Among the most prominent are the neoclassical view, the Keynesian perspective, and the Ricardian Equivalence Hypothesis. Each paradigm reflects a distinct analytical posture toward the economic implications of budget deficits.

The Neo-Classical View

The neoclassical view has a mainly skeptical approach towards fiscal deficits, with heavy stress on the negative consequences of macroeconomic balance and growth in the long-term in future. Advocates of such an opinion (Bernheim, 1989) pinpoint the fact that a government deficit will cause higher interest rates because it will diminish national savings especially when there is not enough saving by the private sector to offset the dissaving by the government. This is because the cost of capital would go up due to an increased rate of shrinking lending sources of funds.

With increased interest rate, there is a crowding out of the private investment thereby reducing the prospects of formation of productive capital. This displacement effect weakens the expenditure of the private sector and its long term growth potentials. Besides, government demand at full employment will create inflationary pressure on the economy leading to price volatility instead of economic growth.

The Neo-Classical model has three major assumptions. The consumers nationwide are first involved in intertemporal optimizations of consumption and savings choices where they fully exploit the credit markets to borrow and loan at the market rate of interest. Second, people live to death, and they belong to successive generations, hence, economic choices affecting future economic results are made by present-day groups. Thirdly, the market clearing assumption implies that the prices and quantities are changed once the demand and supply are equal in every market.

In this context, fiscal deficits would be regarded as distortive and ultimately counterproductive since they impair savings, discourage venture and result in inflationary pressures, which in aggregate depress economic growth.

The Keynesian Perspective

Unlike the neoclassical model, the Keynesian one keeps fiscal deficits in a more practical and more realistic approach to the situation. Keynesian economists believe that deficit spending is a useful policy tool to revive economic growth especially during recession or when idle capacity prevails in the economy (Bernheim, 1989). Abandoning the view that the economy is at full employment, this model appreciates the idea that underemployment of both labour and capital is a good reason why the government should be active in order to stop it.

In the Keynesian perspective, such a problem can be solved by raising the aggregate demand with the help of a multiplier due to raised government expenditure either in consumption or investment. The increase in production, revenues, and jobs creates a positive cycle of economic growth. Under this situation, the public borrowing behaviour does not displace the corollary crowding out of private investment; rather, it may give way to crowding-in of the activity in the sphere of the private sector because of uplifting the general economic statistics and growth of expectations on profit generation.

Furthermore, according to the Keynesian absorption theory, deficit-financed expenditure boosts local absorption, which can on its own raise imports and result in a current account deficit. Although this might seem to be a bad thing, it may be regarded as being a benign consequence of greater income and domestic demand but not a structural fault.

In terms of Keynesian economics, fiscal deficit is not an unacceptable condition in itself but it has to be properly timed and proportional, and economic circumstances must be considered. Such deficits during times of economic recession are perceived to be central to restoring economic stability, creating job opportunities and promoting social welfare.

The Ricardian Equivalence Hypothesis

Unlike the Neo-Classical and the Keynesian schools, the Ricardian Equivalence Hypothesis deals with the issue of fiscal deficits in a more neutral manner. This theory was initiated by the writings of David Ricardo and refined by Robert Barro arguing that deficit financing is essentially not relevant in its macroeconomics effects since rational people linearly take into account the consequences of government borrowing (Bernheim, 1989).

In this sense, according to this school of thought, when a government decides to finance its expenditure with debts as opposed to direct taxation, forward-looking consumers expect to pay future taxes to service the debt. This leads to them putting more in personal savings in anticipation of this eventual tax burden and thus cancels the expansionary effects of the deficit. In summary, a given amount of extra public spending increases the level of savings of the private sector undermining effects of the desired stimulus in the economy; hence it does not affect aggregate demand, interest rates, private investments, and economic growth.

Such a hypothesis is based on a number of strict assumptions, among which is the existence of rational and farsighted agents with access to the perfect capital markets who are intergenerationally altruistic. As a matter of fact, these conditions are hardly met entirely. Ricardian outcomes may also fail, for instance in case governments wait longer to collect tax, than the people who are subjected to taxation live, or in case individuals are unable to optimally adapt their savings due to liquidity constraints. In this case, real economic variables may certainly be affected by fiscal deficits.

However, Ricardian Equivalence is adding a caveat of great importance to the debate over fiscal policy: the success of budgetary expansion lies crucially in consumer expectations, in access to financial markets, and in generational distribution of tax burdens. In cases where such assumptions are true to the real world, fiscal deficits might not cause significant effects to the macroeconomic outcomes.

2.2. Review of Empirical Studies

Although there are theoretical discussions that point out some contending arguments about the growth implication of fiscal deficits, the definitive verdict lies on the empirical analysis. Many researchers have been working on how fiscal deficits and economic growth relate to each other in different macroeconomic conditions. We will list some of the most important empirical contributions employing ARDL, VECM, and VAR methods to give some understanding of this complicated relationship below.

Patra and Acharya (2011) applied a VECM model with the objective of evaluating the relationship between fiscal deficit and growth in India in 1980-2010. They verified the long-run cointegration between the fiscal deficit and output, and the fiscal imbalance was the negative, but significant influence to the growth. In the same vein, Mohanty and Mishra (2016) applied the ARDL bounds testing process to review the 'fiscal deficit-growth nexuses in India over the 1981 to 2012 time horizon. They found considerable long-run adverse effects of fiscal deficits of the central government on economic growth countering the neoclassical stand on the outcomes of crowding-out efforts.

On a larger South Asian scale, Siddiqui (2017) utilised a VAR model with the Pakistani data set running between 1970 and 2015. The paper identified a two-way causation relationship between fiscal deficit and growth of GDP which identified that the increased deficits had reduced growth and the decreased growth increased deficits. Similarly, Malik and Amjad (2013) reporting the results based on the study of the Pakistani economy via VECM also concluded that fiscal imbalances led to macroeconomic instability, which depressed the growth potential and lowered private investment in the long run.

To turn towards the African economies, Nzotta et al. (2017) reviewed the fiscal performance of Nigeria by employing the ARDL model during 1980-2015. The findings illustrated a long-run negative relationship that exists between fiscal deficits and GDP, but short-run dynamics were too weak and not statistically relevant. The research represented the crucial role of fiscal discipline in facilitating a sustainable economic growth. Similarly, Kumar and Jomo (2009) considered the Malaysian economy under a VECM-based model and observed that the budget deficits caused growth in the short run but the effect on growth in the long run was contractionary as the strands of increasing debts servicing and crowding-out of the privately-furnished investment were proceeding.

Chude and Chude (2013) used a VECM in studying fiscal-growth interaction in the United States in the period between 1975 and 2010. According to these results, there was a negative correlation between deficit and growth in the long run, but short-term fiscal expansions have slight stimulative impact as it was explained by the Keynesian counterproposal. A study by Uddin et al. (2012) on Bangladesh found evidence that is both mixed, in that public spending funded by moderate deficit encouraged growth, and unsustainable deficit caused pressures on inflation as well as inefficient investment.

Gathering back to India, researchers Srinivasan and Rao (2006) has explored the relationship between the fiscal deficit and the growth, based on quarterly data and the structural VAR model. The paper has discovered that higher fiscal deficits deteriorated the

fundamentals of the macroeconomics, such as inflation and external balance conditions, thus, indirectly slowing economic growth. Kaur, Mukherjee, and Singh (2014) went further and applied a multivariate ARDL to provide the results according to which the capital component of fiscal expenditure was associated with more favorable effects with growth, and revenue deficits were strongly correlated with negative growth.

Collectively, these studies reinforce the complex and often country-specific nature of the fiscal deficit–growth relationship. The evidence suggests that the composition of fiscal deficits, their mode of financing, and the institutional context significantly shape their impact on macroeconomic performance. A consistent theme across studies is that while deficits may temporarily support aggregate demand, persistent imbalances often undermine growth prospects through inflation, interest rate hikes, and crowding-out of private investment.

3. Methodology

This paper seeks to make an empirical study of the relationship between fiscal deficit and economic growth in India between 1970-71 and 2021-22. In analyzing the data, the Autoregressive Distributed Lag (ARDL) Bounds Testing methodology has been employed, which was first proposed by Pesaran and Shin (1999) and later refined by Pesaran et al. (2001) to explicate short-run dynamics and long-run equilibrium associations at the same time. The model uses real growth in GDP as the dependent variable and central government fiscal deficit as a percent of GDP as one of the independent variables, gross domestic capital formation, broad money supply (M3), Trade openness, Consumer Price Index (as a proxy for inflation), and the exchange rate (expressed as rupees per US dollar) as other independent variables of the model. The other variables, besides growth rate and fiscal deficit (which are already expressed in rates or percentages), have undergone log transformation in order to stabilize the variance and make the estimated coefficients of interest susceptible to interpretation in terms of elasticities. All the variables data series are taken based on RBI Handbook of Statistics on the Indian Economy (2022 edition).

The functional relationship under investigation is specified as follows:

$$GDPG_t = f(FDt, \log(EXT), \log(GFCF_t), \log(M3_t), \log(TradeOpen_t), \log(CPI_t))$$

GDPG_t: Real GDP Growth Rate (dependent variable)

FD_t: Fiscal Deficit (% of GDP)

Log(EX_t): Log of Exchange Rate (INR/USD)

Log(GFCF_t): Log of Gross Fixed Capital Formation

Log(M3_t): Log of Broad Money Supply (M3)

Log(TradeOpen_t): Log of Trade Openness (Exports + Imports as % of GDP)

Log(CPI_t): Log of Consumer Price Index

The ARDL equation in the model is as follows:

$$\begin{aligned} \Delta \text{GDPGt}_t = & \alpha_0 + \sum_{i=1}^n \delta_i \Delta \text{GDPGt}_{t-i} + \sum_{i=0}^m [\beta_1 \Delta \text{FD}_{t-i} + \beta_2 \Delta \ln(\text{EX})_{t-i} + \\ & \beta_3 \Delta \ln(\text{GFCF})_{t-i} + \beta_4 \Delta \ln(\text{M3})_{t-i} + \beta_5 \Delta \ln(\text{TO})_{t-i} + \beta_6 \Delta \ln(\text{CPI})_{t-i}] + \\ & \gamma_1 \text{GDPGt}_{t-1} + \gamma_2 \text{FD}_{t-1} + \gamma_3 \ln(\text{EX})_{t-1} + \gamma_4 \ln(\text{GFCF})_{t-1} + \gamma_5 \ln(\text{M3})_{t-1} + \\ & \gamma_6 \ln(\text{TO})_{t-1} + \gamma_7 \ln(\text{CPI})_{t-1} + \mu_t \end{aligned} \quad (1)$$

The ARDL equation presented captures the dynamic relationship between real gross domestic product growth rate and selected macroeconomic indicators in India. In this model, the dependent variable is the real gross domestic product growth rate, and the independent variables include fiscal deficit, exchange rate, gross fixed capital formation, broad money supply, trade openness, and consumer price index. The symbol Δ represents the first difference, indicating short-run changes, while the level terms capture long-run equilibrium relationships. The constant term (α_0) reflects the drift component of the model. The coefficients β_1 to β_7 represent the long-run effects of the corresponding independent variables on real gross domestic product growth rate, while γ_1 to γ_7 capture the short-run dynamics. The term μ_t is the error term that accounts for random disturbances or unexplained variations in the model. In order to examine the long-run relationship among the variables, bound testing procedure has to be used using F-test (Pesaran, Shin, & Smith, 2001). Where, F-test will test the null hypothesis stating that there is no co-integration among the variables. Here, the null hypothesis and alternate hypothesis can be represented as follows:

H0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$ (There is no co-integration among the variables.)

H1: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq 0$ (There is co-integration among the variables.)

After performing the bound test in ARDL model, Error correction mechanism is employed using the equation as mentioned below:

$$\begin{aligned} \Delta \text{GDPGt}_t = & \alpha_0 + \sum_{i=1}^n \theta_i \Delta \text{GDPGt}_{t-i} + \sum_{i=0}^m [\phi_1 \Delta (\text{FD})_{t-i} + \phi_2 \Delta \ln(\text{EX})_{t-i} + \\ & \phi_3 \Delta \ln(\text{GFCF})_{t-i} + \phi_4 \Delta \ln(\text{M3})_{t-i} + \phi_5 \Delta \ln(\text{TO})_{t-i} + \phi_6 \Delta \ln(\text{CPI})_{t-i}] + \psi \text{ECT}_{t-1} + \\ & \mu_t \end{aligned} \quad (2)$$

The ARDL Bounds Testing approach is appropriate for analyzing long-run relationships between variables irrespective of whether the underlying series are integrated of order zero $I(0)$ or order one $I(1)$, but not of order two $I(2)$. Once a long-run relationship is confirmed, the Error Correction Model (ECM) is applied to capture short-run dynamics. The coefficient of the error correction term (ECM_{t-1}) reflects the speed of adjustment toward long-run equilibrium and is expected to be negative and statistically significant, indicating that short-run deviations are corrected over time.

4. Empirical analysis

The empirical part starts with the descriptive statistics of the crucial variables during the analysis of the period 1970-2021. Table 1 shows the descriptive statistics (measures of central tendencies, dispersion, and normality of all variables included in the model). The mean rate of real GDP growth (GGDP) was 5.40 with the highest growth rate of 9.69 and

the lowest growth rate of -5.7 that is very high volatility. These are observations indicated in the high standard deviation (3.21) and the strong negative skewness (1.62) indicating regular downside movement. This volatility is explained by a number of macroeconomic and structural events like oil shocks in the 1970s, balance of Payments crisis in 1991, Structural economic reforms of the 1990s, the global financial crisis of 2008-09 and the contraction of the economy because of the COVID-19 pandemic in 2020-21.

Table 1. *Descriptive Statistics*

Variables	Mean	Median	Max	Min	Std Dev	Skewness	Kurtosis	Jarque-Bera	p-value
GGDP	5.40	5.98	9.69	-5.7	3.21	-1.62	6.3	44.8	0.00
FD%GDP	5.19	5.13	9.18	2.53	1.49	0.36	2.73	1.26	0.53
LNT0	2.98	3.02	3.79	2.04	0.49	0.00	1.81	2.91	0.23
LNGCDF	3.20	3.12	3.69	2.70	0.28	0.30	1.65	4.55	0.10
LNEX	3.27	3.59	4.31	2.03	0.79	-0.37	1.55	5.57	0.06
LM3	13.45	13.53	16.83	9.61	2.23	-0.10	1.74	3.37	0.18
LNCPI	3.06	3.75	5.25	1.61	1.08	-0.14	1.78	3.27	0.19

Source: Author's own calculations.

The other variables, like fiscal deficit (FD%GDP), had a mean 5.19 with a moderate standard deviation (SD = 1.49) and a symmetrical distribution. These include the log-transformation of trade openness (LNT0), gross capital formation (LNGCDF), exchange rate (LNEX), broad money supply (LM3), and consumer price index (LNCPI) have a reasonable standard deviation and skewness value, and this shows they are stable with regard to time. The Jarque-Bera statistics indicate that except the GGDP, most variables are not significantly different in normality at 5 percent immediately. These outputs are a good diagnostic before performing unit root test and cointegration test.

Unit Root Test

After conducting the diagnostic checks to ensure the validity of the model, unit root tests were performed to examine the stationarity properties of the variables. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (P-P) tests were applied at both level and first difference forms. The results reveal that Gross Domestic Product Growth and Fiscal Deficit as a percentage of Gross Domestic Product are stationary at level, i.e., integrated of order zero $I(0)$.

Table 2. *Unit Root*

Variables	ADF Test		P-P Test		Remark
	Levels	1 st Difference	Levels	1 st Difference	
GRGDP	-7.51 (0.00)*	5.64(0.00)*	-7.53(0.00)*	-23.14(0.00)*	I (0)
FD%GDP	-2.99 (0.04)*	-6.55(0.00)*	-2.24(0.04)*	-7.97(0.00)*	I (0)
LNT0	-1.68 (0.44)	-4.42(0.00)*	-1.65(0.44)	-5.39(0.00)*	I (1)
LNGCDF	-1.16(0.68)	-4.96(0.00)*	-1.00(0.74)	-8.42(0.00)*	I (1)
LNEX	-0.89(0.78)	-6.55(0.00)*	-0.89(0.79)	-4.99(0.00)*	I (1)
LM3	-2.83(0.06)*	-8.24(0.00)*	-2.75(0.07)	-3.47(0.01)*	I (1)
LNCPI	-2.48(0.13)	-5.02(0.00)*	-2.03(0.27)	-4.89(0.00)*	I (1)

Source: Author's own calculations.

However, the other variables, such as trade openness, gross domestic capital formation, exchange rate, broad money supply, and consumer price index, are non-stationary at levels but become stationary after first differencing, indicating they are integrated of order one

I(1). The presence of a mix of I(0) and I(1) variables justifies the use of the Autoregressive Distributed Lag (ARDL) Bounds Testing approach for assessing the long-run relationship among the variables.

Lag Selection

To determine the optimal lag structure for the ARDL model, the Akaike Information Criterion (AIC) was employed. Based on the minimum AIC value, the ARDL(2, 0, 1, 2, 0, 2, 2) model was selected, where the dependent variable—growth rate of gross domestic product—was included with two lags, while the independent variables—fiscal deficit-to-GDP ratio, gross capital formation, exchange rate, broad money supply, trade openness, and consumer price index—were incorporated with their respective lag orders.

Cointegration test

Once the stationarity conditions were met, then the procedure of the ARDL bounds testing was used to determine that there is a long-run relationship among the variables. F-statistic results in 7.38 which is higher than the upper critical value of 3.28 at 5 % and the value of 2.94 at 10 % which is an indication of the model containing four regressors ($k = 4$). Accordingly, the null hypothesis of no cointegration was rejected, and thereby indicating the presence of a long-run equilibrium relationship between economic growth and the chosen macroeconomic variables.

Table 3. Bound test of cointegration

Test-statistics	Value	Significance	I (0)	I (1)
F-statistics k	7.38 6	5%	2.27	3.28
		10%	1.99	2.94

Source: Author's own calculations.

Long-run analysis

Long-run ARDL estimates are shown in table 4, which boldly support the neoclassical growth point of view, which focuses its major centers of interest on the importance of fiscal discipline, effective capital use, and overall sound macro fundamentals as the foundation to steady economic growth

Table 4. Long-Run Result ARDL

Variables	Coefficients	Std. Error	T-Stats	P-Value
Constant (C)	49.1958**	19.1972	2.5625	0.0151*
FISCAL_DEFICIT_GDP	-0.8598	0.2151	-3.9968	0.0004*
LNEX (Exchange Rate)	-11.6103	2.5267	-4.5959	0.0002*
LNGCDF (Cap Formation)	-7.5715	2.6116	-2.8986	0.0068*
LNM3 (Money Supply)	7.5255	2.0356	3.6966	0.0012*
LNT0 (Trade Openness)	-4.3093	1.3304	-3.2385	0.0026*
LOG_CPI (Inflation)	23.4294	5.1489	4.5504	0.0002*

Source: Author's own calculations.

Most important, the regression coefficient of the fiscal deficit-to-GDP ratio has the negative and significant value (-0.8598, $p < 0.01$), meaning that the increasing fiscal deficit is related to the decreasing real GDP growth in the long-term perspective. This conclusion is quite consistent with the neoclassical hypothesis that persistent government deficits can eventually cause crowding out of private investment since growing state borrowing would

push the interest rates to go up and possibly diminish investor confidence. In long-run growth, fiscal imbalances can lead to less-than-optimal resource allocation by unproductively consuming the national savings and thus crowding out other productive activities of the private sector.

In addition, there exists a strong but negative relationship between real exchange rate (LNEX) and GDP in the long run (-11.6103, $p < 0.01$). Under the neoclassical model, this outcome highlights the destabilizing effects of depreciating exchange rates lacking accompanying increases in productivity or export competitiveness. Chronic depreciation raises the price of imported capital goods and leads to imported inflation, which suppresses the investment climate and discourages long-run economic development.

The gross capital formation (LNGCDF) variable is an unexpected but significant finding with a negative long-run coefficient (-7.5715, $p < 0.01$). Although neoclassical models assume that accumulation of capital is central to growth, this negative coefficient is probably indicative of inefficiencies in investment processes in India, whether through delays in project execution, misallocation of capital or inadequate institutional arrangements, which may constrain the productivity of investment in the long run. This finding therefore supports the neoclassical criticism that capital effectiveness and not amount is what promotes long-term economic growth.

From the monetary perspective, general money supply (LNM3) has a significant positive correlation with long-run growth (7.5255, $p < 0.01$), and this supports the Neoclassical stress on the financial sector development and monetary stability. The provision of transactions, transaction costs, and adequate liquidity that may be offered by a sound and growing money supply may be within reach so long as the inflationary pressures are kept within bounds.

The trade openness variable (LNT0) shows contrary results to expectations and has a strong impact (negative) of growth in the long-run (4.3093, $p < 0.01$). Although neoclassical models tend to propose open trade regimes to countries, they also warn that openness does not lead to growth on its own but should be backed by domestic rivalry, well-developed infrastructure, and good institutional quality. The case of India would seem to illustrate the dangers of being subjected to global market competition too soon, not accompanied by any investment in efficiency or innovation.

Finally, there is inflation (LOG_CPI), which indicates that there is a large positive influence in the long run (23.4294, $p < 0.01$) on growth. Within the neoclassical perspective, the same could be argued to be a sign that with moderate and predictable inflation, growth can be achieved through reduced insurance rates in the real world and increased consumption and investment—provided, of course, that inflation is managed to remain at a reasonable standard and does not give rise to macroeconomic insecurity.

Short-Run Analysis

The short-run dynamics as presented in table 5, are based on the ARDL model, and these dynamics are largely within the neoclassical expectations, being agreeable to the significance of policy credibility in the short run and macroeconomic adjustment mechanisms.

The error correction term (ECT(-1)) is negative and very highly significant (-1.1847, $p < 0.01$) and shows that there is a strong process of adjustment to long-run equilibrium level.

The size of the coefficient would mean that about 118 percent of the deviation in the equilibrium would be reversed in one period, indicating not only a strong convergence in values but possible overreactions in the short term. This rapid pace of adaptation fits with the neoclassical view that markets can clear imbalance problems quite rapidly, provided the neoclassical assumption that when left to operate efficiently, markets will adjust through the process of rational expectations and forward-looking behaviour.

Table 5. *Short-Run Result ARDL*

Variable	Coefficient	Std. Error	t-Statistic	p-Value
D(FISCAL_DEFICIT)	-1.0188	0.2476	-4.1126	0.0005*
D(LNEX)	-15.7537	3.2790	-4.8043	0.0003*
D(LNGCDF(-1))	-8.2245	2.4608	-3.3424	0.0046*
D(LOG_CPI(-1))	20.5711	4.6557	4.4173	0.0013*
D(LNTO)	-9.6283	4.4284	-2.1742	0.0386*
D(LNM3(-1))	27.1704	12.7992	2.1228	0.0431*
ECT(-1)	-1.1847*	0.1638	-7.2338	0.0000*

Source: Author's own calculations.

On the individual coefficients, the short-run coefficient of the fiscal deficit (D(FISCAL_DEFICIT)) is negative and significant (-1.0188, $p < 0.01$), thereby reemphasizing that the fiscal imbalances (fiscal deficit) have a negative effect on output even in the short term. It could be a response to fears on taxation or sustainability in the future, and this could inhibit investment and consumption by businesses in a precautionary behaviour.

The real exchange rate (D(LNEX)) maintains a high negative influence (-15.7537, $p < 0.01$) saying that the exchange rate instability or depreciation can instantly affect the trade dynamics, raise the cost of input to the firms that depend on the imported capital goods, and inflate the inflationary forces, all of which are hostile to growth as perceived by the neoclassical economic perspective.

Another statistic that shows negative bond in the short-run dynamics in gross capital formation (D(LNGCDF(-1)) = -8.2245, $p < 0.01$) is reported. This is in as much as it may be reflecting the time delays and the wastefulness in the movement of investment into productive output, what neoclassical theorists argue is rather the form and quality of investment instead of its extent.

Interestingly, inflation (D(LOG_CPI(-1))) is an interesting finding as it shows a significant positive short-run effect (20.5711, $p < 0.01$) which lends credence to the fact that for an average level of inflation, as anticipated and predictable over time, the factor can help to keep real wage rigidities away, promote profits, and induce activities related to production and employment in the short run.

Also, trade openness (D(LNTO)) has negative effects in the short-run impact to output (-9.6283, $p = 0.0386$) and this may indicate that initial exposure to international markets may cause volatility and job displacements in sectors before any benefits of an efficient globalization are felt. The discovery is aligned with neoclassical warnings of transitional costs of adjustment of liberalizing economies.

And, lastly, there is the positive and significant relationship between lagged money supply (D(LNM3(-1))) and output (27.1704, $p = 0.0431$), which suggests that the provision of liquidity may serve as a short-run stabilizer, contributing to the increased aggregate demand

and resulting in a smoother adaptation to shocks—something Neoclassical schools focused on the monetary discipline and financial depth.

Residuals Diagnostic Test and Stability Test

Since the long-run and short-run dynamics have been confirmed with the help of the ARDL model, a set of residual diagnostic tests has been carried out to determine the robustness and statistic reliability of the model. The serial correlation test conducted using the Breusch-Godfrey LM method has a statistical test equal to 0.25 and p value equals 0.77 and is not statistically significant at any common level. It means that no autocorrelations of the residuals occur; hence, the estimates of the model are not biased because of the serial dependence. In the same way, the Breusch-Pagan-Godfrey test of the heteroskedasticity showed the test statistic of 1.53 and p-value of 0.21, which proves that the variance of residuals is not time dependent and that the assumption that the heteroskedasticity assumption does not hold.

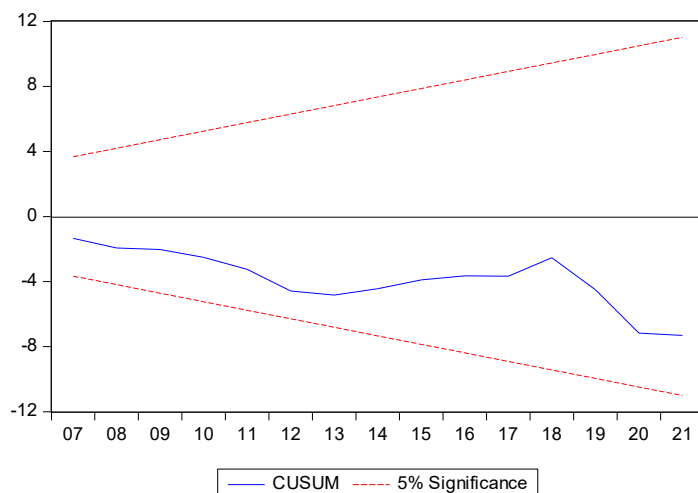
Table 5. *Residuals Diagnostic Test*

Residuals Diagnostic Test	Statistics	P-value
Serial Correlation test	0.25	0.77
Heteroskedasticity test	1.53	0.21
Normality test	3.57	0.16

Source: Author's own calculations.

Moreover, Jarque-Bera test of normality gave a test statistic of 3.57 with a p-value of 0.16, which indicates that the residuals are normally distributed. The satisfaction of this assumption speaks even more of the efficiency of the model and the reliability of its interpretation. Collectively, the results of the diagnostic checks serve to support the justification of using the ARDL model and to provide a sound statistical support in favour of this modelling approach. The presented estimate coefficients and its interpretations are therefore robust, consistent and fit to policy inferences in the study context.

Figure 2. *CUSUM Test*



Source: Author's own calculations.

The stability of the estimated ARDL model was examined using the CUSUM test, as shown in Figure 2. The CUSUM plot remains well within the 5% significance bounds throughout the sample period, indicating that the model is structurally stable. This suggests that the parameters of the model do not experience significant shifts over time, thereby confirming the robustness of the long-run and short-run estimates.

5. Conclusion

The current study explored the dynamic interrelationship between Indian fiscal deficit and economic growth empirically through the Autoregressive Distributed Lag (ARDL) method for 1970 to 2021. The Neoclassical school of thought was used to aid in the analysis by focusing its attention on the significance of fiscal restraint and macroeconomic stability to attaining long-term growth. The findings indicate that fiscal deficit in percentage GDP has a great negative effect on real economic growth both in the short run and in the long run. This observation conforms with the neoclassical position that as a result of sustained fiscal imbalances, productive investments may be crowded out, and mispricing of investment resources, distortion of resource allocation and introduction of economic inefficiencies are paralleled over the long term.

In addition to these, there were also other leading macroeconomic variables which included capital formation, exchange rate and inflation; which also came out as important factors of growth. It was observed that capital formation negatively affected the long-term, and this can potentially assume inefficiencies or misallocations in investment, and the money supply (M3) also influenced positively implying the benefit that monetary increase has via an increment in growth during sustained inflationary cycles. However, inflation displayed an intense and persistent negative impact on output, and this underlines the necessity of having price stability. The openness to trade, normally linked to growth, had a contractionary feature under Indian circumstances, perhaps because of the imbalances in trade or constraints in the tradable segment.

From a policy perspective, the findings underscore the importance of maintaining fiscal discipline to foster long-term economic growth. Policymakers must ensure that fiscal deficits are kept within sustainable limits and that public expenditures are efficiently directed toward growth-inducing sectors. Additionally, complementary macroeconomic policies focusing on inflation control, financial deepening, and export competitiveness are essential to create a stable and growth-conducive environment. In this context, fiscal consolidation strategies and institutional reforms that enhance the quality of public spending and investment efficiency could play a pivotal role in strengthening India's growth trajectory.

References

- Chakraborty, L., and Dash, B.B. (2017). Fiscal deficit, capital formation, and crowding out in India: Evidence from ARDL approach. *Economic Modelling*, 63, 344–356.
- Chude, N.P., and Chude, D.I. (2013). Impact of government expenditure on economic growth in Nigeria. *International Journal of Business and Management Review*, 1(4), 64–71.
- Government of India. (2004). *Fiscal Responsibility and Budget Management Act, 2003*. Ministry of Finance.
- IMF. (2021). *India: 2021 Article IV Consultation—Staff Report*.
- Kaur, B., Mukherjee, S., and Singh, J. (2014). Public expenditure and economic growth: Evidence from the ARDL approach for India. *South Asian Journal of Macroeconomics and Public Finance*, 3(2), 191–212.
- Kumar, R., and Jomo, K.S. (2009). Fiscal policy, public debt and monetary policy in developing countries. *Economic and Political Weekly*, 44(13), 59–68.
- Malik, S., and Amjad, M. (2013). Fiscal deficit and macroeconomic performance: Pakistan's case. *International Journal of Economic Practices and Theories*, 3(1), 10–15.
- Mohanty, A.R., and Mishra, B.R. (2016). Fiscal deficit–economic growth nexus in India: A cointegration approach. *Theoretical and Applied Economics*, 23(4), 207–216.
- Mohanty, D. (2012). Evidence of fiscal dominance in India. *RBI Working Paper Series No. 6*.
- Nzotta, S.M., Okereke, E.J., and Nwagbara, E.N. (2017). Fiscal deficits and economic growth in Nigeria: A multivariate analysis. *Journal of Finance and Economic Research*, 2(1), 20–34.
- Patnaik, I., and Pandey, R. (2019). The FRBM Act and the dynamics of India's fiscal architecture. *NIPFP Working Paper No. 266*.
- Patra, D., and Acharya, D. (2011). Fiscal deficit and economic growth in India: An empirical analysis. *International Journal of Economics and Business Research*, 3(1), 80–95.
- Rangarajan, C., and Srivastava, D. (2005). Fiscal deficits and government debt: Implications for growth and stabilisation. *Economic and Political Weekly*, 40(27), 2919–2934.
- Reserve Bank of India. (2010). *Report on Currency and Finance 2008–09*.
- Siddiqui, R. (2017). The causal relationship between budget deficit and economic growth in Pakistan. *Pakistan Economic and Social Review*, 55(2), 385–403.
- Srinivasan, T.N., and Rao, M.G. (2006). Fiscal deficits and government debt in India: Implications for growth and stabilization. *National Institute of Public Finance and Policy Working Paper*.
- Uddin, M.G.S., Chowdhury, M.B., and Islam, M.S. (2012). An empirical study on the impact of budget deficit on economic growth in Bangladesh. *Bangladesh Economic Review*, 29(1), 123–135.
- 15th Finance Commission. (2021). *Report for 2021–2026*. Government of India.

Non-linearity and market behavior in the Romanian capital market: a rescaled range analysis of BET index

Genia-Iulia TABĂRĂ

Transilvania University of Brasov
genia.tabara@unitbv.ro

Abstract. *This study employs Rescaled Range (R/S) analysis to investigate the non-linear dynamics and long-range dependence of returns in the Romanian capital market, specifically analyzing the benchmark BET index from 2000 to 2024. By calculating the Hurst exponent over Fibonacci-based subseries, the research examines the extent of persistence and non-random behavior within the index. Additionally, the Lyapunov exponent was estimated to assess the sensitivity of the BET index to initial conditions, providing insights into potential chaotic dynamics. The results reveal significant long-term memory, persistent trends, and marginally chaotic behavior, indicated by a positive yet near-zero Lyapunov exponent. These findings challenge the assumptions of weak-form market efficiency and align with earlier studies highlighting structural and behavioral inefficiencies in emerging financial markets. The implications are significant for investors, suggesting that trend-following strategies might offer superior predictive capacity compared to traditional random-walk models. For policymakers and regulators, the evidence underscores the need for enhanced market transparency and institutional robustness to mitigate structural inefficiencies. Overall, this study contributes to the growing literature that applies complexity science to financial markets, emphasizing the necessity of integrating nonlinear analytical frameworks for a deeper understanding of market dynamics in emerging economies.*

Keywords: #rescaledrange; #hurstexponent; #nonlinearity; #stockmarket; #chaostheory.

JEL Classification: G1.

1. Introduction

Financial markets are increasingly recognized as complex adaptive system structures composed of numerous interacting agents whose collective behavior cannot be accurately captured by linear models. These systems display hallmark features such as nonlinearity, emergence, feedback loops, and scale-invariance, all of which complicate traditional modeling approaches. Historically, the study of nonlinear dynamics in finance began with the seminal contributions of Benoît Mandelbrot in the 1960s (Mandelbrot, 1963), who introduced fractal geometry and the concept of long-term memory into financial analyses, fundamentally altering the conventional views of market behavior. Further developments emerged in the 1990s when Edgar Peters formalized the Fractal Market Hypothesis (FMH) (Peters, 1994), explicitly recognizing markets as inherently nonlinear systems displaying persistent trends, self-similarity, and scale-invariance.

The Romanian capital market, represented by the BET index, offers a fertile ground for examining such complexity in an emerging market context. While the Efficient Market Hypothesis (EMH) remains a dominant paradigm in financial theory (Fama, 1970), it has been progressively contested by interdisciplinary perspectives including chaos theory, behavioral finance, and fractal market theory. The latter, championed by Benoît Mandelbrot and later expanded by Edgar Peters, frames financial markets as non-linear, multi-scale systems populated by heterogeneous agents reacting asymmetrically to new information. Peters introduced the Fractal Market Hypothesis in the 1990s (Peters, 1994), emphasizing that markets consist of investors with diverse time horizons and that price movements reflect long-memory and self-similarity rather than randomness. To quantify this memory effect, Mandelbrot adapted a method from hydrology known as Rescaled Range (R/S) analysis, introduced by Harold Edwin Hurst (Hurst, 1956). The central indicator, the Hurst exponent (H), distinguishes between short-term and long-term dependence in time series data. A value of $H > 0.5$ indicates persistence (trending behavior), while $H < 0.5$ implies anti-persistence, and $H \approx 0.5$ suggests a random walk. In the context of the BET index, understanding whether price dynamics follow persistent patterns or exhibit non-linear and chaotic traits can have practical implications for market predictability and risk management. While prior studies have largely focused on developed markets such as the S&P 500, this research investigates the Romanian BET index using R/S analysis and additional tools such as the BDS test and Lyapunov exponents to examine the nature of nonlinearity and local instability. Rather than assessing the entire series in aggregate, we analyze subseries defined by Fibonacci-based windows, a method inspired by natural proportionality and scale. This approach allows us to investigate local variations in complexity and test for the presence of long-range dependence and non-linear structures in different temporal scales. By employing this multifaceted analytical approach, our study contributes significantly to the ongoing discourse regarding market efficiency in emerging economies. It also underscores the importance of integrating advanced nonlinear analytical frameworks to accurately capture the complexity inherent in financial market behavior, providing valuable insights into the structural and dynamic properties of the Romanian BET index.

2. Literature review

The study of long-term memory, nonlinearity, and chaotic dynamics in financial markets has evolved significantly since the introduction of the Rescaled Range (R/S) analysis by H.E. Hurst (Hurst, 1956) in the context of hydrology. Benoît Mandelbrot later adapted this method to financial time series, proposing the concept of fractional Brownian motion to account for observed persistence and "fat tails" in asset returns (Benoit B. Mandelbrot, 1968). Edgar Peters (Peters, 1994) further integrated these ideas into the Fractal Market Hypothesis (FMH), emphasizing the self-similarity and scale invariance of financial markets. Numerous empirical studies have validated the use of the Hurst exponent as a measure of long-range dependence on stock returns. For example, Lo (Andrew W. Lo, 1991) introduced modified R/S statistics to distinguish between short- and long-term dependencies. Studies by Granger, and Engle (Engel & Granger, 1987), and Lee and Robinson (Kong et al., 1996) confirmed the prevalence of long-memory behavior in various global indices. More recently, Monte (Monte, 1994) and Vogl & Rötzel (Vogl & Rötzel, 2022) explored low-dimensional chaos in the S&P 500, revealing a hybrid behavior combining stochastic noise and deterministic chaos. To complement memory tests, researchers have applied the BDS test (Brock, Dechert, Scheinkman & LeBaron, 1996) and (Robert Savit, 1991) as a robust method for detecting nonlinearity in time series. Despite criticisms regarding its ability to differentiate chaos from stochastic processes (Yousefpoor, 2008), it remains a widely used nonparametric tool. Extensions such as the Grassberger-Procaccia correlation dimension (Grassberger & Procaccia, 1983) or the Kaplan test have further enriched nonlinear diagnostics. In parallel, Empirical Dynamic Modeling (EDM), as discussed by Munch, Rogers, and Sugihara (Munch et al., 2023), has offered model-free approaches especially useful in short or incomplete time series, broadening the applicability to emerging markets. Regarding regional focus, Ozkaya & Ozkaya (Ozkaya & Ozkaya, 2012), Dutta & Prajapati (Dutta & Prajapati, 2014), and Ozkaya (Ozkaya, 2022) applied nonlinear and chaos theory methods to the BIST-100 (Turkey), revealing deterministic chaos and long-range dependencies. In the Romanian context, studies by Leonardo Badea&Armeanu (Leonardo Badea; Daniel Stefan Armeanu; Iulian Panait and Stefan Cristian Gherghina, 2019), have explored similar dynamics, although rarely applying tools like R/S, BDS or Lyapunov exponents. The scarcity of such studies motivates a more detailed investigation of the BET index, especially given its role as a benchmark for the Romanian capital market. Additionally, Lapenta & Abecasis (Lapenta & Abecasis, 2016) and Hantias et al. (Hantias et al., 2020) showed how combining R/S analysis, BDS tests, and Lyapunov exponent estimation can provide a comprehensive view of the complexity embedded in financial time series. These methods uncover structures that traditional linear models fail to capture, including nonlinear determinism, persistent behavior, and transition regimes often associated with market crises or systemic shocks. Although David Nawrocki (Nawrocki, 1995) questioned the existence of long-term memory in stock indices using Mandelbrot's infinite memory theory, recent evidence suggests otherwise—particularly in emerging markets, where institutional inefficiencies, lower liquidity, and heterogeneous investor behavior can amplify non-randomness. This paper contributes to this literature by applying a multi-method approach R/S analysis, BDS test, and Lyapunov exponent to the BET index, segmented into Fibonacci-based subseries.

The goal is to assess the market's memory, nonlinearity, and sensitivity to initial conditions, providing insight into its structural complexity and its divergence from classical EMH assumptions.

3. Data and methodology

This study is based on daily closing prices of the BET index, covering the period from January 17, 2000, to January 19, 2024, yielding a total of 8,769 observations. The logarithmic returns were computed as the first difference of the natural logarithm of the BET price series, offering a stationary representation of the price dynamics.

3.1. Stationarity and Seasonality

Prior to nonlinearity testing, we assessed the stationarity of the return series using three complementary tests:

- Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979),
- Phillips-Perron (PP) test (Phillips & P. Perron, 1988),
- Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test (Kwiatkowski D.; Phillips P.C.B.; P. Schmidt P., 1991).

To identify potential seasonal effects, we employed ANOVA (Analysis of Variance) and F-tests using calendar-based segmentation (monthly and yearly grouping). These analyzes help detect recurring patterns or calendar effects, which may influence the memory or chaotic structure of the series. However, the results indicated no significant seasonality, reinforcing the suitability of treating the data as homogeneous over time.

3.2. BDS Test for Nonlinearity

The Brock-Dechert-Scheinkman (BDS) test was applied to the return series and its subseries to detect nonlinear dependencies. The null hypothesis assumes that the data are independently and identically distributed (i.i.d.). Rejection of the null (at 1%, 5%, or 10% significance levels) implies the presence of nonlinearity or hidden structure, violating classical linear assumptions. We used embedding dimensions $m = 2$ to 5, and multiple epsilon values (0.5σ , 1σ , 1.5σ) to ensure robustness of the test across scales.

3.3. Lyapunov Exponent Estimation

The calculation of Lyapunov exponents is a fundamental tool in chaos theory and is used to measure the sensitivity of a dynamical system to initial conditions. This concept was introduced by the Russian mathematician Aleksandr Lyapunov in the late 19th century and is essential in determining the chaotic character of a system (Aleksandr Mikhailovich Lyapunov, 1892). Chaotic dynamical systems are characterized by exponential dependence on initial conditions, which means that small initial perturbations can lead to completely different trajectories over time. This property is what makes long-term predictions in such systems impossible if they are completely deterministic. The Lyapunov exponent measures the exponential rate at which nearby trajectories in the reconstructed phase space diverge, thus offering insight into the system's sensitivity to initial conditions. To assess whether the BET dynamics display chaotic properties, we estimated the Lyapunov exponent (λ)

using Wolf's algorithm (Wolf et al., 1985). This method reconstructs the phase space using time-delay embedding and evaluates the divergence of nearby trajectories. The interpretation of λ is as follows:

Formally, Lyapunov exponents are used to describe the behavior of a dynamic system governed by a set of differential equations, as follows:

$$F(X) = \frac{dX}{dt}$$

Where:

X is the state vector.

$F(X)$ is the function governing the system's dynamics.

Following an initial perturbation of a point on the trajectory by an infinitesimal vector $\delta X(0)$, the direction of divergence of the system grows over time. This evolving perturbation is described by the relation:

$$|\delta X(t)| \approx |\delta X(0)| e^{\lambda t}$$

Where:

$|\delta X(0)|$ is the initial magnitude of the disturbance.

$|\delta X(t)|$ is the magnitude of the disturbance at time

λ is the Lyapunov exponent associated with that direction, representing the exponential rate of divergence. Lyapunov exponents are formally defined as:

$\lambda > 0$: chaos (sensitive dependence on initial conditions),

$\lambda \approx 0$: quasi-periodicity,

$\lambda < 0$: convergence and local stability.

A chaotic system exhibits at least one positive Lyapunov exponent.

3.4. Rescaled Range (R/S) Analysis and the Hurst Exponent

To investigate long-term memory, we applied Rescaled Range analysis (R/S) following the steps procedure proposed by Peters (Peters, 1994). The key metric derived is the Hurst exponent (H):

$H > 0.5$ indicates persistence (trend-reinforcing behavior),

$H < 0.5$ signals anti-persistence (mean-reverting behavior),

$H \approx 0.5$ reflects a random walk.

To analyze memory across scales, the dataset was segmented into subseries using the first 10 Fibonacci numbers, starting from 3 (i.e., 3, 5, 8, ..., 233 days). This segmentation reflects a natural multiscale approach, allowing examination of scaling laws and temporal heterogeneity.

The Rescaled Range (R/S) analysis is a method for detecting long-range dependence in time series. Introduced by Hurst (1951) and popularized in finance by Mandelbrot and Peters, it is computed as follows:

Step 1: Transform the original price series $P_0, P_1, \dots, P_T$, of size M into a series of logarithmic returns of size:

$$N = M - 1$$

Thus,

$$N_i = \log \frac{M_i + 1}{M_i}$$

Step 2: Divide this period into periods of length n , such that:

$$A * n = N$$

Each subperiod is denoted as I_a with $a = 1, 2, \dots, A$. Furthermore, each element of I_n is denoted by $N_{k,a}$ such that $k=1,2,3,\dots,n$. For each I_a of length n , the average value is defined as:

Where e_a is the average value of $N(i)$ contained in sub-period $I(a)$ of size " n "

Step 3: The series of cumulative deviations $[X(k,a)]$ from the mean for each sub-period $I(a)$, is defined as follows:

$$X_{k,a} = \sum_{i=1}^k (N_{i,a} - e_a)$$

$$k = 1, 2, 3, \dots, n$$

Step 4: The interval is defined as the difference between the maximum and minimum of the value $X(k,a)$ within each sub-period $I(a)$:

$$R_{Ia} = \max(X_{k,a}) - \min(X_{k,a})$$

Where $1 \leq k \leq n$

Step 5: Calculate the standard deviation for each sub-period $I(a)$ according to formula:

Step 6: Each interval, $R(I_a)$ will be normalized by dividing by the corresponding standard deviation ($SI(a)$). Then, the rescaled interval for each sub-period (I_a) is equal to:

$$\frac{R_{Ia}}{SI_a}$$

From step 2, we have A under adjacent periods of size n , so the average R/S for length n is defined as:

Step 7: The length n is increased to the next larger value, and $(M - 1)/n$ is an integer value. We use values of n that include the start and end points of the series, and steps 1 to 6 are repeated until $n = (M - 1)/2$ (E. Peters, 1991). An ordinary least squares regression is performed on $\log(n)$ as the independent variable and $\log(R/S)n$ as the dependent variable (Peters, 1994c). The intercept is the estimate of $\log(c)$, constant. The slope of the equation is the estimate of the Hurst exponent, H .

Step 8: Thus, we obtain resized average intervals $(R/S)n$ for the corresponding sub-interval lengths. The resized interval is then scaled as:

where "c" is a finite positive constant independent is known as the rescaled range because it has a mean of zero and is related to the local standard deviation. The Hurst exponent can be approximated by plotting $(R/S)n$ versus $\log(n)$ and solving for the slope using an ordinary least squares (OLS) regression. The following equation is obtained:

$$\log_b\left(\frac{R}{S}\right)n = \log_b(c) + H * \log_b(n)$$

Where:

“H” is the Hurst exponent.

$0.50 < H < 1.00$ implies a persistent time series characterized by long memory effect.

$0 < H < 0.50$ signifies anti-persistent, chaotic.

$H = 0.50$ signifies the existence of an independent process, random movement.

In short, the Hurst exponent is calculated to assess long-term memory and self-similarity in financial time series data, indicating the presence of trends and potential nonlinear dynamics.

A custom Python implementation was used to perform these calculations, including visualization of trajectories and estimation of attractor structure.

4. Empirical results

4.1. Stationarity and Seasonality

Before conducting nonlinear analyses, the stationarity was verified using three complementary tests: Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS). The results consistently indicated that BET index is non stationary at conventional significance levels, confirming the suitability of the series for subsequent modeling and memory analysis.

Table 1. Stationarity test results for the BET index

Test	Statistics	BET	1%	5%	10%	Conclusions
ADF	Statistical test	0.411	-3.430	-2.860	-2.570	Non-stationary
	p-value	0.9819	-	-	-	
KPSS	Statistical test (max lag=12)	10.829	0.216	0.146	0.119	Non-stationary
Phillips-Perron	Test-statistics (Z(t))	-0.086	-3.430	-2.860	-2.570	Non-stationary
	p-value	0.951	-	-	-	

Source: Own calculation, using STATA 18 on daily BET data (2000-2024).

To examine the potential presence of seasonality, we applied ANOVA and F-tests based on calendar segmentations—specifically, monthly and annual groupings. These tests sought to uncover any regular, recurring patterns that might distort memory or chaos detection. However, findings revealed no significant seasonal effects, allowing the treatment of the series as time homogeneous.

Table 2. Results of seasonality tests for the BET return series

Test	Statistics	Value	Prob > F (p-value)	Conclusion
ANOVA	F-test	1.474	0.134	No seasonality
Testul F	F (11, 8756)	1.470	0.1337	No seasonality

Source: Own calculation, using STATA 18 on daily BET data (2000-2024).

4.2. BDS Test for Nonlinearity

The BDS (Brock-Dechert-Scheinkman (Brock, Dechert, Scheinkman & LeBaron, 1996)) test was used to detect nonlinear dependence structures in the BET series and its subseries. The null hypothesis of the BDS test assumes that the observations are independent and identically distributed (i.i.d.). We applied the test across embedding dimensions to, and for multiple values of epsilon. In all configurations, the null hypothesis was strongly rejected (p-values < 0.001), confirming the presence of nonlinearity and hidden structure. For the BET index, the BDS statistics are significant at small values of the epsilon threshold (eps), indicating that small-scale price fluctuations appear to exhibit nonlinear dependencies, potentially reflecting microstructural inefficiencies. For example, at $\text{eps} = 0.5\text{sd}$, the BDSstat value for $m = 2$ is very high (758.027), and for $m = 3$ it increases even more (1491.572), suggesting that the nonlinear structures are more pronounced at larger embedding sizes.

These results imply that for small changes in the index, there is the possibility of predictive models, which could reflect a form of small-scale market inefficiency. As the epsilon value increases, the BDS statistics decrease (for example, for $\text{eps} = 2.5\text{sd}$, BDSstat is 357.781 for $m = 2$ and 332.103 for $m = 3$), and at high levels of data they begin to behave like a random process.

This shows that large-amplitude movements of indices follow a pattern compatible with the random walk hypothesis.

Table 3. Results of the BDS (Brock, Dechert, Scheinkman) test for independence applied to the BET index over the period 2000-2024

	eps	m	BDSstat	stderr	z-value	count
fp0.7	5248.590	2	328.966	0.001	0.000	26796751
—	5248.590	3	354.818	0.001	0.000	26710521
0.5sd	1734.040	2	758.027	0.000	0.000	10800157
—	1734.040	3	1491.572	0.000	0.000	10671360
1.0sd	3468.080	2	388.614	0.001	0.000	19258609
—	3468.080	3	510.777	0.001	0.000	19152351
1.5sd	5202.110	2	329.076	0.001	0.000	26612762
—	5202.110	3	356.294	0.001	0.000	26525101
2.0sd	6936.150	2	325.221	0.000	0.000	32206206
—	6936.150	3	317.783	0.001	0.000	32140636
2.5sd	8670.190	2	357.781	0.000	0.000	35669203
—	8670.190	3	332.103	0.000	0.000	35645281

Note: The test is applied to the BET series, with parameters $N(0,1]$, n (adjusted) = 8767, $\text{sd} = 3468.076$; eps – Threshold (epsilon) used to determine dependencies. This is expressed as a fraction of the standard deviation (e.g., 0.5sd, 1.0sd, 1.5sd, etc.) and defines how close two values must be to be considered similar in the BDS test analysis.

m – Embedding dimension. This is the area of construction of the used lags that is done in the phase space. A higher value of m allows the identification of more complex structures in the series.

BDSstat – The value of the BDS statistic, which measures the deviation from independence and identical distribution (i.i.d.). A high value indicates a significant deviation from independence.

stderr – The standard errors associated with the BDS statistic. These are used to estimate the precision of the test.

z-value – The value of the Z statistic associated with the BDS test. This indicates the level of deviation of the series from the null hypothesis of independence. If the Z value is very large (positive or negative), this indicates that the series shows a significant nonlinear dependence.

count – The number of observations for each combination of epsilon and m in the BDS test.

Source: Own calculation, using STATA 18 on daily BET data (2000-2024).

These findings highlight the importance of nonlinear analyses for understanding market behavior and the need to integrate more sophisticated models to detect possible dependency structures in financial data.

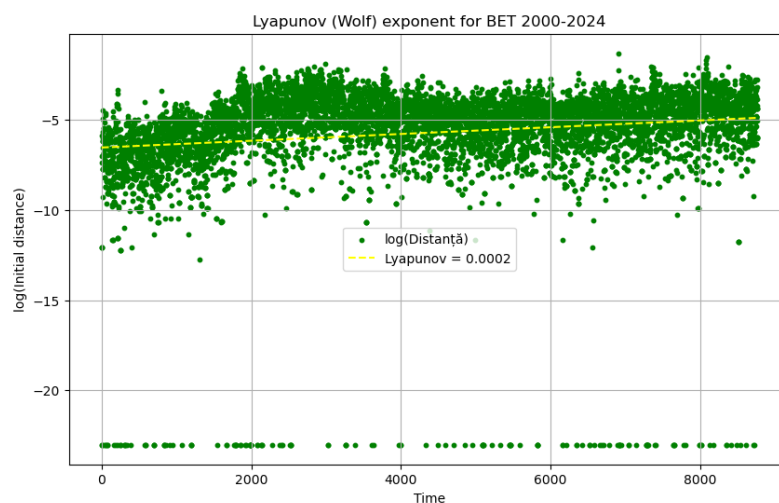
4.3. Lyapunov Exponent Estimation

The largest Lyapunov exponent (λ) was calculated using Wolf's algorithm (Wolf et al., 1985), which reconstructs the phase space of the time series and measures the exponential divergence of nearby trajectories.

The horizontal axis represents the time of observations in the BET time series, expressed in terms of time steps. This indicates the moment at which the distance between the trajectories is measured and reflects how these differences propagate in the evolution of the BET index. Larger values on the X-axis correspond to longer time intervals, allowing the analysis of the dynamic stability of the system over the long term.

The vertical axis, Y, represents the natural logarithm of the initial distance between close trajectories. This measures how quickly two trajectories that started from very close points separate. If the system is chaotic, this distance should grow exponentially over time, which is reflected in a linear increase in the logarithm of the initial distance.

Figure 1. Lyapunov (Wolf) exponent for BET 2000-2024



Note:

X-axis – temporal evolution of the system, expressed in time steps

Y-axis – natural logarithm of the distance between close trajectories

Source: Author. Digitally generated in Python using Jupiter Notebook, 2025

The plotted green points visualize the logarithmic divergence of initially proximate trajectories, offering insight into the local instability of the system across temporal steps. They reflect the differences in evolution between two very similar states of the system, indicating the extent to which a small initial perturbation influences the long-term market trajectory. Scattered dots that deviate from the main structure suggest large fluctuations in market dynamics, signaling periods of instability or phase transitions in the structure of the

financial market. These phenomena can be associated with macroeconomic events or moments of financial crisis that cause sudden changes in market trends.

The yellow line represents the linear fit of the data, with a slope of approximately 0.0002. The very close to zero value of the Lyapunov exponent for BET indicates that price movements do not exhibit exponential sensitivity to initial conditions, which means that the market is not evolving in a severely chaotic manner and there is no rapid separation of trajectories. For the BET index, we found λ (BET prices) = 0.0002.

4.4. Hurst Exponent via Rescaled Range (R/S) Analysis

The graph presented illustrates the analysis of the Hurst exponent for the BET index during the period 2000-2024, using the R/S method (Rescaled Range Analysis), according to the methodology described in the previous subchapter, with time intervals selected based on the Fibonacci sequence.

The horizontal axis represents the logarithmic scale of the time intervals, and the vertical axis represents the logarithmic value of the R/S ratio.

Higher values on the Y axis indicate a stronger tendency for autocorrelation in the data, i.e. a long-term memory of the market. The graph is a log-log representation, which means that both the X and Y axes are in logarithmic scale, allowing the visualization of a power law relationship between temporal dependence and series variation.

The green dots indicate the values obtained for each interval, and the dashed yellow line represents the linear regression applied to them, with the slope corresponding to the Hurst exponent, in this case the value $H=0.9831$, is very close to 1, which indicates a strong long-term dependence and persistent behavior of the market. This highlights that past trends greatly influence future movements, and the market does not behave as a random process, but rather as a long-term autocorrelated system.

In this analysis, the intervals used were set based on the first ten Fibonacci numbers starting with 3 (3, 5, 8, 13, 21, 34, 55, 89, 144, 233 days), an approach that allows for an optimized scaling of the data, avoiding possible deviations that could occur by using equidistant intervals. The choice of these values is based on the mathematical properties of the Fibonacci sequence that is found in natural phenomena and growth models, thus offering an alternative way of analyzing the long-term dependencies of a financial series.

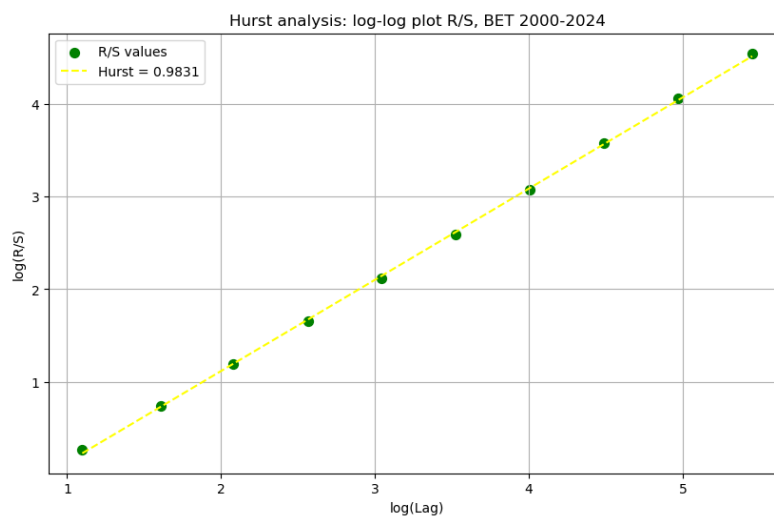
The obtained value of the Hurst exponent, approximately 0.9831, indicates a very persistent dynamics of the analyzed time series, which means that the price movements of the BET index tend to continue in the previous direction rather than following a random behavior. This result suggests the presence of long-term memory structures in the market evolution and is thus interpreted as a deviation from the efficient market hypothesis in its weak form. The observed persistence may be due to several factors such as the behavioral inertia of investors, institutional interventions or macroeconomic trends affecting the stock market in the long term.

The use of Fibonacci intervals provides a complementary perspective on how different time scales influence market behavior, allowing the identification of hidden patterns in its

dynamics. At the same time, a Hurst exponent above the threshold of 0.5 suggests that trend-following strategies may be relevant for this market, as there is a higher probability that previous price movements will be followed by similar developments. In contrast, a Hurst exponent lower than 0.5 would indicate anti-persistent behavior, typical of markets characterized by rapid mean-reversion. The fact that all green points align closely along the yellow line with a slope close to 1 ($H = 0.9831$) indicates that each time interval used in the R/S analysis using the Fibonacci sequence exhibits high persistence.

This indicates that regardless of the size of the time window, the BET index series continues to exhibit long-term dependence. In other words, trends observed in the past tend to persist in the future, if we analyze market movements over different time intervals. This conclusion is important, because not only a few periods show memory, but the entire BET time series behaves in this way. This aspect confirms that the BET market is not a random walk, but has a structure based on long-term autocorrelation. This analysis provides a quantitative perspective on the predictability of BET market movements, but the interpretation must be done with caution to see the possible influence of exogenous factors, as well as the limitations of the R/S method.

Figure 2. Hurst analysis: log-log plot R/S, BET 2000-2024



Source: Author, digitally generated in Python using Jupiter Notebook, 2025.

5. Conclusions

This study explored the dynamic behavior of the BET index through a comprehensive nonlinear lens, combining statistical stationarity and seasonality testing with advanced tools such as the BDS test, Lyapunov exponents, and Rescaled Range (R/S) analysis for Hurst estimation.

The BDS test provided strong evidence against the null hypothesis of independent and identically distributed observations across all tested embedding dimensions and thresholds.

These results suggest that the Romanian capital market, as represented by the BET index, harbors nonlinear dependencies and hidden structural patterns, particularly for smaller movements. This implies partial inefficiency and motivates the use of nonlinear models for better capturing market behavior.

The Lyapunov exponent analysis reinforced these findings. The value for BET prices ($\lambda \approx 0.0002$) indicates marginal divergence consistent with weak chaotic behavior, suggesting a system that is not strongly chaotic but exhibits local sensitivity under certain conditions.

The most compelling evidence emerged from the Rescaled Range analysis, where the Hurst exponent was estimated at 0.9831. This remarkably high value reflects a persistent structure, indicative of long-term memory and autocorrelation. The application of Fibonacci-based subseries segmentation added robustness to this result, showing that persistence holds across multiple time scales. Such behavior deviates significantly from the assumptions of the weak form of Efficient Market Hypothesis (EMH), indicating that historical price trends may indeed influence future movements.

These results are consistent with prior empirical literature that observed persistent and nonlinear dynamics in emerging and transitional markets. For instance, Peters (Peters, 1994) and Mandelbrot (Benoit. B. Mandelbrot, 1997) emphasized the fractal structure and long memory in financial series, while studies like Caporale et al. (Caporale et al., 2005) found evidence of persistence in Latin American and Eastern European equity markets. Moreover, recent research on the Bucharest Stock Exchange (Leonardo Badea; Daniel Stefan Armeanu; Iulian Panait and Stefan Cristian Gherghina, 2019) highlighted similar tendencies towards nonlinearity and inefficiency, reinforcing the view that emerging markets are structurally distinct from mature, highly efficient ones.

However, it is essential to acknowledge the contrasting perspectives provided by studies such as Nawrocki (Nawrocki, 1995), who questioned the existence of genuine long-term memory in stock indices, arguing that such persistence could be a statistical artifact rather than an intrinsic market characteristic. This divergence in view emphasizes the complexity and ongoing debate surrounding the nature of financial market dynamics.

For market participants, especially investors and asset managers, these findings suggest that trend-following strategies and technical analysis may be more appropriate than pure random-walk-based models. Persistence in returns implies that market movements are not entirely unpredictable and that informational inefficiencies may be exploited in certain time frames. Investors might also benefit from incorporating nonlinear analytical tools, such as fractal analysis and chaos-theory models, into their forecasting frameworks.

For policymakers and regulatory authorities, the presence of long memory and nonlinearity highlights the need for robust market surveillance and policies that promote transparency and liquidity. Strengthening institutional frameworks could mitigate the impact of behavioral and structural anomalies, enhancing overall market efficiency.

Nevertheless, this study acknowledges several methodological limitations, including sensitivity to the choice of subseries length and the initial parameters used in Lyapunov exponent estimation. Future research could extend the current analysis by employing

alternative nonlinear measures, such as multifractal detrended fluctuation analysis (MF-DFA), or by exploring machine learning-based predictive models to further validate and enhance these findings.

In summary, the Romanian stock market, as captured by the BET index, exhibits persistent and nonlinear characteristics, with bounded predictability over time. These findings advocate for the incorporation of nonlinear models, memory-aware trading strategies, and fractal-based approaches in analyzing and forecasting market trends. Moreover, they suggest that emerging markets, while less chaotic than expected, are far from fully efficient and retain exploitable patterns valuable for both academic research and investment practice.

References

- Aleksandr Mikhailovich Lyapunov. (1892). *General Problem of the Stability of Motion*.
- Andrew W. Lo. (1991). *Long-Term Memory in Stock Market Prices*.
- Badea, L., Armeanu, D.S., Panait, I. and Gherghina, S.C. (2019). *A Markov Switching Approach towards Assessing Resilience of Romanian Collective Investment Undertakings*.
- Benoit. B. Mandelbrot. (1997). *Fractals and Scaling in Finance: Discontinuity, Concentration, Risk*.
- Benoit B. Mandelbrot, J.R.W. (1968). Noah, Joseph, and Operational Hydrology. *Water Resources Research*, 4(5), 909-918.
- Brock, Dechert, Scheinkman and LeBaron. (1996). *A Test for Independence Based on The Correlation Dimension*.
- Caporale, G.M., Ntantamis, C., Pantelidis, T., and Pittis, N. (2005). The BDS test as a test for the adequacy of a GARCH (1,1) specification: A Monte Carlo study. *Journal of Financial Econometrics*, 3(2), 282-309. <<https://doi.org/10.1093/jjfinec/nbi010>>
- Dickey and Fuller. (1979). *Distribution of the Estimators for Autoregressive Time Series with a Unit Root*.
- Dutta, T.K., and Prajapati, P.K. (2014). *Analysis on stability of periodic points, period doubling bifurcation and lypunov exponent in a chaotic model*. 8(8), 1-12.
- Engel, R.F., and Granger, C.W. (1987). *Co-integration and Error Correction Representation, Estimation and Testing Econometrica*, Vol. 55. (2) 251-76.
- Fama, E. (1970). Efficient Capital Markets: A Review of the Theory. *The Journal of Finance*, 25(2), 383-417.
- Grassberger, P., and Procaccia, I. (1983). Characterization of strange attractors. *Physical Review Letters*, 50(5), 346-349. <<https://doi.org/10.1103/PhysRevLett.50.346>>
- Hanias, M., Tsakonas, S., Magafas, L., Thalassinou, E.I., and Zachilas, L. (2020). Deterministic chaos and forecasting in Amazon's share prices. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 15(2), 253-273. <<https://doi.org/10.24136/eq.2020.012>>
- Hurst, H.E. (1956). The problem of long-term storage in reservoirs. *International Association of Scientific Hydrology. Bulletin*, 1(3), 13-27. <<https://doi.org/10.1080/02626665609493644>>

- Kong, L., Lee, D.K.C., and Robinson, P.M. (1996). *Semiparametric Exploration of Long Memory in Stock Prices*. 155-174.
- Kwiatkowski, D., Phillips, P.C.B., and P. Schmidt, P. (1991). *Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root*.
- Lapenta, E.S., and Abecasis, S.M. (2016). *Identifying Nonlinearity in Financial Time Series*. 103-108. <<https://doi.org/10.21528/cbrn2001-022>>
- Mandelbrot, B. (1963). *The Variation of Certain Speculative Prices*. 19(0), 39-78. <https://doi.org/10.1142/9789814566926_0003>
- Monte, B.M. (1994). *Chaos and the stock market*.
- Munch, S.B., Rogers, T.L., and Sugihara, G. (2023). Recent developments in empirical dynamic modelling. *Methods in Ecology and Evolution*, 14(3), 732-745. <<https://doi.org/10.1111/2041-210X.13983>>
- Nawrocki, D. (1995). R/S Analysis and Long Term Dependence in Stock Market Indices. *Managerial Finance*, 21(7), 78-91. <<https://doi.org/10.1108/eb018529>>
- Ozkaya, A. (2022). Detecting multiple-equilibria and chaos in oil prices and global commodity markets. *International Journal of Research in Business and Social Science (2147- 4478)*, 11(6), 350-361. <<https://doi.org/10.20525/ijrbs.v11i6.1919>>
- Ozkaya, A., and Ozkaya, R. (2012). *Uncovering the chaotic behavior of ISE 100 stock- market index*. 6(7), 2727-2737. <<https://doi.org/10.5897/AJBM11.2521>>
- Peters, E.E. (1994). Fractal market analysis: applying chaos theory to investment and economics. In I. John Wiley&Sons (Ed.), *Wiley finance TA - TT - (1952nd- ed.)*.
- Phillips and P. Perron, P. (1988). *Testing for a Unit Root in Time Series Regression*.
- Robert Savit, M.G. (1991). *Time series and dependent variables*. 50, 95-116.
- Vogl, M., and Rötzel, P.G. (2022). Chaoticity versus stochasticity in financial markets: Are daily S&P 500 return dynamics chaotic? *Communications in Nonlinear Science and Numerical Simulation*, 108. <<https://doi.org/10.1016/j.cnsns.2021.106218>>
- Wolf, A., Swift, J.B., Swinney, H.L., and Vastano, J.A. (1985). Determining Lyapunov exponents from a time series. In *Physica D: Nonlinear Phenomena* (Vol. 16, Issue 3, pp. 285-317). <[https://doi.org/10.1016/0167-2789\(85\)90011-9](https://doi.org/10.1016/0167-2789(85)90011-9)>
- Yousefpoor, P. (2008). *Looking for systematic approach to select chaos tests*. 198, 73-91. <<https://doi.org/10.1016/j.amc.2007.08.070>>

From adversity to triumph: Türkiye's economic resilience and adaptation strategies amidst disasters

Erick OKOTH

Sakarya University, Turkey
erick.okoth@ogr.sakarya.edu.tr

Abstract. *This study investigates the macroeconomic impacts of disasters in Türkiye from 1999 to 2023 using ARDL and Impulse Response Functions. Findings reveal that disaster-induced economic losses significantly reduce GDP per capita in both the short and long run. However, a rise in disaster victims appears to stimulate growth due to reconstruction and aid flows. Capital accumulation drives growth, while ODA has a temporary negative effect. Insurance and financial services consistently hamper growth, suggesting weak risk-transfer mechanisms. The study advocates strengthened financial resilience, increased recovery spending, and enhanced international cooperation to mitigate disaster risks and promote sustainable economic stability.*

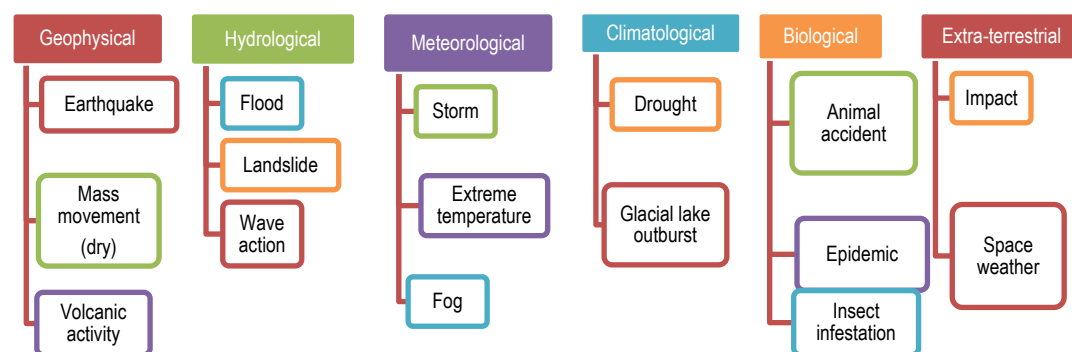
Keywords: disasters, economics, ARDL, IRFs, Türkiye.

JEL Classification: Q54, H84, O44.

Introduction

In the current decade, the number of natural and anthropogenic disasters has exponentially increased, a phenomenon attributed to the effects of climate change and human activity. Disasters, causing physical and human capital losses and disruptions to production and supply chains, indirectly slow economic growth. Consequently, examining these effects can inform disaster preparedness and mitigation. Disasters, both natural and man-made, have been a persistent threat to societies worldwide, with their frequency and intensity on the rise in recent decades, a trend that is likely exacerbated by climate change. The devastating impacts of disasters such as floods, earthquakes, landslides, hurricanes, extreme heatwaves, wildfires, epidemics, and volcanic eruptions have been felt globally, leading to significant physical, economic, and social losses (Xu et al., 2021). A disaster is characterized as an event that exceeds local response capacities and necessitates national or international intervention (Öcal, 2019). Such events result in significant physical, economic, and social losses, causing substantial harm and fatalities, and severely disrupting normal life and activities (Öcal, 2019). The severity of a disaster is typically gauged by the extent of loss of life, injuries, infrastructural damage, and socio-economic impacts resulting from it. (Xu et al., 2021). Globally, the statistics on disasters are staggering, with over 13,386 disasters having occurred, resulting in 3.6 million deaths, affecting 7.7 billion individuals, and causing economic losses amounting to USD 3.3 trillion (Khan et al., 2023). In 2023 alone, there were 399 natural disasters recorded, leading to 86,473 fatalities, affecting 93.1 million individuals, and causing economic losses of USD 202.7 billion (EM-DAT, 2023). These figures underscore the immense toll that disasters take on human lives, livelihoods, and economies. In Figure 1, according to the Emergency Events Database (EM-DAT) natural disasters can be classified into six main groups: Geophysical, Hydrological, Meteorological, Climatological, Biological, and Extra-terrestrial. The focus of this study is mainly on the first four subgroups, which are more common, unlike biological or extra-terrestrial where it is difficult to define the duration of recovery after these class of natural disaster (Frödén, 2023).

Figure 1. Classification of disasters (EM-DAT, 2014)



Türkiye stands out for the severity of disasters it faces, with earthquakes being a significant threat due to its location in a highly active seismic region (Öcal, 2019). The country has witnessed numerous earthquakes, with devastating social, psychological, and economic

consequences (Büyükoğlu, Özpolat & Özsay, 2024). The earthquakes that struck on February 6, 2023, with magnitudes of 7.7 and 7.5 on the Richter scale, resulted in economic losses estimated at USD 34.2 billion according to the World Bank, claiming estimated 50,783 lives and affecting approximately 9 million people. The destruction caused by these earthquakes, including the collapse of 298,000 buildings, highlights the vulnerability of structures and communities to such disasters (EM-DAT, 2023). The rapid urbanization experienced by Türkiye over the past seven decades, leading to a significant increase in the urban population, has further heightened the country's vulnerability to disasters. The surge in buildings and settlements, coupled with high population density, has amplified the potential severity of disasters, making effective disaster risk reduction and resilience-building measures imperative (Başaran-Uysal et al., 2013; Öcal, 2019). Türkiye faces a variety of natural disasters beyond earthquakes, including floods, landslides, avalanches, rockfalls, droughts, wildfires, extreme winter conditions, and storms (Gunay et al., 2019; Doğan, 2024).

Figure 2. Map showing disaster prevalence in Türkiye (AFAD, 2024)

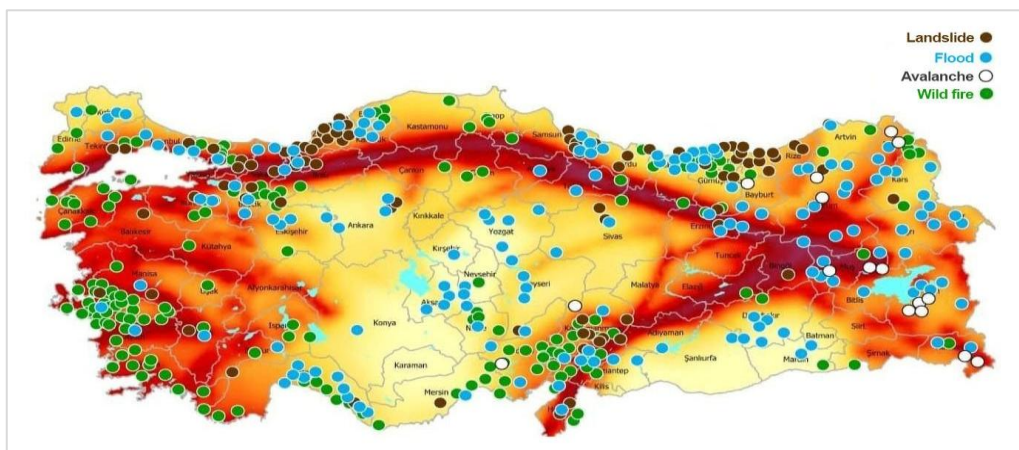


Figure 2 is a map showing disaster prevalence in Türkiye. Drought, a significant challenge exacerbated by irregular precipitation distribution, leading to water shortages in various regions (Aydoğdu et al., 2021). The country's semi-arid climate makes it particularly susceptible to drought, impacting agricultural production and causing severe water scarcity (Zeybekoğlu & Sahin, 2022). In 2007-2008, Türkiye experienced severe drought conditions, resulting in a 15.3% reduction in crop yield (Hameed et al., 2019). The effects of drought extend beyond agriculture, influencing air quality as dry events lead to increased particulate matter with diameter less than ten micrometers (PM10) levels, particularly in regions like Central Anatolia and the Mediterranean (Baltacı et al., 2023). Further, floods also pose a significant threat with varying precipitation levels across the country contributing to the risk. The spatial distribution of annual precipitation in Türkiye ranges from over 2,200 mm along the eastern coast of the Black Sea to less than 350 mm in central Anatolia (Vazifekkhah & Kahya, 2018). This variability in precipitation levels often lead to flash floods in certain regions, impacting infrastructure, agriculture, and livelihoods. Landslides and avalanches are also common in Türkiye, especially in mountainous areas

where heavy rainfall or snowmelt can trigger such events, posing risks to communities and transportation networks (Akkemik et al., 2005).

Wildfires are another natural disaster that Türkiye frequently contends with, especially during periods of drought and hot weather. The impact of climate change on increasing temperatures and evapotranspiration contributes to the drying trend, creating favorable conditions for wildfires to spread rapidly (Schrier et al., 2013). These fires not only devastate natural habitats but also pose risks to human settlements and infrastructure, requiring significant resources for containment and recovery efforts. Extreme winter conditions, including heavy snowfall and blizzards, particularly affect regions in eastern Türkiye, leading to disruptions in transportation and posing challenges for residents in terms of access to essential services (Tosunoğlu et al., 2018). Storms, including severe thunderstorms and hailstorms, are also prevalent causing damage to property, agriculture, and infrastructure. The effects of climate change on precipitation patterns can intensify these storms, leading to increased risks of flooding and property damage. Rockfalls, often triggered by heavy rainfall or seismic activity, pose dangers to communities living in mountainous regions, necessitating mitigation measures to ensure public safety (Yücedağ, 2013). The combination of these natural disasters underscores the importance of comprehensive disaster preparedness and risk reduction strategies in Türkiye to mitigate the impacts on both the environment and society.

Notable natural disasters in Turkish history include the devastating 1939 Erzincan earthquake, the severe 1999 İzmit earthquake, and more recent earthquakes in Van (2011), Elazığ (2020) and in Hatay, Adıyaman, Kahramanmaraş and Malatya (2023) (Top et al., 2010; Gürü et al., 2023). The country has also experienced recurrent floods, such as the 2009 Istanbul and 2020 Giresun floods, and wildfires, particularly the extensive fires of 2021 in the Aegean and Mediterranean regions. Periodic droughts, notably in 2007 and 2021, have further affected agriculture and water resources. These events underscore the frequency and diversity of natural disasters in Türkiye.

In line with Sustainable Development Goal 11, which aims to minimize the adverse impacts of disasters on human lives, infrastructure, and economies while prioritizing the protection of vulnerable populations, it is crucial to adopt a comprehensive approach to disaster risk reduction. Strengthening disaster risk reduction frameworks, enhancing preparedness and resilience, and fostering international cooperation are key components of achieving this goal. Building a disaster-resilient economy requires prioritizing policies that enhance preparedness, response, and recovery capabilities. This includes investing in resilient infrastructure, implementing land-use planning regulations to reduce vulnerability, and promoting insurance mechanisms to distribute the financial risks associated with disasters (Sieg et al., 2019). Additionally, fostering community resilience through education, training, and social support systems can enhance the capacity of individuals and communities to cope with and recover from disasters, ultimately contributing to a more resilient economy (Koç & Thieken, 2016). Research plays a vital role in understanding the actual effects of disasters, particularly their economic impacts, which can have far-reaching consequences on individuals' living conditions. Specifically, since the economic effects of

disasters also devastate and distort the living conditions of individuals, clearly examining them is crucial in developing mitigation measures.

The economic impact of these disasters has been substantial, with escalating economic losses observed over time (Yuryeva, 2023). Efforts have been made to improve disaster preparedness and management in Türkiye, including initiatives like the Turkish Disaster Data Bank project, which aims to document and analyze various natural disasters (Haltaş et al., 2021). Türkiye's history has been shaped by a series of natural disasters that have influenced its approach to disaster resilience and management. This study, therefore, seeks to add evidence on the effects of disasters on economies by focusing on the Turkish economy. This study will provide crucial insights in creating a formidable and disaster resilient economy. To achieve this this study uses GDP per capita as the dependent variable, and as explanatory variables: total economic damage from disasters, the number of people affected, insurance and financial services, gross fixed capital formation, and official development assistance and financial aid, to study the influence economic stability and recovery from disaster. Additionally, a dummy disaster variable is also used to augment the study.

2. Literature review

Most literature agree that natural disasters affect economic growth. However, to what extent this impact is, whether long term or short term is debatable. In this section of the study, the focus is drawn to the theories on effects of disasters on economic growth and recovery. Afterwards an empirical literature is discussed.

In examining the indirect economic impacts of natural disasters, theoretical models such as input-output (I-O) and computable general equilibrium (CGE) models elucidate the causal chains linking exogenous events to economic systems (Noy, 2009). I-O models, assuming fixed production functions, predict sectoral disruptions and their propagation through the economy (Lee et al., 2018). CGE models incorporate stable demand and supply functions to forecast market equilibrium changes post-disaster (Felbermayr & Gröschl, 2014). Both models indicate generally negative economic impacts of disasters (Oliveira, 2019), yet they often assume fixed technology and behavior, limiting their dynamic adjustment capabilities over time (Noy, 2009).

To address these limitations, neoclassical growth theory has been employed, suggesting lasting economic impacts only if fundamental parameters like savings or productivity growth are permanently affected (Majid et al., 2022). Endogenous growth models further enrich this understanding by examining how capital and productivity dynamics interact post-disaster, highlighting potential accelerated productivity growth through reconstruction efforts (Shabnam, 2014). These models emphasize endogenous factors like learning and innovation in shaping post-disaster economic trajectories (Botzen et al., 2019). Regional economic models address the critique of mainstream macroeconomic models for neglecting geographical considerations (Bergholt & Lujala, 2012; Idroes, 2023). By incorporating geographic information systems (GISs), catastrophe models estimate potential losses and guide risk management strategies, despite uncertainties in modeling vulnerability

(Yokomatsu, 2023; Wada et al., 2014). Recent integrations of agent-based models aim to improve these estimates by considering dynamic responses to changing risks (Wada et al., 2014). In summary, various theoretical frameworks—from I-O and CGE models to neoclassical and endogenous growth theories—offer valuable insights into the complex mechanisms by which natural disasters impact economic systems. Incorporating geographical considerations and advancing endogenous growth theories enhance these models' sophistication, enabling more nuanced analyses of disaster impacts on macroeconomies (Noy, 2009).

When conducting a literature review on the socioeconomic impact of disasters on economic growth in Turkey, it is essential to include a broad array of studies that provide comprehensive insights into this complex relationship. While focusing on Turkey, examining research from different regions can offer valuable comparative perspectives. In Turkey, the 1999 Kocaeli earthquake inflicted substantial financial losses, with damages estimated at \$9-13 billion (Özdoğan & Güney, 2016). Factors such as rapid population growth, unplanned urban development, and inadequate disaster regulations heighten risks (Başaran-Uysal et al., 2013). Disasters impede economic performance by destroying goods and capital, leading to prolonged negative effects on GDP (Strulik & Trimborn, 2018). Effective disaster preparedness and resilience-building, especially in healthcare and utilizing social capital for recovery are essential (Koçak & Serin, 2023; Ganapati, 2012). While disasters cause economic disruptions and increased unemployment, they can also stimulate short-term booms in certain sectors through recovery efforts and create opportunities for economic growth (Lu & Dudensing, 2015).

To enhance economic recovery and resilience against disasters in Turkey, a multifaceted approach is essential. This involves developing disaster plans, insurance, and information sharing, strengthening social resilience through training and drills for healthcare professionals, and quantitatively assessing and enhancing seismic resilience across multiple dimensions (Taşkıran & Baykal, 2019). Optimizing renewable-integrated transmission systems and addressing environmental health risks are crucial for public health and minimal investment recovery (Niu et al., 2023; Ahmed, 2023). Digital platforms like e-health can improve disaster response, while building agricultural resilience to droughts and developing city planning resilience frameworks are vital for economic stability and sustainability (Akbasli, 2024; Bagherzadeh & Shigemitsu, 2021; Terblanche et al., 2022). Effective governance, community engagement, and strategic interventions enhance disaster management and economic resilience, as seen in global and local contexts (Ningrum, 2024). Collaboration and infrastructure improvements bolster peri-urban resilience, supporting sustainable development and minimizing economic losses (Yang et al., 2020; Yildirim & Deniz, 2021).

Natural disasters profoundly impact individuals and communities psychologically and socially, resulting in symptoms like depression, anxiety, and post-trauma syndrome with long-lasting effects on well-being (Ha, 2020). In the U.S., "Chronic Disaster Syndrome" illustrates the prolonged distress from disasters and socio-economic factors, as seen in New Orleans post-Hurricane Katrina (Adams et al., 2009). In Surabaya, Indonesia, psychological preparedness in coastal communities is vital for mitigating impacts from

events like tsunamis (Palupi, 2022). Social disruptions in these areas lead to economic and social upheaval, worsening vulnerabilities and inequalities (Bakema et al., 2018). In the Netherlands, the link between gas extraction and earthquakes underscores the social dimensions of human-induced disasters and the importance of community resilience in recovery (Cvetković, 2023). Vulnerable populations, especially children and those with pre-existing mental health conditions, face increased risks of distress and impaired functioning (Trabsa et al., 2022). Effective governance structures and economic resilience are critical for enhancing recovery and mitigating long-term impacts in Turkey and other regions (Kalogiannidis et al., 2023; Bringas et al., 2022). An extension of the literature review is in Table 1.

Table 1. Summary of empirical literature

Author	Countries	Period	Methodology	Findings
Idroes, (2023)	Indonesia	1990-2021	FMOLS, DOLS, CCR, VECM	Positive long-run effect of ND and a unidirectional causality on EG.
Majid et al, (2022)	ASEAN	2000-2020	Path analysis and panel moderated regression model	ND negatively affect EG and increase unemployment. Philanthropy is significant in reducing impact of ND
Naoaj, (2023)	Panel of developing and developed countries	1970-2019	Panel regression	Negative effect of ND on EG and agricultural growth.
Tasri et al (2021)	Indonesia	1990-2019	SEM-Partial least squares	Unemployment and poverty had significant effect on ND. ND loss has significant positive effect on income inequality
Khan et al, (2020)	Belt and Road Initiative countries	1990-2018	GMM, CS-ARDL, Driscoll & Kraay regressions	Natural disaster has negative effect on EG and FDI.
Sahin & Yavuz (2015)	Türkiye, Canada, Chile & Greece	2005-2014	ARIMA	Positive effect of ND on EG in Türkiye
Ilham et al, (2023)	30 Indonesian provinces	2013-2019	Partial Least Squares	ND significantly reduce EG, insignificantly increase poverty and significant increase in unemployment
Benali & Saidi, (2017)	41 countries	1990-2014	Granger causality, VECM	ND negatively and unidirectionally cause EG.
Büyükoğlu et al, (2024)	Türkiye	2023	Cross-quantilogram method	BIST100 index and BIST sustainability index were negatively affected by the 2023 earthquake
Noy & Vu (2010)	Vietnam	1953-2008	Blundell-Bond GMM	ND boosts EG in the short run
Sekyere et al, (2021)	SADC countries	2005-2019	Panel data analysis	ND negatively affect EG but reconstruction and recovery efforts if well structured have positive effect on EG a year post-disaster
Bringas et al, (2022)	Philippines	1990-2019	ARDL	ND and foreign aid negatively affect EG in the short run: FDI have a positive effect in the long run.
Panwar & Sen (2019)	Panel of 102 countries	1985-2015	GMM	ND have diverse effects on economic sectors depending on type and intensity.
Rajapaksa et al, (2017)	Panel of 108 countries	1990-2014	Fixed effects panel regressions	Non-linear U-shaped relation exists between ND and natural capital

Note: The notations ND signifies natural disaster, EG- economic growth and FDI-Foreign direct investment.

Existing literature has mainly studied the effect of disasters on economic growth using disaster variables alone. The effects show mixed findings with some asserting a positive effect of disaster supporting the Schumpeterian Growth Theory, while others have found a

negative effect of disasters on economic growth. This study attempts to further the literature on disaster by exploring the impact of economic damage from disasters, the number of affected people, gross capital accumulation, net official development assistance, insurance and financial services and disaster on economic growth.

3. Data and model

3.1. Data

The study focuses on the impact of disaster on Türkiye's economy. In this context, the selected variables for analyzing the economic impacts of disasters on GDP per capita encompass a comprehensive array of factors that significantly influence economic stability and post-disaster recovery. Economic loss from disasters serves as a critical indicator, reflecting the immediate financial ramifications of such events (Yangdol & Sarma, 2019). The number of individuals affected by disasters is essential as it captures the human toll and potential disruptions to labor markets and productivity (Messeri et al., 2015). Capital accumulation plays a pivotal role in post-disaster recovery; investments in rebuilding and infrastructure development can stimulate economic growth (Kaur et al., 2020). Additionally, net official development assistance provides crucial financial support for recovery efforts, aiding in the restoration of economic stability (Popoola et al., 2022). Insurance and financial services are vital in alleviating the financial burden on individuals and businesses post-disaster, facilitating a smoother recovery process (Permani & Xu, 2022). Finally, the inclusion of disaster dummy variables enables the identification of the specific impacts of disasters on GDP per capita, facilitating a focused analysis of post-disaster economic performance (Naoaj, 2023). The period 1999-2023 is selected to focus on a wide range of disasters that has faced the countries over the period. Further details on the variables used are available in Table 2.

Table 2. *Variable description*

Variable	Abbreviation	Measurement	Source
Economic growth	GDP	GDP per capita	World Bank
Number of people affected	AFFECTED	Total number of people affected	EM-DAT
Insurance and financial services	INSFINANCE	Insurance and financial services (% of commercial service imports)	World Bank
Gross fixed capital accumulation	CAPITAL	Percent GDP	World Bank
Net development assistance and aid received	ODA	Current US dollars	World Bank
Economic losses from disaster	ECONLOSS	US dollars	EM-DAT
Disaster	Dummydisaster	Dummy 0 and 1 representing absence and occurrence of disaster respectively	Author compilation

3.2. Model

To assess the effects of natural disasters on economic stability and recovery, econometric tools such as Autoregressive Distributed Lag (ARDL) models and Impulse Response Functions (IRFs) are frequently utilized. ARDL models are particularly adept at capturing both short-term and long-term dynamics within variable relationships, enabling a comprehensive examination of factors such as economic damage, affected populations,

capital accumulation, net official development assistance, insurance and financial services, and disaster dummy variables on GDP per capita (Bringas et al., 2022; Abbas, 2020).

Moreover, the application of IRFs provides valuable insights into the temporal effects of disaster shocks on the variables. This understanding is essential for policymakers aiming to bolster economic resilience and recovery in the aftermath of disasters (Kirigia et al., 2004).

The ARDL model applied is as in Equation 1 below

$$Y_t = a_0 + \sum_{i=1}^p a_i y_{t-i} + \sum_{l=0}^q b_l x_{t-l} + e_t \quad (1)$$

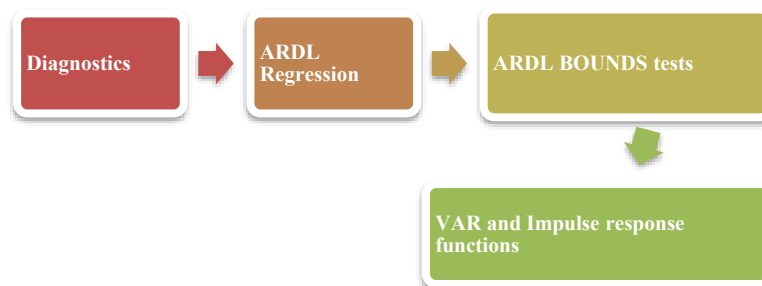
Where Y_t represents the dependent variable, which is GDP per capita, while X_t denotes the independent variables. The constant term for the equation is a , and p and q indicate the lags of Y and X respectively. The coefficients of the dependent variable are denoted by a_i , and those of the independent variables are represented by b_i . Finally, e_t signifies the error term in the equation.

4. Methodology and empirical results

4.1 Methodology

The study employs a four-stage analysis strategy Figure 3, first diagnostics, stationarity and cointegration is tested. In the second stage ARDL is conducted, then an ARDL bounds test is conducted, finally in the last stage IRFs are evaluated.

Figure 3. Analysis strategy



For diagnostics, the study tests for stationarity by employing the Augmented Dickey Fuller test (Table 3), all variables are found to be stationary at first difference except logODA.

Table 3. Stationarity test

Variables	Level		First difference	
	Statistic	P-value	Statistic	P-value
LogGDP	0.52271	0.9839	-3.160808	0.0359
LogECONLOSS	-4.319792	0.0026	-6.582177	0.0000
LogAFFECTED	-3.086656	0.0412	-6.694101	0.0000
LogINSFINANCE	-2.063668	0.2699	-4.586203	0.0023
LogCAPITAL	-1.72991	0.4049	-5.145009	0.0003
LogODA	-0.640083	0.8435	-2.596252	0.1090
Dummydisaster	-0.821937	0.3458	-5.724309	0.0002

The study then conducts the Johansen test (Table 4) and finds evidence for the presence of at least four cointegrating equations.

Table 4. *Cointegration test*

Johansen tests for Cointegration					
Trend: Constant. Sample: 2001-2023			Number of obs=23: Lags=2		
Maximum rank	parms	LL	eigenvalue	Trace statistic	5% critical value
0	42	-101.778	.	151.7320	94.15
1	53	-77.745	0.87630	103.6651	68.52
2	62	-57.698	0.82504	63.5721	47.21
3	69	-42.753	0.72737	33.6808	39.68
4	74	-32.674	0.58373	13.5229*	15.41
5	77	-26.111	0.43487	0.3968	3.76
6	78	-25.912	0.01711		

4.2. Empirical Results

4.1. ARDL Regression

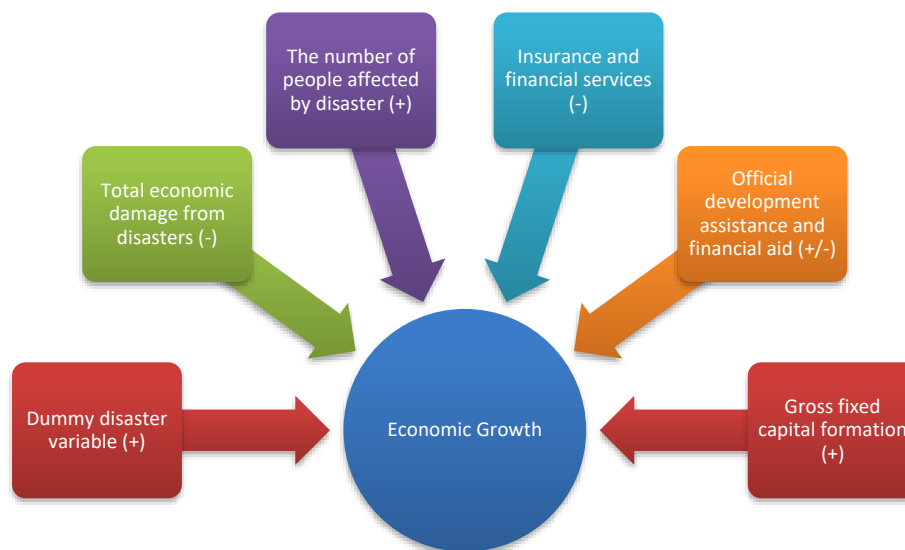
In the second stage, the ARDL model is run shown in Table 5. The error correction term (ECT) coefficient of -0.114727, which is statistically significant (p-value 0.0272), indicates a moderate adjustment speed, with approximately 11.47% of the disequilibrium from the previous period being corrected in the current period. Implying that the system goes back to long-run equilibrium after short-term deviations.

In both the short and long run, economic losses due to disasters exert a negative influence on economic growth, suggesting a consistently detrimental effect on GDP. Conversely, the number of individuals affected by disasters positively influences GDP in both time frames. This counterintuitive outcome can be attributed to the surge in economic activities associated with recovery and reconstruction efforts. When large numbers of people are affected, there is a substantial increase in demand for goods, services, and labor, which can stimulate various sectors of the economy. Additionally, international aid and government spending often rise significantly to address the immediate needs and to rebuild infrastructure, further boosting economic activity. Capital accumulation exhibits positive impacts in both the short and long term, emphasizing its crucial role in promoting economic growth and driving long-term economic performance. Official development assistance and aid shows a negative effect in the short run at 10% significance but a beneficial insignificant effect on GDP in long run. However, insurance and financial services consistently demonstrates a significant negative effect on economic performance, highlighting its adverse impact in both the short and long run. Finally, occurrence of disasters increases economic growth in the short and long run potentially due to heightened recovery activities and international aid inflows, which could stimulate substantial economic activities related to rebuilding and recovery even in the long term. This suggests that despite the perceived negative impacts, the subsequent economic responses and investments can generate a positive growth trajectory.

Table 5. *ARDL Results*

SHORT RUN				
Variable	Coefficient	Std. Error	t-Statistic	p-value
LOGGDP (-1)	-0.1147	0.0465	-2.4667	0.0272
LOGECONLOSS	-0.0228	0.0108	-2.1188	0.0525
LOGAFFECTED	0.0006	0.0032	0.1835	0.8571
LOGINSFINANCE	-0.1052	0.0385	-2.7360	0.0161
LOGCAPITAL	0.6286	0.1078	5.8285	0.0000
LOGODA	-0.0057	0.0029	-1.9670	0.0693
DUMMYDISASTER	0.3199	0.1430	2.2371	0.0421
LONG RUN				
Variable	Coefficient	Std. Error	t-Statistic	p-value
LOGECONLOSS	-0.1990	0.0925	-2.1519	0.0493
LOGAFFECTED	0.0052	0.0275	0.1883	0.8534
LOGINSFINANCE	-0.9172	0.3410	-2.6900	0.0176
LOGCAPITAL	3.3453	0.7676	4.3580	0.0007
LOGODA	0.0761	0.0994	0.7658	0.4565
DUMMYDISASTER	2.7887	1.192806	2.3380	0.0348

A graphical summary of the results is illustrated in figure below

Figure 4. *Graphical abstract*

In the third stage, the ARDL Bounds Test whose null hypothesis is no levels relationship, is run (Table 6). The F-bounds test yielded an F-statistic of 10.05498, which is significantly higher than the upper critical value of 4.05 at the 1% significance level. This robust result leads to the rejection of the null hypothesis of no co-integration, providing strong evidence of a long-run equilibrium relationship among the variables. On the other hand, the t-bounds test produced a t-statistic of -2.466696, which falls between the bounds at all conventional significance levels, rendering the test inconclusive. Although the t-bounds test does not provide definitive evidence for rejecting the null hypothesis, the substantial evidence from the F-bounds test strongly suggests the presence of levels relationship.

Table 6. *Bounds Test*

F-Bounds Test Null Hypothesis: No levels relationship				
Test Statistic	Value	Significance level	1(0)	1(1)
			Asymptotic: n=1000	
F-statistic	10.055	0.100	1.750	2.870
k	6	0.050	2.040	3.240
		0.025	2.320	3.590
		0.010	2.660	4.050
t-Bounds Test Null Hypothesis: No levels relationship				
Test Statistic	Value	Significance level	1(0)	1(1)
t-statistic	-2.467	0.100	-1.620	-3.700
		0.050	-1.950	-4.040
		0.025	-2.240	-4.340
		0.010	-2.580	-4.670

4.2. Impulse Response Functions

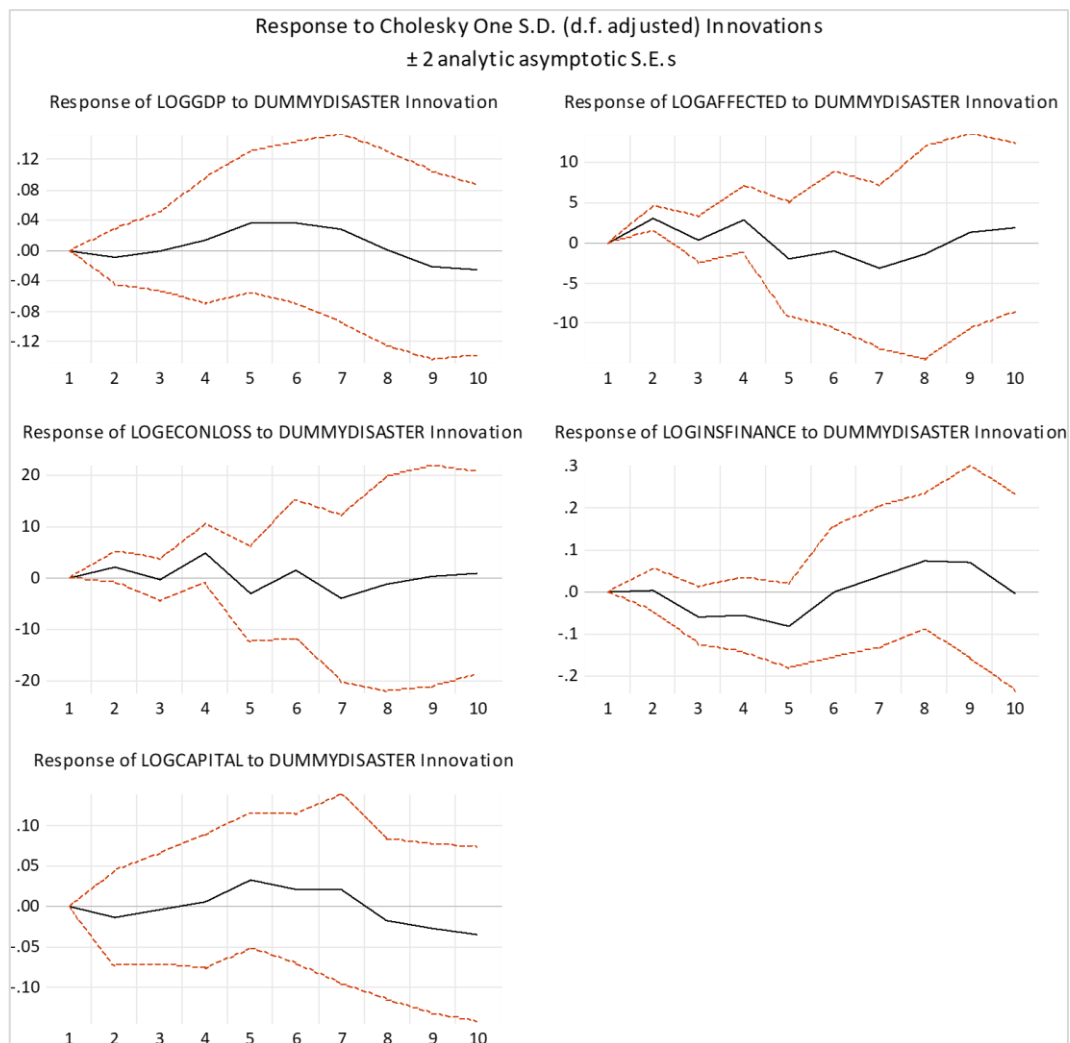
The Impulse Response Functions (IRFs) presented in Figure 5, illustrate the dynamic responses of the variables to a Cholesky one standard deviation disaster shocks. Figure 1A and Figure 2A in the appendix section illustrate the Cholesky variance decomposition and tabulated impulse response functions respectively. Due to non-stationarity of the logODA variable, it is not included in the VAR that generates the impulse functions as its necessary for considered variables to be stationary as first difference.

Following a disaster, GDP experiences an immediate negative impact of approximately 0.4%, but shows resilience, recovering to near steady-state levels within 2-3 years, potentially due to increased economic activities related to disaster recovery and reconstruction efforts. However, the positive impact diminishes over time, and the response gradually trends towards zero, suggesting that the initial boost may not be sustained in the long run. The confidence intervals widen over time, reflecting increasing uncertainty in the long-term impact. The number of people affected peaks sharply at about 0.2 units above the steady state, indicating a prolonged recovery period for impacted populations. This positive response stabilizes over time, indicating that the initial impact on the affected population is substantial and persistent. The relatively stable confidence intervals suggest a consistent long-term effect of disasters on the number of affected individuals. Economic losses exhibit a delayed peak, reaching maximum levels 1-2 years post-shock, suggesting that the full economic impact may take time to materialize. The response is initially negative, as expected, given that disasters typically lead to economic losses. Over time, the negative impact persists but shows signs of stabilization. The widening confidence intervals indicate uncertainty in the magnitude of the long-term effects, though the negative trend underscores the enduring adverse impact of disasters on economic losses.

The insurance and finance sector displays initial delay in the impact of disaster but after period two a negative impact set in indicating that disasters can lead to financial instability. Over time, the negative impact persists, reflecting the long-lasting adverse effects of disasters on financial stability. The confidence intervals widen over time, indicating uncertainty in the magnitude of the long-term impact, though the persistent negative trend underscores the enduring adverse effects. Capital accumulation declines gradually after a disaster. Over time, the positive impact persists, suggesting that disasters may lead to sustained increases in capital formation as economies rebuild. The confidence intervals,

while widening slightly, remain relatively narrow, indicating a degree of certainty in the long-term positive impact on capital accumulation. While GDP recovers relatively quickly, the prolonged effects on affected populations, economic losses, and capital accumulation highlight the extended costs of disasters. This underscores the need for comprehensive disaster management strategies, innovative financial mechanisms, and flexible policy responses to support recovery. The slow recovery of capital accumulation presents challenges for long-term economic growth in disaster-prone areas. Additionally, the persistent impact on the affected population emphasizes the importance of robust social safety nets and long-term support systems. Overall, assessments of disaster impacts should account for both immediate and long-term consequences across various economic and social dimensions.

Figure 5. IRFs of disaster innovations



5. Conclusions and Recommendations

5.1. Conclusions

This study's application of the ARDL model and Impulse Response Functions (IRFs) provides critical insights into Türkiye's economic resilience to natural disasters from 1999 to 2023. The findings reveal that economic losses from disasters consistently harm GDP in both the short and long run. The number of individuals affected by disasters has a positive influence on growth attributed to increased recovery activities, which drive demand for goods, services, and labor and stimulate various economic sectors. Additionally, international aid and government spending rise in response to disasters, further boosting economic activity and demonstrating how disasters can lead to short-term economic growth through recovery efforts. Further, capital accumulation and Official development assistance and aid shows a negative effect in the short run but a beneficial insignificant effect on GDP in long run. Conversely, financial instability consistently has a negative effect on economic performance, emphasizing the need for stable financial systems in disaster management. Overall, the results underscore the complex relationship between disasters, economic variables, and growth. This complexity necessitates a nuanced approach to policy and management in Türkiye, focusing on strengthening financial systems, optimizing public expenditure, and enhancing international cooperation to bolster economic resilience. The findings provide a foundation for policymakers to develop evidence-based strategies aimed at mitigating the adverse effects of natural and anthropogenic disasters on Türkiye's economy. This study advances the disaster economics literature by elucidating how macroeconomic variables mediate the impacts of disasters and offers a robust framework for future research and policy development.

5.2. Recommendations on Policy

Based on the finding of this study, several recommendations can be proposed to enhance disaster resilience in the Turkish economy. It is crucial to recognize the dual impact of disasters on economic growth and the population. Given that economic losses exert a consistently detrimental effect on GDP in both the short and long run, proactive measures should be implemented to mitigate these losses through robust disaster preparedness and risk management strategies. The positive influence of the number of individuals affected by disasters on GDP, driven by recovery and reconstruction efforts, suggests the need for streamlined and efficient post-disaster response mechanisms to harness this potential economic stimulus. Increasing demand for goods, services, and labor during recovery phases highlights the importance of maintaining flexible labor markets and ensuring the availability of essential resources. The influx of international aid and government spending to rebuild infrastructure should be optimized by establishing transparent and efficient allocation systems. Capital accumulation's positive impact underlines the necessity for sustained investments in infrastructure and productive assets, reinforcing the role of long-term economic planning in disaster resilience. While official development assistance shows a short-term negative effect on GDP, its long-term potential underscores the importance of aligning such aid with national development goals. The adverse impact of insurance and financial services necessitates the development of innovative financial instruments and insurance schemes tailored to the Turkish context to enhance financial stability post-

disaster. The dynamic responses illustrated by Impulse Response Functions (IRFs) indicate the need for policies that support quick GDP recovery while addressing the persistent negative impacts on affected populations and economic stability. Comprehensive disaster management strategies should incorporate long-term support systems, social safety nets, and flexible policy responses to sustain recovery efforts. By focusing on both immediate recovery and long-term resilience, Turkey can better navigate the economic and social challenges posed by disasters, ultimately fostering a more resilient economy. These recommendations would enhance Türkiye's trajectory From Adversity to Triumph.

5.3. Recommendations for Further Studies

This study faces limitations, the focus on Türkiye, which may affect generalizability. Future research should address these limitations by including comparative analyses across different countries or regions, investigating sector-specific disaster impacts, and employing advanced econometric and machine learning techniques for better impact assessments. Longitudinal studies tracking recovery trajectories can deepen understanding of resilience factors, while interdisciplinary approaches that incorporate insights from various fields can provide a more comprehensive view of disaster impacts and resilience strategies.

References

- Abbas, Z. (2020). Re-assessing the contribution of energy consumption to GDP per capita: Evidence from developed and developing countries. *International Journal of Energy Economics and Policy*, 10(6), 404-410. <<https://doi.org/10.32479/ijeep.9803>>
- Adams, V., Hattum, T., and English, D. (2009). Chronic disaster syndrome: displacement, disaster capitalism, and the eviction of the poor from New Orleans. *American Ethnologist*, 36(4), 615-636. <<https://doi.org/10.1111/j.1548-1425.2009.01199.x>>
- Ahmed, S. (2023). Environmental health risks after the 2023 Turkey-Syria earthquake and salient mitigating strategies: a critical appraisal. *Environmental Health Insights*, 17. <<https://doi.org/10.1177/11786302231200865>>
- Akbasli, I. (2024). Digital response to physical crises: the role of an e-health platform in the 2023 southern turkey earthquakes. *Disaster Medicine and Public Health Preparedness*, 18. <<https://doi.org/10.1017/dmp.2024.63>>
- Akkemik, Ü., Dağdeviren, N., and Aras, A. (2005). A preliminary reconstruction (a.d. 1635–2000) of spring precipitation using oak tree rings in the western Black Sea region of Türkiye. *International Journal of Biometeorology*, 49(5), 297-302. <<https://doi.org/10.1007/s00484-004-0249-8>>
- Aydoğdu, M., Cançelik, M., Sevinç, M., Çullu, M., Yenigün, K., Küçük, N., ... and Yenikale, A. (2021). Is drought caused by fate? analysis of farmers' perception and its influencing factors in the irrigation areas of gap-şanlıurfa, Türkiye. *Water*, 13(18), 2519. <<https://doi.org/10.3390/w13182519>>
- Bagherzadeh, M. and Shigemitsu, M. (2021). Building the resilience of turkey's agricultural sector to droughts. <<https://doi.org/10.1787/75430b86-en>>

- Bakema, M., Parra, C., and McCann, P. (2018). Analyzing the social lead-up to a human-induced disaster: the gas extraction-earthquake nexus in groningen, the netherlands. *Sustainability*, 10(10), 3621. <<https://doi.org/10.3390/su10103621>>
- Baltaci, H., Tumay, G., and Labban, A. (2023). Impact of drought conditions on air pollution over Türkiye. *International Journal of Climatology*, 43(8), 3647-3663. <<https://doi.org/10.1002/joc.8050>>
- Başaran-Uysal, A., Sezen, F., Özden, S., and Karaca, Ö. (2013). Classification of residential areas according to physical vulnerability to natural hazards: a case study of çanakkale, Turkey. *Disasters*, 38(1), 202-226. <<https://doi.org/10.1111/disa.12037>>
- Benali, N., and Saidi, K. (2017). A Robust Analysis of the Relationship between Natural Disasters, Electricity and Economic Growth in 41 Countries. *Journal of economic development*, 42, 89-110.
- Bergholt, D. and Lujala, P. (2012). Climate-related natural disasters, economic growth, and armed civil conflict. *Journal of Peace Research*, 49(1), 147-162. <<https://doi.org/10.1177/0022343311426167>>
- Botzen, W., Deschênes, O., and Sanders, M. (2019). The economic impacts of natural disasters: a review of models and empirical studies. *Review of Environmental Economics and Policy*, 13(2), 167-188. <<https://doi.org/10.1093/reep/rez004>>
- Büyükoğlu, B., Özpolat, A., and Nakipoğlu Özsoy, F. (2024). The Effects of Natural Disaster on Financial Markets: The Empirical Analysis of 2023 Earthquakes in Türkiye. *Akademik Araştırmalar Ve Çalışmalar Dergisi (AKAD)*, 16(30), 186-197. <<https://doi.org/10.20990/kilisiibfakademik.1439250>>
- Büyükoğlu, B., Özpolat, A., and Nakipoğlu Özsoy, F. (2024). The effects of natural disaster on financial markets: The empirical analysis of 2023 earthquakes in Türkiye. *Akademik Araştırmalar ve Çalışmalar Dergisi (AKAD)*, 16(30), 186-197. Kilis 7 Aralık University. <<https://doi.org/10.36987/akad.1234567>>
- Cvetković, V. (2023). A predictive model of community disaster resilience based on social identity influences. <<https://doi.org/10.20944/preprints202302.0263.v1>>
- Doğan, H. (2024). The roles and duties of physiotherapists on women's health during disaster period. *Togü Sağlık Bilimleri Dergisi*, 4(1), 34-44. <<https://doi.org/10.52369/togusagbilderg.1420415>>
- EM-DAT. (2023). *EM-DAT: The International Disaster Database – 2023 Report*. Retrieved from <https://files.emdat.be/reports/2023_EMDAT_report.pdf>
- Felbermayr, G., and Gröschl, J. (2014). Naturally negative: the growth effects of natural disasters. *Journal of Development Economics*, 111, 92-106. <<https://doi.org/10.1016/j.jdevco.2014.07.004>>
- Frödén, E. S. (2023). *The effect of natural disasters on economic growth: Does frequency of disasters matter?* [Bachelor's thesis, Department of Economics, Lund University]. Lund University Student Papers. <<https://lup.lub.lu.se/student-papers/record/9090481>>
- Ganapati, N. (2012). In good company: why social capital matters for women during disaster recovery. *Public Administration Review*, 72(3), 419-427. <<https://doi.org/10.1111/j.1540-6210.2011.02526.x>>
- Gunay, E., Ersel, M., Yax, J., Sheele, J., Karakurt, G., Acar, K., ... and Frank, S. (2019). Disaster training needs and expectations among Turkish emergency medicine physicians – a national

- survey. *Disaster Medicine and Public Health Preparedness*, 14(2), 229-235. <<https://doi.org/10.1017/dmp.2019.50>>
- Gürü, S., Zaman, S., and Karamercan, M. (2023). Emergency response and clinical insights from a non-epicenter hospital during the 2023 Turkey-Syria earthquake: a retrospective analysis. *Medical Science Monitor*, 29. <<https://doi.org/10.12659/msm.941226>>
- Ha, K. (2020). Mitigating psychological impact: the experience of Korean disaster management. *Community Mental Health Journal*, 57(3), 416-423. <<https://doi.org/10.1007/s10597-020-00671-y>>
- Haltaş, İ., Yildirim, E., Oztas, F., and Demir, İ. (2021). A comprehensive flood event specification and inventory: 1930–2020 turkey case study. *International Journal of Disaster Risk Reduction*, 56, 102086. <<https://doi.org/10.1016/j.ijdr.2021.102086>>
- Hameed, M., Moradkhani, H., Ahmadalipour, A., Moftakhari, H., Abbaszadeh, P., and Alipour, A. (2019). A review of the 21st century challenges in the food-energy-water security in the middle east. *Water*, 11(4), 682. <<https://doi.org/10.3390/w11040682>>
- Idroes, G. (2023). Natural disasters and economic growth in Indonesia. *Ekonomikalia Journal of Economics*, 1(1), 33-39. <<https://doi.org/10.60084/eje.v1i1.55>>
- Idroes, G. (2023). Natural disasters and economic growth in Indonesia. *Ekonomikalia Journal of Economics*, 1(1), 33-39. <<https://doi.org/10.60084/eje.v1i1.55>>
- Ilham, A.P., Muljaningsih, S., and Sasongko, S. (2023). The effect of natural disaster on regional economic growth, unemployment, poverty, and Human Development Index in thirty Indonesian provinces. *Journal of Indonesian Applied Economics*, 11(1). <<https://doi.org/10.21776/ub.jiae.2023.011.01.4>>
- Kalogiannidis, S., Kalfas, D., Chatzitheodoridis, F., and Lekkas, E. (2023). Role of governance in developing disaster resiliency and its impact on economic sustainability. *Journal of Risk and Financial Management*, 16(3), 151. <<https://doi.org/10.3390/jrfm16030151>>
- Kaur, H., Habibullah, M., and Nagaratnam, S. (2020). Malaria and natural disasters: evidence using gmm approach. *International Journal of Business and Society*, 21(2), 703-716. <<https://doi.org/10.33736/ijbs.3284.2020>>
- Khan, A., Chenggang, Y., Khan, G., and Muhammad, F. (2020). The dilemma of natural disasters: Impact on economy, fiscal position, and foreign direct investment alongside Belt and Road Initiative countries. *Science of The Total Environment*, 743, 140578. <<https://doi.org/10.1016/j.scitotenv.2020.140578>>
- Khan, A., Chenggang, Y., Khan, G., and Muhammad, F. (2020). The dilemma of natural disasters: impact on economy, fiscal position, and foreign direct investment alongside belt and road initiative countries. *The Science of the Total Environment*, 743, 140578. <<https://doi.org/10.1016/j.scitotenv.2020.140578>>
- Khan, M.T.I., Anwar, S., Sarkodie, S.A., Yaseen, M.R., and Nadeem, A.M. (2023). Do natural disasters affect economic growth? The role of human capital, foreign direct investment, and infrastructure dynamics. *Journal of Environmental Management*, 336, 116258. <<https://doi.org/10.1016/j.jenvman.2023.116258>>
- Kirigia, J., Sambo, L., Aldis, W., and Mwabu, G. (2004). Impact of disaster-related mortality on gross domestic product in the WHO African region. *BMC Emergency Medicine*, 4(1). <<https://doi.org/10.1186/1471-227x-4-1>>

- Koç, G. and Thieken, A. (2016). Societal and economic impacts of flood hazards in Turkey – an overview. *E3s Web of Conferences*, 7, 05012. <<https://doi.org/10.1051/e3sconf/20160705012>>
- Koçak, H. and Serin, E. (2023). Are nurses ready for a disaster in turkey? a hospital case. *Disaster Medicine and Public Health Preparedness*, 17. <<https://doi.org/10.1017/dmp.2023.100>>
- Lee, D., Zhang, H., and Nguyen, C. (2018). The economic impact of natural disasters in pacific island countries: adaptation and preparedness. *Imf Working Paper*, 18(108), 1. <<https://doi.org/10.5089/9781484353288.001>>
- Lu, R. and Dudensing, R. (2015). Post-ike economic resilience along the Texas coast. *Disasters*, 39(3), 493-521. <<https://doi.org/10.1111/disa.12115>>
- Majid, M., Nurdin, R., Azhar, T., and Sartiyah, S. (2022). The role of philanthropy in reducing impact of disaster on economies of ASEAN-9. *Iop Conference Series Earth and Environmental Science*, 1041(1), 012031. <<https://doi.org/10.1088/1755-1315/1041/1/012031>>
- Majid, M., Nurdin, R., Azhar, T., and Sartiyah, S. (2022). The role of philanthropy in reducing impact of disaster on economies of ASEAN-9. *Iop Conference Series Earth and Environmental Science*, 1041(1), 012031. <<https://doi.org/10.1088/1755-1315/1041/1/012031>>
- Messeri, A., Morabito, M., Messeri, G., Brandani, G., Petralli, M., Natali, F., ... and Orlandini, S. (2015). Weather-related flood and landslide damage: a risk index for Italian regions. *Plos One*, 10(12), e0144468. <<https://doi.org/10.1371/journal.pone.0144468>>
- Naoaj, M. (2023). From catastrophe to recovery: the impact of natural disasters on economic growth in developed and developing countries. *European Journal of Development Studies*, 3(2), 17-22. <<https://doi.org/10.24018/ejdevelop.2023.3.2.237>>
- Ningrum, V. (2024). Emerging collaboration amid the Covid-19 within the context of traditional-state dualism governance in Bali. *Jambá Journal of Disaster Risk Studies*, 16(1). <<https://doi.org/10.4102/jamba.v16i1.1581>>
- Niu, T., Huang, Q., Fang, S., Chen, G., and Liao, R. (2023). Resilient planning for high-renewable-integrated transmission systems under the impacts of ice storm disasters. *Iet Renewable Power Generation*, 18(7), 1091-1105. <<https://doi.org/10.1049/rpg2.12757>>
- Noy, I. (2009). The economics of natural disasters: a survey. <<https://doi.org/10.18235/0010924>>
- Noy, I., and Vu, T. B. (2010). The economics of natural disasters in a developing country: The case of Vietnam. *Journal of Asian Economics*, 21(4), 345-354. <<https://doi.org/10.1016/j.asieco.2010.03.002>>
- Öcal, A. (2019). Natural disasters in Turkey: Social and economic perspective. *International Journal of Disaster Risk Management*, 1(1), 51–61. <<https://doi.org/10.18485/ijdrm.2019.1.1.3>>
- Oliveira, V. (2019). Natural disasters and economic growth in northeast Brazil: evidence from municipal economies of the ceará state. *Environment and Development Economics*, 24(3), 271-293. <<https://doi.org/10.1017/s1355770x18000517>>
- Owusu-Sekyere, E., Lunga, W., and Karuaihe, S. (2021). The impact of disasters on economic growth in selected southern Africa development community countries. *Jambá Journal of Disaster Risk Studies*, 13(1). <<https://doi.org/10.4102/jamba.v13i1.1081>>
- Bringas, B., Bunyi, L.J., and Manapat, C.L. (2022). An Analysis on the Impact of Natural Disasters on the Economy of the Philippines. *Journal of Economics, Finance and Accounting Studies*, 4(1), 163–183. <<https://doi.org/10.32996/jefas.2022.4.1.11>>

- Özdoğan, F. and Güney, D. (2016). The importance of architecture education for disaster mitigation. <<https://doi.org/10.2495/sc160321>>
- Palupi, L. (2022). Psychological preparedness of coastal communities in Surabaya: a preliminary finding. *E3s Web of Conferences*, 340, 05010. <<https://doi.org/10.1051/e3sconf/202234005010>>
- Panwar, V., and Sen, S. (2019). Economic Impact of Natural Disasters: An Empirical Re-examination. *Margin: The Journal of Applied Economic Research*, 13(1), 109-139. <<https://doi.org/10.1177/0973801018800087>>
- Permani, R. and Xu, X. (2022). The nexus between natural disasters, supply chains and trade—revisiting the role of preferential trade agreements in disaster risk reduction. *World Economy*, 45(10), 3002-3030. <<https://doi.org/10.1111/twec.13296>>
- Popoola, M., Ajayi, J., and Tijani, S. (2022). Exchange rate policy regimes, private investment behaviour and economic growth in Nigeria (1960 -2020). *Financial Markets Institutions and Risks*, 6(3), 105-115. <[https://doi.org/10.21272/fmir.6\(3\).105-115.2022](https://doi.org/10.21272/fmir.6(3).105-115.2022)>
- Rajapaksa, D., Islam, M., and Managi, S. (2017). Natural capital depletion: the impact of natural disasters on inclusive growth. *Economics of disasters and Climate Change*, 1(3), 233-244. <<https://doi.org/10.1007/s41885-017-0009-y>>
- Sahin, I., and Yavuz, O. (2015). Econometric Analysis of Natural Disasters' Macro-Economic Impacts: An Analysis on Selected Four OECD Countries. *Journal of Business Economics and Finance*, 4(3). <<https://doi.org/10.17261/Pressacademia.2015313064>>
- Schrier, G., Barichivich, J., Briffa, K., and Jones, P. (2013). A scpsdi-based global data set of dry and wet spells for 1901–2009. *Journal of Geophysical Research Atmospheres*, 118(10), 4025-4048. <<https://doi.org/10.1002/jgrd.50355>>
- Shabnam, N. (2014). Natural disasters and economic growth: a review. *International Journal of Disaster Risk Science*, 5(2), 157-163. <<https://doi.org/10.1007/s13753-014-0022-5>>
- Sieg, T., Schinko, T., Vogel, K., Mechler, R., Merz, B., and Kreibich, H. (2019). Integrated assessment of short-term direct and indirect economic flood impacts including uncertainty quantification. *Plos One*, 14(4), e0212932. <<https://doi.org/10.1371/journal.pone.0212932>>
- Strulik, H. and Trimborn, T. (2018). Natural disasters and macroeconomic performance. *Environmental and Resource Economics*, 72(4), 1069-1098. <<https://doi.org/10.1007/s10640-018-0239-7>>
- Taşkıran, G. and Baykal, Ü. (2019). Nurses' disaster preparedness and core competencies in turkey: a descriptive correlational design. *International Nursing Review*, 66(2), 165-175. <<https://doi.org/10.1111/inr.12501>>
- Tasri, E., Karimi, K., and Muslim, I. (2022). The effect of economic variables on natural disasters and the impact of disasters on economic variables. *Heliyon*, 8(1), e08678. <<https://doi.org/10.1016/j.heliyon.2021.e08678>>
- Terblanche, T., Sousa, L., and Niekerk, D. (2022). Disaster resilience framework indicators for a city's disaster resilience planning strategy. *Jàmá Journal of Disaster Risk Studies*, 14(1). <<https://doi.org/10.4102/jamba.v14i1.1264>>
- Top, M., Gider, Ö., and Taş, Y. (2010). An investigation of hospital disaster preparedness in turkey. *Journal of Homeland Security and Emergency Management*, 7(1). <<https://doi.org/10.2202/1547-7355.1781>>

- Tosunoğlu, F., Can, İ., and Kahya, E. (2018). Evaluation of spatial and temporal relationships between large-scale atmospheric oscillations and meteorological drought indexes in Türkiye. *International Journal of Climatology*, 38(12), 4579-4596. <<https://doi.org/10.1002/joc.5698>>
- Trabsa, A., Nabin, L., and Lee, J. (2022). Posttraumatic stress symptoms, physical illness, and social adjustment among disaster victims. *Disaster Medicine and Public Health Preparedness*, 17. <<https://doi.org/10.1017/dmp.2022.89>>
- Vazifehkhah, S. and Kahya, E. (2018). Hydrological drought associations with extreme phases of the North Atlantic and Arctic oscillations over Türkiye and northern Iran. *International Journal of Climatology*, 38(12), 4459-4475. <<https://doi.org/10.1002/joc.5680>>
- Wada, H., Wakigawa, K., Yokomatsu, M., and Takeya, K. (2014). The role of a macro-economic model for disaster risk reduction policy in developing countries. *Journal of Integrated Disaster Risk Management*, 4(1), 12-29. <<https://doi.org/10.5595/idrim.2014.0088>>
- Xu, H., Yang, L., Tan, Y., and Deng, N. (2021). A scientometric review of urban disaster resilience research. *International Journal of Environmental Research and Public Health*, 18(7), 3677. <<https://doi.org/10.3390/ijerph18073677>>
- Yang, Y., Guo, H., Chen, L., Liu, X., Gu, M., and Pan, W. (2020). Multiattribute decision making for the assessment of disaster resilience in the three gorges reservoir area. *Ecology and Society*, 25(2). <<https://doi.org/10.5751/es-11464-250205>>
- Yangdol, R. and Sarma, M. (2019). Demand-side factors for financial inclusion: a cross-country empirical analysis. *International Studies*, 56(2-3), 163-185. <<https://doi.org/10.1177/0020881719849246>>
- Yildirim, Ş. and Deniz, B. (2021). Evaluation of effective parameters in disaster risk reduction plans with multi criteria decision making method: an analysis on selected country samples. <<https://doi.org/10.21203/rs.3.rs-1064405/v1>>
- Yokomatsu, M. (2023). Climate-related disaster and human capital investment in the global south — household heterogeneity and growth. <<https://doi.org/10.21203/rs.3.rs-3532426/v1>>
- Yücedağ, C. (2013). Morphological and genetic variation within and among four quercus petraea and q. robur natural populations. *Turkish Journal of Botany*. <<https://doi.org/10.3906/bot-1205-18>>
- Yuryeva, O. (2023). Increasing economic losses from natural disasters as a last decade trend. *E3s Web of Conferences*, 458, 05005. <<https://doi.org/10.1051/e3sconf/202345805005>>
- Zeybekoğlu, U. and Sahin, A. (2022). Boyabat yöresi yıllık kuraklıklarının farklı meteorolojik kuraklık indisleri kullanılarak araştırılması. *Sürdürülebilir Mühendislik Uygulamaları Ve Teknolojik Gelişmeler Dergisi*, 5(1), 1-8. <<https://doi.org/10.51764/smutgd.993652>>
- Zhou, F., and Botzen, W. (2021). Firm level evidence of disaster impacts on growth in Vietnam. *Environmental and Resource Economics*, 79(2), 277-322. <<https://doi.org/10.1007/s10640-021-00562-0ss>>

Appendix

Figure 1A. Cholesky variance decomposition

Variance Decomposition of LOGGDP:							
Period	S.E.	LOGGDP	LOGAFFE...	LOGECON...	LOGINSFI...	LOGCAPITAL	DUMMYDI...
1	0.070761	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.110900	96.48879	2.519530	0.257808	0.036406	0.133247	0.564216
3	0.150998	95.46315	2.990284	0.923896	0.120701	0.193148	0.308823
4	0.192079	94.18918	2.968431	1.258914	0.109607	0.826229	0.647636
5	0.236850	90.94875	1.952678	2.412195	0.127377	1.745901	2.813097
6	0.273736	89.96541	1.830655	2.155804	0.195701	1.924389	3.928039
7	0.307672	89.73983	2.271575	1.937787	0.326408	1.738970	3.985428
8	0.334488	90.66558	2.242115	1.654158	0.587798	1.472688	3.377660
9	0.360651	91.39245	1.947535	1.456740	0.693428	1.290560	3.219284
10	0.389703	91.48202	2.222924	1.368116	0.614334	1.105370	3.207234

Variance Decomposition of LOGAFFECTED:							
Period	S.E.	LOGGDP	LOGAFFE...	LOGECON...	LOGINSFI...	LOGCAPITAL	DUMMYDI...
1	2.183241	1.161044	98.83896	0.000000	0.000000	0.000000	0.000000
2	5.262918	2.484096	27.58513	9.793122	16.75162	10.25505	33.13098
3	6.228404	7.830405	19.74133	20.26817	20.17381	8.055002	23.93129
4	8.445867	5.963829	30.10447	20.68966	12.85387	5.755166	24.63302
5	10.11429	9.521555	21.06197	28.01114	13.71194	6.274726	21.41867
6	10.36187	9.105165	20.20122	29.46576	13.44256	6.544114	21.24118
7	11.34404	10.07029	19.40572	27.65787	11.36461	6.493723	25.00779
8	11.89676	9.214741	24.34394	25.67077	10.78036	5.929041	24.06115
9	12.25923	8.737610	23.42295	25.36208	11.82242	6.806817	23.84812
10	12.45147	8.501743	22.93413	24.63712	11.49636	7.182287	25.24835

Variance Decomposition of LOGECONLOSS:							
Period	S.E.	LOGGDP	LOGAFFE...	LOGECON...	LOGINSFI...	LOGCAPITAL	DUMMYDI...
1	5.626466	3.713394	20.41941	75.86720	0.000000	0.000000	0.000000
2	7.029672	2.380488	16.41853	48.63295	10.65635	13.79288	8.118806
3	8.656379	9.323358	22.87665	41.90426	10.19389	9.976535	5.725301
4	12.80023	6.252268	27.49203	34.52336	8.835903	6.463051	16.43338
5	15.87221	7.566598	18.18139	41.40506	12.21826	5.967074	14.66162
6	17.0910	7.653188	17.39587	43.63553	12.64851	5.205790	13.46112
7	18.66265	8.760144	15.48086	42.27309	11.88000	5.507302	16.09861
8	19.06237	8.600004	16.59021	41.96651	11.75236	5.292465	15.79845
9	19.17529	8.503306	16.71774	41.48376	12.15177	5.513388	15.63003
10	19.32226	8.374979	17.71558	40.85648	12.01205	5.485318	15.55559

Variance Decomposition of LOGINSFINANCE:							
Period	S.E.	LOGGDP	LOGAFFE...	LOGECON...	LOGINSFI...	LOGCAPITAL	DUMMYDI...
1	0.100440	10.27680	24.99121	7.473007	57.25899	0.000000	0.000000
2	0.127025	21.02758	30.78710	5.073889	36.53384	6.371617	0.160963
3	0.154501	20.48740	22.73857	6.162646	28.26293	8.082467	14.26598
4	0.169160	18.70919	19.21773	5.873277	23.65698	9.509953	23.03287
5	0.211720	14.08419	24.36122	9.850483	15.27108	7.049421	29.38361
6	0.228936	12.04824	27.30688	12.68617	16.30556	6.522352	25.13080
7	0.234881	11.64132	26.52572	12.29430	15.76699	7.587273	26.18440
8	0.250565	10.24599	24.57835	11.16280	13.89891	8.651879	31.46207
9	0.275428	8.731554	29.87687	9.256928	11.52394	7.718024	32.89269
10	0.294416	10.40107	31.20167	9.886339	12.09859	7.616999	28.79532

Variance Decomposition of LOGCAPITAL:							
Period	S.E.	LOGGDP	LOGAFFE...	LOGECON...	LOGINSFI...	LOGCAPITAL	DUMMYDI...
1	0.110359	74.37642	5.385444	7.788587	7.115105	5.334439	0.000000
2	0.135026	76.79287	3.603614	8.423052	4.883764	5.207774	1.088926
3	0.143633	78.78442	3.484357	7.497740	4.617853	4.603523	1.012106
4	0.151221	78.17802	4.124729	8.023424	4.238904	4.373832	1.061092
5	0.166453	73.13096	3.831756	8.896370	3.759832	5.805848	4.575236
6	0.171206	71.90230	4.050644	8.477836	3.879040	5.861030	5.829150
7	0.179258	68.90154	7.146258	8.205382	3.610229	5.410035	6.726557
8	0.184150	66.15416	7.394379	9.140463	4.555911	5.588880	7.166208
9	0.188417	64.83943	7.200155	8.733009	4.410254	5.863109	8.954047
10	0.195086	61.88098	8.856564	8.153488	4.115267	5.701183	11.29252

Cholesky One S.D. (d.f. adjusted)
Cholesky ordering: LOGGDP LOGAFFECTED LOGECONLOSS LOGINSFINANCE LOGCAPITAL
DUMMYDISASTER

Figure 2A. *Tabulated impulse response functions*

Period	LOGGDP	LOGAFFE...	LOGECON...	LOGINSFI...	LOGCAPITAL
1	0.000000 (0.00000)	0.000000 (0.00000)	0.000000 (0.00000)	0.000000 (0.00000)	0.000000 (0.00000)
2	-0.008330 (0.01849)	3.029310 (0.74375)	2.003001 (1.50016)	0.005096 (0.02619)	-0.014090 (0.02885)
3	-0.001010 (0.02616)	0.327029 (1.46630)	-0.527372 (2.04873)	-0.058133 (0.03433)	-0.003204 (0.03396)
4	0.012982 (0.04178)	2.878840 (2.08886)	4.757655 (2.87564)	-0.056440 (0.04478)	0.005818 (0.04114)
5	0.036594 (0.04650)	-2.083182 (3.54944)	-3.164046 (4.62034)	-0.081120 (0.05041)	0.032016 (0.04170)
6	0.036949 (0.05328)	-0.946191 (4.90895)	1.542559 (6.68738)	0.000296 (0.07821)	0.020999 (0.04556)
7	0.028798 (0.06160)	-3.061949 (5.09308)	-4.093222 (8.12130)	0.035696 (0.08484)	0.021281 (0.05856)
8	0.002513 (0.06449)	-1.368428 (6.63558)	-1.156239 (10.4240)	0.072850 (0.08110)	-0.016391 (0.04913)
9	-0.020206 (0.06236)	1.336630 (6.00799)	0.250754 (10.8005)	0.072110 (0.11577)	-0.027361 (0.05183)
10	-0.026144 (0.05574)	1.817639 (5.21992)	0.778758 (9.85427)	-0.002712 (0.11684)	-0.033451 (0.05341)

Cholesky One S.D. (d.f. adjusted)

Cholesky ordering: LOGGDP LOGAFFECTED LOGECONLOSS LOGINSFINANCE
LOGCAPITAL DUMMYDISASTER

Standard errors: Analytic

Trust at first reply and how AI-language systems alter human trust calibration

Dumitru Alexandru BODISLAV

Bucharest University of Economic Studies, Romania
alex.bodislav@ase.ro

Raluca Iuliana GEORGESCU

Bodislav & Associates, Romania
raluca.georgescu@infinitumgroup.com

Ionuț Valeriu ANDREI

Bucharest University of Economic Studies, Romania
Romanian Lottery National Company (CNLR), Romania
ionut.andrei@loto.ro

Abstract. *Regardless of the underlying factual accuracy, large language models (LLMs) are tuned to generate text outputs that are confident and coherent. This design feature can cause a phenomenon known as confidence inflation, during which the consistent delivery of high-certainty responses alters human epistemic calibration. Repeated exposure to confidently presented but occasionally inaccurate information over time can weaken the brain's ability to critically evaluate information, shift the weighting of certainty cues over evidentiary substance, and reduce scepticism. This study explores the mechanisms through which confidence inflation arises, drawing on cognitive psychology and neuroeconomics. These mechanisms include heuristic reliance on fluency, reinforcement of implicit trust, and diminished error detection. It additionally examines the downstream cognitive, behavioural, and societal consequences, which include belief entrenchment, reduced source discrimination, and collective epistemic drift. To maintain epistemic caution in the face of increasingly authoritative AI-generated communication, the analysis ends by describing mitigation strategies, which range from targeted scepticism training to calibrated confidence signalling in AI interfaces.*

Keywords: artificial intelligence, large language models, confidence inflation, cognitive bias, neuroeconomics, trust calibration, epistemic drift, human–AI Interaction.

JEL Classification: C45, D83, D87, O33, Z13.

1. Introduction

The incorporation of large language models (LLMs) into everyday information environments has created a new dynamic in human-machine interaction: responses are delivered with unwavering confidence, even when the underlying accuracy is unknown. While confidence in communication can improve clarity and decisiveness, it also serves as a persuasive cue in epistemic contexts, one that human cognition has been shown to prioritize over evidentiary quality. This creates conditions for confidence inflation, a process in which repeated exposure to confidently stated but variably accurate AI outputs raises trust thresholds for such systems while eroding the instinct to verify information.

Epistemic caution, which represents the cognitive habit of maintaining proportional scepticism until evidence is evaluated and assessed, protects against premature belief adoption. When confidence inflation takes place this safeguard weakens, generating changes not only in individual reasoning processes but also in collective information norms. As AI-generated content becomes more integrated into education, professional decision-making, and public discourse, the balance between information delivery efficiency and critical evaluation becomes increasingly important.

This paper investigates confidence inflation as a multi-layered phenomenon, first defining its cognitive and neuroeconomic foundations, then mapping the mechanisms by which LLM outputs influence human trust calibration, and finally considering the broader societal implications. Our objective is to identify both the risks of confidence inflation and the design or educational interventions that can mitigate its effects.

2. Background and conceptual framework

Empirical studies show that large language models (LLMs) have systematic overconfidence in their outputs, with probability estimates of correctness frequently exceeding actual accuracy by 20% to 60% (Sun et al., 2025). This miscalibration is most noticeable for low-confidence items, where models not only overestimate correctness but also fail to adjust confidence in the face of prior errors (Steyvers, 2025).

Iterative reasoning techniques like chain-of-thought prompting have been proposed to improve accuracy; however, if calibration is not explicitly incorporated into model training, these approaches can exacerbate overconfidence (Huang et al., 2025). Chhikara (2025) shows that confidence miscalibration persists across datasets, domains, and model architectures, implying that it is a structural feature of current LLM design rather than an isolated artefact.

Empirical studies show that large language models (LLMs) have systematic overconfidence in their outputs, with probability estimates of correctness frequently exceeding actual accuracy by 20% to 60% (Sun et al., 2025). This miscalibration is most noticeable for low-confidence items, where models not only overestimate correctness but also fail to adjust confidence in the face of prior errors (Steyvers, 2025).

Iterative reasoning techniques like chain-of-thought prompting have been proposed to improve accuracy, however, if calibration is not explicitly incorporated into model training, these approaches can exacerbate overconfidence (Huang et al., 2025). Chhikara (2025) shows that confidence miscalibration persists across datasets, domains, and model architectures, implying that it is a structural feature of current LLM design rather than an isolated artefact.

Several calibration interventions have been evaluated, including Answer-Free Confidence Estimation (AFCE), which separates the process of generating confidence estimates from content generation (Zhang et al., 2025). Other approaches involve using auxiliary "confidence models" like the Thermometer framework to detect potentially overconfident errors in real time (Lee et al., 2024). While these methods can reduce calibration errors in specific domains, they have yet to show consistent generalizability across tasks and content types.

The fluency heuristic is related to the tendency to evaluate the truth or reliability of information based on the ease with which it can be processed, rather than on evidentiary strength (Hertwig et al., 2008). This effect has been demonstrated in numerous experimental paradigms, demonstrating that perceptual or cognitive fluency, such as clear formatting, coherent syntax, or familiarity, can increase perceived accuracy even when the content is factually incorrect (Jacoby and Dallas, 1981; Reber and Schwarz, 1999).

Neurocognitive research has linked fluency-based judgments to specific brain activation patterns. Volz et al. (2008) discovered that perceptual fluency engages regions associated with subjective feelings of rightness, which may reinforce confidence regardless of factual accuracy. In the context of LLMs, the consistent delivery of syntactically coherent and semantically fluent responses may lead users to overestimate truthfulness, reducing the likelihood of critical evaluation.

Authority bias is the cognitive tendency to assign more credibility to information presented by authoritative sources, regardless of the objective quality of the evidence (Milgram, 1974; Metzger and Flanagan, 2013). While the bias was initially studied in the context of human authority figures, it now extends to machine-generated content, especially when it is presented with markers of expertise such as precise language, confident tone, and structured argumentation (Logg et al., 2019).

Recent studies have shown that exposure to confident AI-generated statements increases both short-term and long-term belief adoption, even when participants are informed that the content may be incorrect (Zhang and Daumé, 2023). Furthermore, bias acquisition from AI outputs can persist after interaction has ended, indicating that the effects are not only transient (Wang et al., 2024). The perceived authority of LLM outputs is enhanced by their consistent stylistic coherence, which can mimic the communication patterns of subject-matter experts, thereby increasing trust.

3. Cultural Consequences

Confidence inflation results from the interaction of LLM outputs' communicative characteristics and the established heuristics that humans use to evaluate reliability. One of the primary mechanisms underlying this process is the reliance on confidence cues in situations where direct verification of factual accuracy is exceedingly costly, impractical, or impossible. According to psychological research, individuals frequently deduce truthfulness from peripheral features such as tone, decisiveness, and syntactic fluency, especially when under cognitive load or informational ambiguity (Chaiken, 1980; Petty and Cacioppo, 1986). LLMs, which have been trained to produce coherent and decisive outputs using reinforcement learning, consistently generate language patterns that correspond to these high-confidence signals. As a result, users are more likely to assign credibility to responses based on presentation rather than the underlying evidentiary foundation, a phenomenon previously documented in human-AI interaction studies (Logg et al., 2019).

This credibility attribution becomes self-reinforcing after multiple exposures. When high-confidence outputs are perceived as correct, whether factual or not, the relationship between the system and reliability strengthens, which is in line with established findings on asymmetric belief updating in neuroeconomic models (Sharot et al., 2011). Such reinforcement is disproportionately sensitive to confirmations: correct outputs have a greater effect on increasing trust than incorrect outputs do on decreasing it, resulting in a dynamic that gradually raises the system's baseline trust. Recent studies of algorithmic advice have empirically demonstrated this persistence of trust even after encountering errors, with participants maintaining reliance on a system despite repeated exposure to inaccurate recommendations (Wang et al., 2024).

In addition to cognitive bias, structural convenience also plays a major role in this persistence. The barrier to ongoing engagement is lowered by the availability of LLMs, which offer prompt answers at no additional expense and eliminate the need for the financial, social, or logistical work necessary to consult a human expert. Because of how simple it is to get information from an AI, even when users are aware of possible errors, the advantages may seem greater than the disadvantages. The mechanisms of confidence inflation can function more frequently and with less resistance because of this situational incentive structure, which strengthens habitual reliance.

In addition to cognitive bias, structural convenience also plays a major role in this persistence. The barrier to ongoing engagement is lowered by the availability of LLMs, which offer prompt answers at no additional expense and eliminate the need for the financial, social, or logistical work necessary to consult a human expert. Because of how simple it is to get information from an AI, even when users are aware of possible errors, the advantages may seem greater than the disadvantages. The mechanisms of confidence inflation can function more frequently and with less resistance because of this situational incentive structure, which strengthens habitual reliance.

This effect is further enhanced by authority transfer. LLM outputs frequently reflect the linguistic precision, domain-specific vocabulary, and structured reasoning that are associated with human experts, causing users to reassign epistemic authority from traditional sources to the AI system (Metzger and Flanagin, 2013). As time passes, this transfer can normalise the system's role as a primary source of information, minimizing the perceived necessity for independent corroboration.

Error blindness also plays an important role. Responses that are well-organized and clear can obscure embedded inaccuracies, especially when the information is consistent with pre-existing beliefs or expectations (O'Reilly and Tenbrink, 2019). This alignment causes confirmation bias, in which people selectively look for evidence that supports their prior beliefs, reinforcing both the original belief and their trust in the system (Nickerson, 1998). The combined effect of confirmation bias and the fluency heuristic build a reinforcing loop: ease of processing increases perceived accuracy, while perceived accuracy reduces the likelihood of evaluation, thereby deepening trust. The interaction of confirmation bias and the heuristic results in a cycle in which each process strengthens the other. When information corresponds to what a person already believes and is presented in clear, well-structured language, the ease of reading or listening feels like a sign of certainty. This feeling frequently replaces the need to verify the facts, which causes individuals to accept the information as true without further investigation. The more often this occurs, the more deeply embedded the belief becomes, making it more difficult to change later. Part of the reason for this persistence is that accepting familiar ideas is mentally easier and more comfortable than considering evidence that contradicts them. Over time, each experience of having the individual's beliefs confirmed in a fluent, confident manner serves as a small reward, reinforcing both the belief and trust in the source. This gradual reinforcement increases people's likelihood of returning to the same source in the future, further reducing their willingness to question what it generates.

These mechanisms together show that confidence inflation is caused by a complex interplay of cognitive biases, learned trust, authority perception, and situational cost-benefit considerations. This multifactorial nature makes it resistant to simple mitigation strategies, emphasizing the importance of interventions that address both the psychological and practical aspects of human-AI interaction.

4. Cognitive and behavioural consequences

The mechanisms that drive confidence inflation have direct implications for both individual cognition and observable behaviour. At the cognitive level, repeated exposure to confidently presented information, whether correct or not, can reset an individual's internal threshold for what constitutes evidence that is trustworthy. This recalibration manifests as decreased epistemic vigilance, in which the instinct to double-check facts or seek out

validating sources becomes less automatic. According to research on trust calibration in human-machine interaction, once users become accustomed to high-confidence outputs, they are more likely to skip verification entirely, even in high-stakes or unfamiliar domains (Lee and See, 2004; Dzindolet et al., 2003). Importantly, this shift does not result from a deliberate rejection of caution, but rather from the gradual erosion of verification habits caused by a combination of reinforcement and structural convenience. The immediacy of LLM responses, their constant availability, and the lack of social, logistical, and financial costs associated with consulting human experts make them an appealing default. For many users, the ability to obtain a quick, understandable response serves as a problem-solving tool, reducing the perceived need for time-consuming corroboration. When weighing the costs and benefits of information-seeking, this convenience eventually becomes a deciding factor, making using AI the more practical, and consequently, habitual option.

From a behavioural standpoint, relying on LLM outputs can lead to the consolidation of initial impressions into stable, resistant beliefs. The anchoring effect reinforces this process by using initial information as a cognitive reference point to shape the interpretation of subsequent evidence (Tversky and Kahneman, 1974). When an AI-generated response serves as the initial anchor, it can influence how all subsequent information on the topic is evaluated, frequently biasing interpretation toward consistency with the first answer received. If the initial information is incorrect, subsequent corrections may have little impact, especially if they are delivered with less confidence, clarity, or immediacy than the original output. This resistance to change illustrates the continued influence effect, which occurs when misinformation remains in memory and continues to shape reasoning even after it is explicitly corrected (Lewandowsky et al., 2012). The problem is further complicated by the speed and convenience of the initial AI response, which allows the user to quickly bridge the perceived knowledge gap. Once this sense of resolution has been established, there is little perceived incentive to revisit or question the information, making corrective interventions less likely to be investigated or accepted.

The behavioural consequences also apply to group-level information processes. In a group setting, a confidently delivered AI output may rapidly become the focal point of discussion or agreement, not only because the information seems to be based on extensive knowledge, but also because it eliminates the delays and coordination efforts associated with consulting multiple experts or other sources of information. This efficiency advantage may cause group members to defer to the AI-derived position, reinforcing the authority transfer described previously. Over time, such dynamics can result in an epistemic cascade in which the same unverified or inaccurate information is repeatedly circulated and endorsed, becoming embedded in the group's shared knowledge base (Bikhchandani et al., 1992).

Another long-term consequence is reduced source discrimination. As LLMs become the standard first point of reference, users may increasingly regard them as interchangeable with verified human expertise. This shift may flatten the perceived hierarchy of sources,

making the distinctions between peer-reviewed research, expert opinion, and AI-generated text less important in decision-making. In such a setting, convenience serves as a weighting factor, prioritizing accessibility and speed over methodological rigour. The risk here is not only the inclusion of incorrect information, but also a broader redefinition of what constitutes a credible source. In the long run, this might give rise to what Fricker (2007) terms epistemic injustice, where the credibility of certain sources is inflated or reduced based on delivery characteristics rather than evidentiary quality.

Dealing with the problem of belief entrenchment involves understanding that removing reliance on confidently delivered AI outputs without offering viable alternatives risks leaving an informational void, which individuals will naturally seek to fill. With the goal to preserve the efficiency and accessibility that make LLMs attractive while minimizing epistemic drift, corrective mechanisms must be included within the interaction process itself. These mechanisms could include the explicit signalling of uncertainty, allowing users to recognise when further verification is needed; the automatic provision of direct citations to primary or peer-reviewed sources, reducing the friction involved in corroboration; and the integration of parallel reference pathways to pre-validated expert resources. By making verification as convenient and immediate as consulting the AI, these interventions counteract the anchoring effect and encourage a return to evidence-based evaluation without jeopardizing the practical appeal of AI systems. With this approach, epistemic caution can be maintained without discouraging use, but rather by incorporating structures that allow for examination and correction.

5. Psychological and neuroeconomic views and long-term consequences

By looking at how cognitive psychology and neuroeconomics explain decision-making under uncertainty, we can develop a better understanding of the dynamics of confidence inflation. Neuroeconomic models describe information-seeking as a cost–benefit process, in which individuals measure the expected value of improved accuracy against the effort, time, and potential discomfort of obtaining additional evidence (Glimcher and Fehr, 2014). The perceived benefit of further verification is frequently diminished when an LLM provides rapid, coherent, and confident responses, while the cost, in terms of time, attention, or complexity, remains salient. This recalibration makes the user more likely to accept the first answer the AI provides, because it feels like the quickest and most efficient option, even if it is not necessarily the most accurate. From a psychological perspective, confidence inflation takes advantage of the interaction between reinforcement learning and heuristic reasoning. According to Hertwig et al. (2008), the fluency heuristic causes individuals to equate truthfulness with ease of processing, and confirmation bias favours beliefs that support preconceived notions (Nickerson, 1998). In terms of reinforcement learning, every time an LLM gives a belief-congruent response that is subsequently

regarded as accurate, it serves as a reward signal. The probability of using the AI once more in future decision-making situations increases because of this encouraging feedback (Sharot et al., 2011). Even without explicit accuracy tracking, the brain efficiently updates its trust calibration over time, giving the AI a higher baseline reliability rating.

In this framework, convenience has two functions. First, it reduces the perceived "cost" side of the cost-benefit equation by acting as an extrinsic factor. It frequently takes a lot more work to validate information using conventional methods—such as speaking with an expert, reading original research, or cross-referencing several reliable sources—than it does to accept the AI's response. Secondly, convenience serves as a reward in and of itself. The brain's preference for cognitive efficiency is satisfied when a knowledge gap is immediately closed. This results in a slight but gratifying sense of closure that influences future behaviour to follow the same low-effort pathway (Kool et al., 2010). The speed and ease of interacting with AI not only make decisions faster but also influence how the brain judges the value and reliability of different sources of information.

The consequences of confidence inflation will extend beyond individual decision-making and begin to reshape collective information norms if it becomes a widespread and persistent feature of human–AI interaction. Collective epistemic drift, which is the gradual reduction in the standard of evidence that groups expect before accepting a claim as true, is one of the most significant risks (Bhimani et al., 2019). The expectation for independent verification may decrease as more individuals become accustomed to receiving immediate, confident responses from AI systems. As time passes, this can normalize a form of informational shorthand, in which the perceived authority of an answer relies more on how it is presented than on the validity of the underlying evidence (Lewandowsky et al., 2012).

This change has the potential to undermine the mechanisms that typically filter and challenge inaccurate claims in public discourse. Editorial oversight and peer review function as gatekeepers in traditional media and academic publishing, thereby reducing the distribution of inaccurate information and offering structured opportunities for correction (Bastick, 2021). In environments that are shaped by AI-generated content, these processes can be completely bypassed, allowing unverified statements to circulate widely before any evaluation occurs. These statements can be challenging to dislodge once they have settled in public discourse, particularly when they are attributed to a source that is perceived as neutral or purely technical (Vosoughi, Roy, and Aral, 2018).

The influence on education is also substantial. As learners become more dependent on AI for explanations, summaries, and interpretations, there is a possibility that their critical thinking and independent research abilities will diminish (Fisher, 2023). Students may be less inclined to question information when it is presented fluently and with confidence, which can result in a diminished ability to evaluate the quality of sources. This has an impact on more than just individual competence; it can result in a population that is unable

to navigate complex or contested topics without automated guidance over the course of generations (Snyder, 2019).

Confidence inflation can impact both public opinion and institutional decision-making in governance and policymaking. Policy debates frequently depend on technical or specialized information that may be challenging for the public to assess. If AI-generated summaries of such information are accepted at first glance without deeper investigation, they can shape voter perceptions and political agendas in manners that are not aligned with the best available evidence (Susser, Roessler and Nissenbaum, 2019). In a similar way, if policymakers themselves depend heavily on AI for briefing materials or scenario analyses, there is a risk that errors or biases embedded in the outputs will cascade into legislative or regulatory actions (Morley et al., 2021).

The structural benefits of speed, accessibility, and perceived neutrality that initially draw people to AI consultation also increase these risks (Rahwan et al., 2019). The informational ecosystem becomes more susceptible to subtle, large-scale distortions if these characteristics are adopted as the primary criterion for what constitutes trustworthiness. This could eventually result in an environment in which the appearance of certainty consistently surpasses the actual process of establishing truth. To resolve these implications, it will be necessary to reinforce institutional and cultural norms that prioritize evidence-based reasoning over presentation-driven credibility, in addition to making technical adjustments to AI systems (Fricker, 2007).

6. Conclusion

Interventions that address both the cognitive tendencies of users and the technical design of AI systems are necessary to mitigate the effects of confidence inflation. One of the most effective methods from a system design perspective is to enhance the confidence calibration of LLM outputs. The process of confidence calibration involves the alignment of the degree of certainty expressed in an answer with the likelihood that the answer is accurate (Kadavath et al., 2022). This can be accomplished by using model training methods that incorporate uncertainty estimation and probabilistic reasoning, and through post-processing layers that adjust language to match empirical accuracy levels. For instance, models can be programmed to explicitly communicate when a claim is uncertain, identify areas that require further verification, or present multiple plausible alternatives rather than a single, definitive statement (Kull et al., 2017).

Nevertheless, technical modifications alone are insufficient. Psychological interventions that maintain epistemic caution are equally significant. One approach is to incorporate "friction points" into AI interfaces, which are small prompts or cues that motivate and encourage users to pause and reflect before accepting a response as authoritative (Thaler and Sunstein, 2008). For example, while some current systems already provide citations,

source links, or summaries of differing viewpoints, these features are often inconsistent, rely on secondary or unverified material, or present comparisons generated solely from the model's internal synthesis. A stronger approach would require that links lead directly to verifiable primary sources, and that comparative summaries clearly distinguish between areas of established expert consensus and domains where significant disagreement remains. These features enable verification to be as accessible as the initial AI response by reducing the cognitive cost. Users are more inclined to participate in verification when the process of verifying an AI claim is as effortless and rapid as the initial receipt (Pennycook and Rand, 2019).

Additionally, educational initiatives are essential. Media and information literacy programs can be modified to incorporate AI literacy, which teaches users how LLMs generate outputs, where errors are most likely to occur, and how to interpret uncertainty cues. Research on inoculation theory indicates that by providing users with examples of AI outputs that are confidently delivered but misleading, as well as explanations of why they are misleading, they can become more resilient to similar errors in the future (van der Linden et al., 2017). Even in environments where AI is deeply integrated, the integration of these practices into formal education and workplace training can assist in the preservation of verification habits.

Institutions that use AI for decision support should implement layered review processes, in which domain experts evaluate AI-generated content before it is used in policy or operational contexts. This approach is like the peer-review model used in academia, and it serves as a safeguard against direct adoption of potentially flawed outputs. Regulatory frameworks may also require transparency in how confidence levels are calculated and communicated, allowing end users to make informed decisions about the reliability of the information they receive (Floridi et al., 2018).

Finally, effective mitigation must address the convenience factor that drives confidence inflation. If accepting an AI's response is significantly easier than verifying it, structural incentives will continue to favour trust without examination. The goal should not be to make AI less accessible or slower, but to make the verification process equally fast and fluid. By incorporating calibrated confidence, transparent sourcing, and low-effort verification into standard AI interactions, it is possible to retain the efficiency benefits of LLMs while protecting the cognitive safeguards that prevent epistemic erosion.

Confidence inflation is a subtle but significant consequence of how large language models generate and deliver information. By consistently providing confident responses, these systems can reset individual's views of reliability, resulting in less verification, fixed beliefs, and source discrimination. The appeal of speed and convenience amplifies this effect, making AI consultation the default option even when users are aware of the possibility of error. Over time, these dynamics can reshape collective evidence norms,

reducing the importance of verification in both personal decision-making and public discourse.

The mechanisms driving this process are based on well-known cognitive tendencies such as the heuristic, confirmation bias, and authority bias, but they are amplified by AI interaction's unique characteristics.

Neuroeconomic research shows that the speed and convenience of receiving an immediate response from an AI serve as rewards for individuals to keep coming to use it in the future. Psychological studies also show that when such systems make mistakes, users frequently do not adjust their trust levels, either because the errors are easy to overlook or due to the overall convenience still surpassing the perceived risks. In combination, these factors create a situation in which how certain an answer appears can be more important to the user than whether it is supported by strong evidence.

Mitigating confidence inflation necessitates two approaches. On the technical side, AI systems must be designed to accurately communicate uncertainty, connect users to verifiable primary sources, and make verification as simple as receiving the initial answer. However, even when such features are available, many users may choose not to use them because clicking through to a source or reading further requires an additional step. Without addressing this behavioural tendency, technical improvements are unlikely to significantly reduce confidence inflation.

Interventions on the human side should focus on promoting and strengthening verification habits through education, transparency, and institutional safeguards. The goal is not to discourage the use of AI, given its obvious efficiency and accessibility benefits, but to incorporate the cues, tools, and pathways that support evidence-based evaluation.

Early intervention is critical in resolving this issue. If left unchecked, confidence inflation has the potential to perpetuate a culture of uncritical acceptance in which presentation and accessibility define credibility. By aligning AI design with epistemic caution principles and reinforcing those principles in user behaviour, it is possible to preserve the benefits of these technologies while maintaining the quality of knowledge that underpins individual and collective decision-making.

References

- Bastick, Z. (2021). COVID-19 and Fake News in the Early Months of the Pandemic: Detecting Key Players and Trends, *Policy & Internet*, 13(2), 187–210.
- Bhimani, A., Mention, A.L. and Barlatier, P.J. (2019). Social media and trust in AI: Risk and opportunity in algorithmic decision-making, *Journal of Business Research*, 98, 183–190.
- Bikhchandani, S., Hirshleifer, D. and Welch, I. (1992). A Theory of Fads, Fashion, Custom, and Cultural Change as Informational Cascades, *Journal of Political Economy*, 100(5), 992–1026.

- Bodislav, D.A. (2011). The Birth of the Regulated Company in the Macroeconomic Environment, *Theoretical and Applied Economics*, vol. 18, no. 6(55), 129-140.
- Bodislav, D.A., Georgescu, R.I. (2023). A Sustainable and Resilient Socio-Economic Paradigm through Corporate Governance Intervention, *Theoretical and Applied Economics*, vol. 30, no. 4(637), 77-82.
- Bodislav, D.A., Georgescu, R.I., Andrei, I.V., Osiceanu, D.C. (2023). Modern Leadership Communication and Strategic Lobbying, *Theoretical and Applied Economics*, vol. 30, no. 3(636), 219-230.
- Chaiken, S. (1980). Heuristic versus systematic information processing and the use of source versus message cues in persuasion, *Journal of Personality and Social Psychology*, 39(5), 752–766.
- Chhikara, S. (2025). Evaluating calibration stability of large language models across formats and domains, arXiv preprint, arXiv:2502.11028.
- Dzindolet, M.T., Peterson, S.A., Pomranky, R.A., Pierce, L.G. and Beck, H.P. (2003). 'he role of trust in automation reliance, *International Journal of Human-Computer Studies*, 58(6), 697–718.
- Fisher, M. (2023). AI and the erosion of critical thinking, *Educational Technology Research and Development*, 71(4), 2035–2051.
- Floridi, L., Cowls, J., Beltrametti, M., Chatila, R., Chazerand, P., Dignum, V., Luetge, C., Madelin, R., Pagallo, U., Rossi, F., Schafer, B., Valcke, P. and Vayena, E. (2018). AI4People—An Ethical Framework for a Good AI Society: Opportunities, Risks, Principles, and Recommendations, *Minds and Machines*, 28, 689–707.
- Fricker, M. (2007). *Epistemic Injustice: Power and the Ethics of Knowing*. Oxford: Oxford University Press.
- Georgescu, R.I. (2023). Modern leadership in business organisations during economic disruption, *Theoretical and Applied Economics*, vol. 30, no. 2(635), 73-82.
- Georgescu, R.I., Vasilescu, A.C., Mair, A., Andreica, C., Sarbu, A.M. (2021). Human Capital and Administrative Leadership, *Proceedings of the 17th Administration and Public Management International Conference*, Bucharest, Romania, 15-16 October, available online at: <http://confcamp.ase.ro/2021/wp-content/uploads/18_Georgescu_Vasilescu_-Mair_Andreica_Sarbu.pdf>, [accessed on 28th of January 2024].
- Glimcher, P.W. and Fehr, E. (2014). *Neuroeconomics: Decision Making and the Brain*. 2nd edn. London: Academic Press.
- Hertwig, R., Herzog, S.M., Schooler, L.J. and Reimer, T. (2008) Fluency heuristic: A model of how the mind exploits a by-product of information retrieval, *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 34(5), 1191–1206.
- Huang, S., et al. (2025). Self-improvement and overconfidence in large language models, arXiv preprint, arXiv:2504.02902.
- Jones-Jang, S.M. (2023). Recalibrating trust after algorithmic errors: How humans respond to flawed machine recommendations, *Journal of Computer-Mediated Communication*, 28(1), zmac029.
- Kadavath, S., et al. (2022). Language models (mostly) know what they know, arXiv preprint, arXiv:2207.05221.

- Kool, W., McGuire, J.T., Rosen, Z.B. and Botvinick, M.M. (2010). Decision making and the avoidance of cognitive demand, *Journal of Experimental Psychology: General*, 139(4), 665–682.
- Kull, M., Silva Filho, T.M. and Flach, P. (2017). Beyond sigmoids: How to obtain well-calibrated probabilities from binary classifiers with beta calibration, *Electronic Journal of Statistics*, 11(2), 5052–5080.
- Lee, J.D. and See, K.A. (2004). Trust in automation: Designing for appropriate reliance, *Human Factors*, 46(1), 50–80.
- Leng, Y. (2024). ‘Reinforcement learning from human feedback and its unintended effects on model confidence’, arXiv preprint, arXiv:2410.09724.
- Lewandowsky, S., Ecker, U.K.H., Seifert, C.M., Schwarz, N. and Cook, J. (2012). Misinformation and Its Correction: Continued Influence and Successful Debiasing, *Psychological Science in the Public Interest*, 13(3), 106–131.
- Logg, J.M., Minson, J.A. and Moore, D.A. (2019). Algorithm appreciation: People prefer algorithmic to human judgment, *Organizational Behavior and Human Decision Processes*, 151, 90–103.
- Metzger, M.J. and Flanagin, A.J. (2013). Credibility and trust of information in online environments: The use of cognitive heuristics, *Journal of Pragmatics*, 59, 210–220.
- Morley, J., Floridi, L., Kinsey, L. and Elhalal, A. (2021). From What to How: An Initial Review of Publicly Available AI Ethics Tools, Methods and Research to Translate Principles into Practices, *AI and Ethics*, 1, 489–506.
- Nickerson, R.S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises, *Review of General Psychology*, 2(2), 175–220.
- Nyhan, B. and Reifler, J. (2010). When corrections fail: The persistence of political misperceptions, *Political Behavior*, 32(2), 303–330.
- O’Reilly, K. and Tenbrink, T. (2019). Error blindness in human–AI interaction: When coherent presentation masks factual inaccuracy, *Cognitive Science*, 43(7), e12742.
- Pennycook, G. and Rand, D.G. (2019). Fighting misinformation on social media using crowdsourced judgments of news source quality, *Proceedings of the National Academy of Sciences*, 116(7), pp. 2521–2526.
- Rahwan, I., Cebrian, M., Obradovich, N., Bongard, J., Bonnefon, J.F., Breazeal, C., Crandall, J.W., Christakis, N.A., Couzin, I.D., Jackson, M.O., Jennings, N.R., Kamar, E., Kloumann, I.M., Larochelle, H., Lazer, D., McElreath, R., Mislove, A., Parkes, D.C., Pentland, A., Roberts, M.E., Shariff, A., Tenenbaum, J.B. and Wellman, M. (2019). Machine behaviour, *Nature*, 568, 477–486.
- Sharot, T., Korn, C.W. and Dolan, R.J. (2011). How unrealistic optimism is maintained in the face of reality, *Nature Neuroscience*, 14(11), 1475–1479.
- Shen, X., et al. (2024). *Thermometer: A calibration framework for large language models*, in Proceedings of the 41st International Conference on Machine Learning.
- Steyvers, M. (2025). Comparative calibration of human and AI decision-making in multiple-choice tasks, *Nature Machine Intelligence*, 7(1), 45–54.
- Sun, H., et al. (2025). Quantifying overconfidence in large language models, arXiv preprint, arXiv:2505.02151.

- Susser, D., Roessler, B. and Nissenbaum, H. (2019). Online Manipulation: Hidden Influences in a Digital World, *Georgetown Law Technology Review*, 4, 1–45.
- Tversky, A. and Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases, *Science*, 185(4157), 1124–1131.
- van der Linden, S., Roozenbeek, J. and Compton, J. (2017). Inoculating Against Fake News, *Global Challenges*, 1(2), 1–5.
- Vered, M. (2023). Nudging users toward verification in AI-assisted decision-making, *Artificial Intelligence*, 322, 103966.
- Vosoughi, S., Roy, D. and Aral, S. (2018). The spread of true and false news online, *Science*, 359(6380), 1146–1151.
- Zhai, X., et al. (2024). The influence of generative AI on student learning and critical thinking, *Smart Learning Environments*, 11(1), 32.

The economic value of data. From data to decisions in the public sector

Florentina PANĂ-MICU

National University of Political Studies and Public Administration, Romania
florentina.micu@snsa.ro

Abstract. *This paper explores the economic value of data in the public sector and its role in optimizing decision-making. With the emergence of big data, artificial intelligence, and machine learning techniques that can leverage data to provide multiple benefits in forecasting certain phenomena, thus leading to better decision-making, data has become a national asset. Considering that a decision must, first and foremost, be informed—based on the analysis of all options, scenarios, and alternatives—data proves to be an essential resource in the process of optimizing decisions. Thus, data-driven public administration revolutionizes decision-making processes by integrating data analytics and evidence-based approaches to enhance governance and service delivery. By examining frameworks for data governance, open data initiatives, and the value of data as a strategic asset, the study highlights how data-driven decision-making improves transparency, accountability, and operational efficiency.*

Keywords: data-driven decision-making, public administration, data-driven public sector, data governance, optimization.

JEL Classification: H83, C80, D80.

1. Introduction

Decision-making holds a crucial place in all ongoing activities, as it defines a goal and the means needed to achieve it. From a range of options, small or large, the best approach to realizing the defined goal, using available resources, is chosen through a deliberative thought process.

Over time, researchers and psychologists have developed several theories to understand and predict how people make decisions. Decision theory is a complex field of study that examines how decisions are made, particularly in situations involving uncertainty and multiple alternatives. This field has evolved, incorporating new insights and adapting to advances in various disciplines, while some earlier theories have been challenged or disproven. Traditionally, decision theory has emphasized rational decision-making, focusing on the systematic analysis of goal-directed behavior. This involves understanding how individuals or groups make choices when faced with various options, influenced by external events or conditions beyond their control. These choices lead to different outcomes, each with associated positive or negative consequences, which are often evaluated according to specific criteria or a rational approach.

The rational decision-making model is the opposite of intuitive decision-making. In this approach, individuals rely on facts and information, perform analyses, and follow a structured, step-by-step process to reach a decision.

The rational decision-making model includes five steps as follows:

1. Identifying the problem that requires a solution
2. Identifying the solution scenario
3. Carrying out a gap analysis
4. Gathering facts, options, and alternatives
5. Analyzing option outcomes
6. Selecting the best possible options
7. Implement the decision and evaluate the outcome. (Uzonwanne, 2016)

In public administration, decision-making implies that public administrators are responsible for setting public strategy objectives and choosing the most suitable methods to achieve them. This decision-making process is governed by a form of rationality specific to the public sector, meaning that decisions rely on a careful and reasoned analysis of available options to identify solutions that best serve the public interest.

More specifically, administrators not only establish the direction of action but must also consider existing resources and constraints, ensuring that their choices are both efficient and sustainable. This rational approach to administrative decision-making supports the implementation of coherent policies that contribute to the development and proper functioning of the public sector.

The rational model is particularly beneficial in scenarios where clear data and well-defined goals exist, as it minimizes ambiguity and uncertainty, providing a logical framework for choosing the best solution.

Traditional approaches, such as the rational model of decision-making, provided a structured method grounded in logic and order. However, the rise of big data and analytics has introduced new methodologies that allow decisions to be guided by empirical evidence, patterns, and real-time insights. Moving from the rational model to data-driven decision-making reflects a shift in how organisations can achieve precision, adaptability, and competitive advantage.

According to Picciano, fundamental to data-driven decision making is a rational model directed by values and based on data. (Picciano, 2012)

Soares da Silva et al consider that., “with the rapid technological changes in data storage and processing, managers and administrators have been changing the way they make decisions, relying less on their intuitions and more on data”. (Silva, et al., 2022)

In the article “Strength in Numbers: How Does Data-Driven Decision making Affect Firm Performance?”, Brynjolfsson et al. (2011) demonstrated through statistical analysis that companies adopting data-driven approaches tend to experience significant productivity improvements, with gains ranging from 4% to 6%. Their findings also reveal a strong, nearly causal correlation between data-driven decision-making (DDDM) and enhanced financial performance metrics, such as higher returns on assets and equity, improved asset utilization, and increased market value. Similarly, in the context of public administration, the adoption of DDDM has been shown to boost productivity by approximately 5% to 6%, surpassing the improvements typically attributed to traditional inputs or the use of information technology alone. (Brynjolfsson, et al., 2011)

In the report “The Path to Becoming a Data-Driven Public Sector”, the OECD highlights that “a truly data-driven public sector recognises data as a key strategic asset with its value defined and its impact measured, reflects active efforts to remove barriers to managing, sharing and re-using data, applies data to transform the design, delivery and monitoring of public policies and services and values efforts to publish data openly as much as the use of data between, and within, public sector organisations”. (OECD, 2019)

According to OECD, the analytical framework for assessing the full scope of a Data-Driven Public Sector (DDPS) is organized around three key focus areas:

- 1) a comprehensive data governance model,
- 2) the use of data to create public value,
- 3) the role of data in fostering public trust. (idem)

This study explores the role of data-driven decision-making in public administration, the value of data as an asset, and the implementation of robust data governance structures. It examines how the use of data can enhance governance, improve service delivery, and foster public trust, which are essential components of effective public administration. By analyzing data governance frameworks and open data initiatives, the study aims to shed light on the ways in which data can support the development of evidence-based policies, drive operational efficiencies, and improve societal outcomes.

2. The Role of Data as a Strategic Asset for The Public Sector

According to Tao et al., since the turn of the 21st century, advancements in technology such as cloud computing, the Internet of Things, and artificial intelligence have greatly enhanced data processing capabilities, leading to a significant increase in the value of data. (Tao Xu, et al., 2023)

The authors define data as "resources that are owned or controlled by an enterprise and have real or potential value, comply with data laws, and are recorded electronically. As an important asset of an enterprise, data assets are of great significance in decision-making, business development, and innovation. (idem)

When we are talking about the private sector, data is an important asset to price due to the fact that it changes firm valuation and is a key consideration for an entrepreneur starting a new firm. (Veldkamp, 2023)

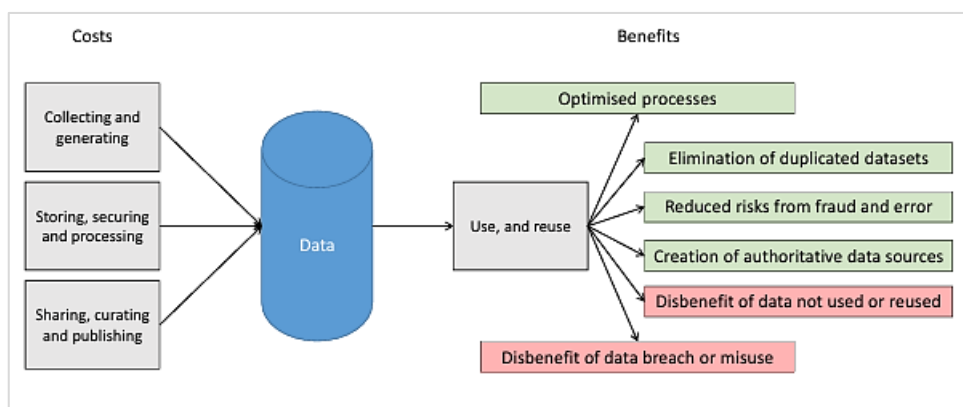
Veldkamp states that data is digitized information that reduces the uncertainty around a prediction. In other words, data can resolve uncertainty or risk. (idem)

In finance terms, the three essential characteristics of an asset have been identified as:

1. Does the asset have service potential or provide future economic benefits, where the benefit comes from the use of the asset or its sale?
2. Is the asset controlled by the organisation? That is to say, does the organisation have the power to benefit from the asset and deny or regulate how others access it?
3. Is the asset the result of previous activity? Has the asset been collected through a process, acquired from a source in some way, or through carrying out some work to develop it? (OECD, 2019)

OECD states that data are not tangible assets and their value cannot be measured in the same way. For tangible assets, a measure can be taken in terms of an initial cost, the current market value, or a calculated potential for generating future revenue. Despite the challenges of treating an intangible asset in this manner, the OECD considers it essential for public sectors to develop practical methods for identifying the value of data. (idem)

Figure 1. OECD's representation on identifying the value of data in the public sector



Source: (OECD, 2019).

According to Directive (EU) 2019/1024 of the European Parliament and the Council, “public sector information represents an extraordinary source of data that can contribute to improving the internal market and to the development of new applications for consumers and legal entities. Intelligent data usage, including their processing through artificial intelligence applications, can have a transformative effect on all sectors of the economy”. (European Parliament, 2019)

“Open data”, when referring to data issued by the government, means public sector data and publicly funded data made available for reuse for any purpose.

Allowing public sector data to be reused for other purposes, including commercial ones, can:

- foster economic growth and innovation through the development of new products and services;
- help address societal challenges through innovative solutions, such as in healthcare and transport;
- enhance evidence-based policymaking and boost efficiency in public administrations;
- become a vital asset for developing new technologies like artificial intelligence (AI), which requires the processing of vast amounts of high-quality data;
- foster citizen participation in political and social life, and increase government transparency. (idem)

Launched in 2015, the portal data.europa.eu serves as a central access point for open data across Europe, facilitating improved data availability and reuse. Its primary goals include enhancing access to high-quality open data and promoting impactful reuse of data to drive innovation and societal benefits. (The official portal for European data, 2024)

The open data maturity (ODM) assessment by data.europa.eu measures the progress of European countries in making public sector information available and stimulating its reuse. The results show the level of maturity of the participating countries and support the development and sharing of best practices regarding open data across Europe.

The ODM questionnaire is structured in four dimensions:

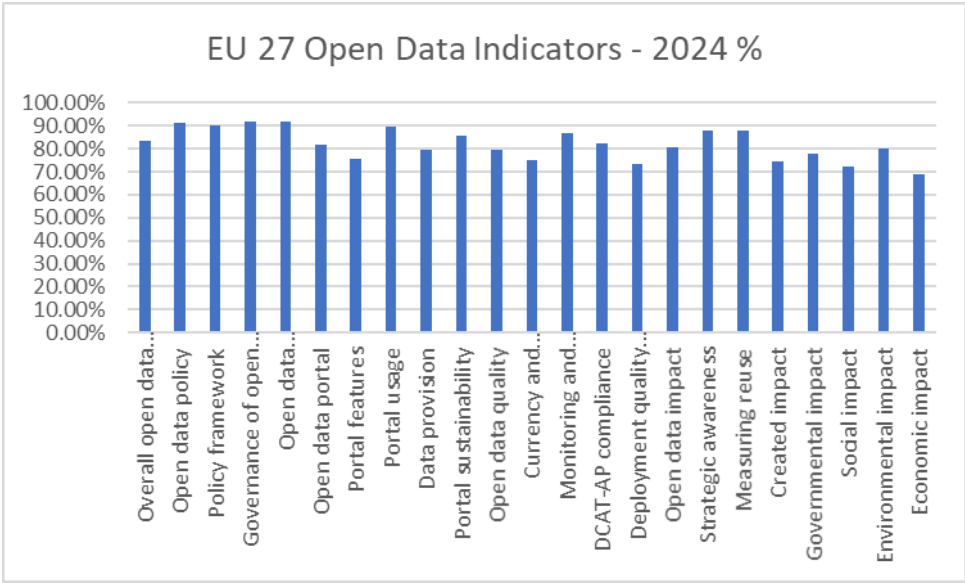
- (1) open data policy,
- (2) open data impact,
- (3) open data portal and
- (4) open data quality. (European Commission, 2023)

These dimensions are subdivided into indicators. The four dimensions are outlined below. Open data policy investigates countries’ policies and strategies regarding open data, the national governance models for managing open data, and the measures deployed to implement the policies and strategies. To evaluate these elements, the dimension is composed of three indicators:

- (1) policy framework,
- (2) governance of open data and
- (3) open data implementation.

In 2024, this study involved 27 EU Member States, 3 European Free Trade Association (EFTA) countries (Iceland, Norway, and Switzerland), and 4 candidate countries (Bosnia and Herzegovina, Albania, Serbia, and Ukraine).

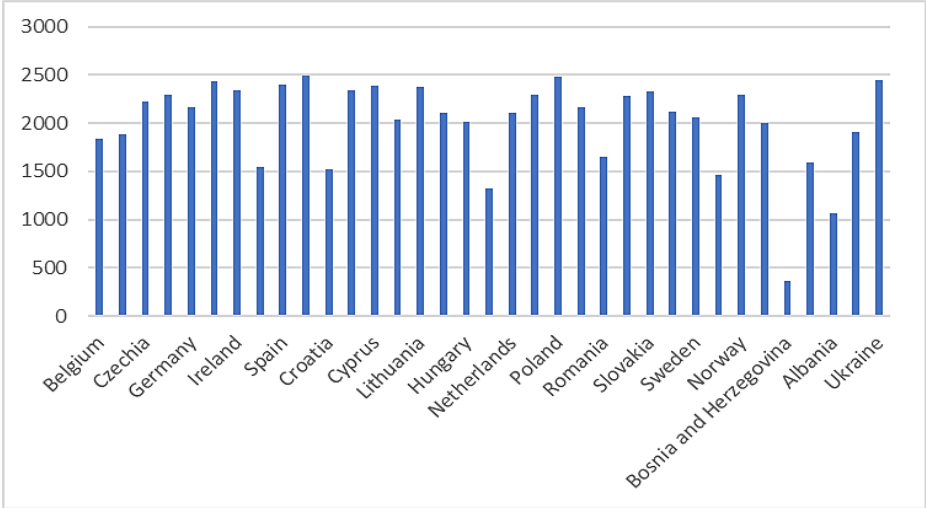
Figure 2. *European Union Overview on Open Data Indicators - 2024*



Source: The author based on the statistics available on data.europa.eu

The 2024 data shows a collective effort across EU nations to enhance open data policies and infrastructures. The EU Member States improved their average maturity score, increasing from 46 % in 2015 to 83 % in 2024. (European Commission, 2024)

Figure 3. *Country Overview on Open Data Score - 2023*



Source: The author based on the statistics available on data.europa.eu

Figure 3 highlights the open data scores obtained by member states in 2023. The most mature countries in the EU-27 are France (98.3 %), Poland (97.9 %), and Estonia (96.2 %). The most mature European Free Trade Association country is Norway (90.2 %), and the most mature candidate country is Ukraine (96.3%). (European Commission, 2023)

Tabel 1. *Country Overall ranking on Open Data - 2024*

Country	Overall Ranking
France	1
Poland	2
Ukraine	3
Slovakia	4
Ireland	5
Spain	6
Lithuania	7
Czechia	8
Italy	9
Estonia	10
Cyprus	11
Denmark	12
Latvia	13
Slovenia	14
Portugal	15
Norway	16
Austria	17
Serbia	18
Luxembourg	19
Switzerland	20
Sweden	21
Netherlands	22
Finland	23
Hungary	24
Germany	25
Belgium	26
Romania	27
Croatia	28
Bulgaria	29
Greece	30
Iceland	31
Malta	32
Albania	33
Bosnia and Herzegovina	34

Source: The author based on the statistics available on data.europa.eu

The table ranks 35 countries based on their overall open data performance, highlighting their maturity and impact.

As we can see, France (1) is the top performer in open data due to robust policy frameworks, effective governance, and high-quality portals, followed by Poland (2) and Ukraine (3), which show remarkable progress, leveraging open data for societal and economic benefits.

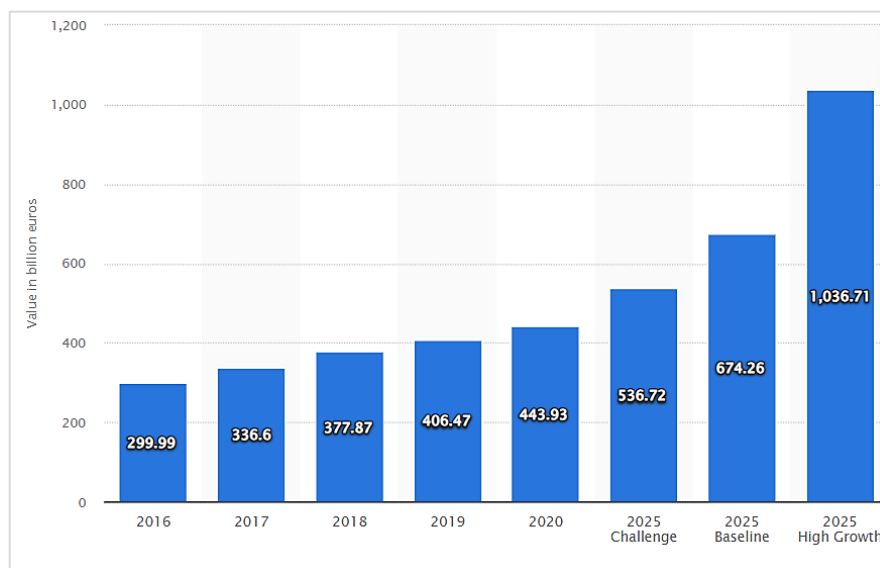
On the bottom of the list, Romania (27), Bulgaria (29), and Greece (30) face many challenges in implementing open data strategies effectively and ensuring data usability.

5. The Economic Value of Data

According to Coyle and Li (2021), “the value of data depends on processing it to enable firms to make better decisions, enhancing their competitiveness, growth and profits”. The authors consider that the value of data lies in knowledge derived from the use of data.

As reported by the European Commission, the estimated value of the data economy across the 27 European Union Member States and the United Kingdom surpassed €440 billion in 2020.

Figure 4. *Value of the data economy in the European Union (EU) and United Kingdom from 2016 to 2020 and in 2025*



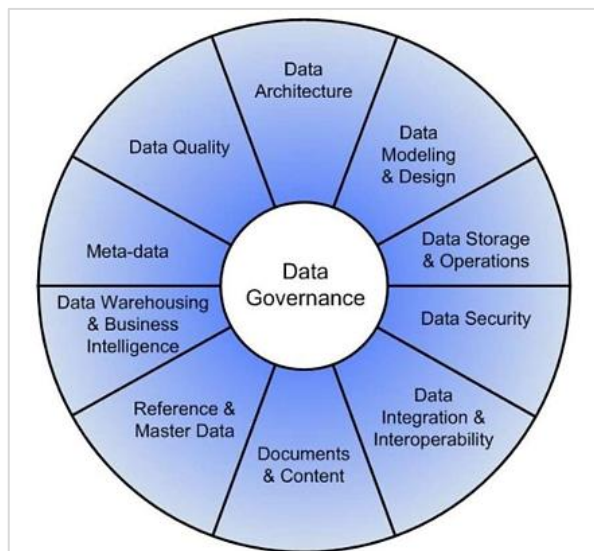
Source: Statista.

To fully realize the economic potential of data, a robust governance system that guarantees data quality and ethical use is indispensable.

IBM was one of the earliest companies that develop the structure for data governance. According to IBM, data governance is “the data management discipline that focuses on the quality, security, and availability of an organisation’s data. Data governance helps ensure data integrity and data security by defining and implementing policies, standards, and procedures for data collection, ownership, storage, processing, and use. (IBM, 2024)

On the other hand, the Data Management Association (DAMA International) gave a comprehensive framework for data management across organisations.

The DMBOK (Data Management Body of Knowledge), elaborated by DAMA International, serves as a guide for data professionals, offering structured methodologies, terminology, and guidelines for managing data effectively and securely within any organisation. According to DAMA International, the areas of Data Management Knowledge are represented above:

Figure 5. *The representation of the 11 Data Management Knowledge Areas*

Source: (DAMA International, 2017).

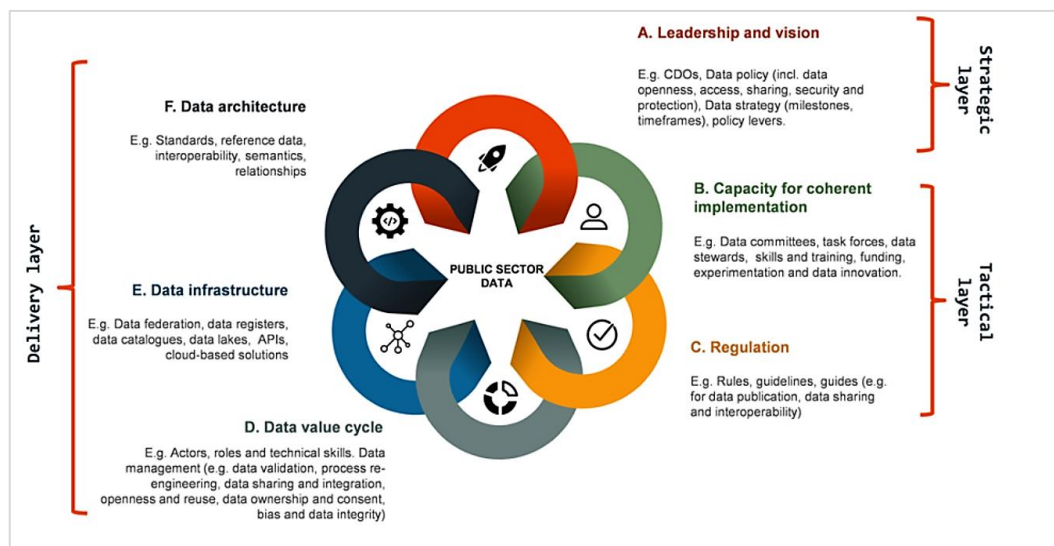
Data governance is defined by OECD as the "arrangements, including technical, policy, regulatory or institutional provisions, that affect data and their creation, collection, storage, use, protection, access, sharing and deletion across policy domains and organisational and national borders". (OECD, 2022)

The report of OECD, "The Path to Becoming a Data-Driven Public Sector", reveals to us that "good data governance can contribute to setting a common vision; enhancing coherent implementation and co-ordination; and strengthening the institutional, regulatory, capacity and technical foundations to better control and manage the data value cycle, i.e. collect, generate, store, secure, process, share and reuse data, as means to enhance trust and deliver value". (OECD, 2019)

According to European Commission, there are three levels of data governance:

- Strategic, which defines the long-term vision, gives direction, oversees progress, takes strategic decisions, and acts as the highest point of reference for issues and matters related to data governance and data policies;
- Managerial, which is accountable and responsible for developing and implementing data policies at corporate level and local level. It monitors progress, reports to the strategic level and refers to them any issues and matters that are beyond its decision-making power or mandate;
- Operational, where data policies are actually implemented and most decisions about data are taken. Whenever necessary, issues are escalated to the managerial level for resolution. (European Commission, 2020)

OECD developed a model that serves as a foundation to coordinate various data-related efforts across organizational, policy, and technical domains to achieve shared policy objectives (fig. 6).

Figure 6. OECD's Data Governance in the Public Sector Framework

Source: (OECD, 2019).

3. Conclusions

This article highlights the significant importance of data-driven decision-making in public administration, emphasizing the role of data as a valuable asset. With the emergence of big data, advanced analytics, and artificial intelligence, public sector organizations can now optimize decision-making processes to achieve transparency, accountability, and operational efficiency.

Therefore, an enhanced framework for data collection and management is required, one that establishes clear policies for the collection, storage, use, and sharing of data. As observed, open data initiatives also demonstrate the value of providing access to public sector data for reuse, driving innovation, and fostering economic growth.

Beyond its administrative role, data also carries significant economic value. Increasingly recognized as an intangible asset, data contributes directly to competitiveness, productivity, and the emergence of new business models, forming the foundation of the digital economy. According to European Commission estimates, the data economy already represents hundreds of billions of euros annually, confirming that investment in data infrastructures and governance policies generates measurable economic benefits.

While the European Union's progress in open data maturity underscores the collective efforts of member states to improve policies, infrastructure, and data quality, the challenges faced by lower-ranking countries such as Romania, Bulgaria, and Greece emphasize the need for targeted interventions to enhance their open data capabilities.

In conclusion, data-driven public administration represents a paradigm shift in governance, enabling governments to address complex challenges with precision and foresight. By adopting data as a strategic asset, promoting robust governance, and supporting open data initiatives, public sector organizations can achieve greater efficiency, improved responsiveness, and enhanced public trust.

References

- Brynjolfsson, E., Lorin Hit and Heekyung Kim (2011). Strength in Numbers: How does data-driven decision-making affect firm performance?
- Commission, E. (2020). Data governance and data policies, s.l.: s.n.
- Commission, E. (2023). Open Data Maturity Report, s.l.: s.n.
- IBM (2024). What is data governance? [Online] Available at: <<https://www.ibm.com/topics/data-governance>>
- Coyle, D. and Li, W. (2021). The data economy: Market size and global trade. *SSRN Electronic Journal*. Available at: <<https://doi.org/10.2139/ssrn.3973028>> [Accessed 25 August 2025].
- International, D. (2017). Data Management Body of Knowledge Overview of the DMBOK2. [Online] Available at: <<https://www.dama.org/cpages/body-of-knowledge>>
- OECD (2019). The Path to Becoming a Data-Driven Public Sector, s.l.: s.n.
- OECD (2022). Going Digital to Advance Data Governance for Growth and Well-being, s.l.: s.n.
- Parliament, E. (2018). Directive (EU) 2019/1024 of the European Parliament and of the Council. s.n.
- Picciano, A.G. (2012). The Evolution of Big Data and Learning Analytics in American Higher Education. *Journal of Asynchronous Learning Networks*.
- Silva, R.S.S. d., Claudelino Martins Dias Junior and Rogério Tadeu de Oliveira Lacerda (2022). Data-Driven Decision Making in the Public Sector: A Systematic Review. *International Journal of Advanced Engineering Research and Science (IJAERS)*.
- Statista (2025). Value of the data economy in the European Union and the United Kingdom from 2016 to 2025. Available at: <<https://www.statista.com/statistics/1134993/value-of-data-economy-eu-uk/>> [Accessed 25 August 2025].
- Tao Xu, Jianxin You and Hanning Shi and Yongjiang Shi (2023). From data to data asset: conceptual evolution and strategic imperatives in the digital economy era. Emerald Insight.
- Union, E., n.d. The official portal for European data. [Online] Available at: <<https://data.europa.eu/en>> [Accessed December 2024].
- Uzonwanne, F.C. (2016). Rational Model of Decision Making. Global Encyclopedia of Public Administration, Public Policy, and Governance.
- Veldkamp, L. (2023). Valuing Data as an Asset. Review of Finance.