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Evaluating the International Financial Reporting Standards (IFRS) adoption in developing countries: an institutional theory review

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Abstract. *Due to the rising globalization over the last three decades, several nations are searching for internationally standardized financial reporting rules. More uniformity in financial reporting is now desired. The application of institutional theory can lead to a better comprehension of how IFRS Standards are implemented; however, it has been demonstrated that institutional features have a significant influence on social conduct and are hence crucial in characterizing the emerging countries. It follows that it seems reasonable to infer that developing nations would adopt IFRS for objectives beyond economic ones.*

The goal of the current study is to conduct a review of the institutional theory literature with a focus on investigating the application of IFRS in developing countries; particularly the relationships among this theory. A systematic review of the literature was the approach employed, and the main papers were discovered utilizing the following databases: books, the most cited publications, and the Web of Science. Consequently, in the context of accounting systems for developing countries, this research will provide an opportunity to support further studies that foster a greater appreciation for the theoretical contributions' capacity to determine the institutional structure of change procedures associated with the adoption of IFRS.

Keywords: international financial reporting standards (IFRS), institutional theory, developing countries, systematic literature review, Governance.

JEL Classification: M41.

1. Introduction

It has been the International Financial Reporting Standards (IFRS) that managed to accomplish the task of global accounting becoming more consistent rule. The present aim is to make clear why such accounting principles represent the very beginning of the way to the final world-wide recognition of a single set of the international accounting principles. The (IFRS) were introduced in 2001.

In an attempt to achieve credibility, several developing nations have changed their accounting strategies to conform to IFRS because they feel that the nations who achieve so with the greatest level of similarity and transparency are More reputable and, as a result, provide more chances to draw in additional investments, raise the financial excess and attain a greater pace of growth for the economy. The implementation of IFRS still is one manifestation of the worldwide demand for reform that exists in the term of legitimacy and the needs of the major countries. (Mehaoua et.al 2021)

Harmonization is more than just establishing boundaries and eliminating options to promote uniformity in processes; it also entails mixing and merging diverse nations' accounting standards into a coherent whole. Financial statement regulators and preparers, in addition to financial statement consumers, are pressuring financial statement providers to standardize their disparate accounting procedures. Unity is the essence of harmony. Since financial reporting practices differ across international boundaries and there is already variation in accounting as a result of information asymmetry. In order to make the accounting data gathered globally easily comparable, comprehensible, and pertinent for financial decision-making, the fundamental goal of the harmonization of accounting standards is to tear down national borders. (Emovon and Agbo, 2023).

In an effort to find a suitable theory that would help businesses and nations deal with the changing nature of accounting systems. Businesses react to institutional change in order to enhance their legitimacy, and the institutional theory presents appropriate interpretations for these actions. Despite being created and implemented first in modern economies, a number of studies have demonstrated that the institutional theory positively influences the growth of international accounting standards in developing and emerging economies. Because it incorporates economic theory with cultural, social, political, and technical fields, institutional theory is appealing because it provides a much wider reach within the social sciences. (Sellami and Gafsi, 2019)

As a result, this study aims to provide a thorough assessment of the institutional theory literature with a particular focus on developing countries that have adopted IFRS. Three mains research questions are looked at in this paper:

1. From an institutional theory views, what has scholarly research affected the adoption of IFRS in developing nations?
2. Which the kinds of institutional theory were they for?
3. What the potential benefits are wanted to be contributed to the body of literature by a discussion of institutional theory?

Upon the beginning of it, the research goes conducted in this manner: The first section covers the introduction to this topic. Section two explains the data and techniques used in the present study. Section three provides an overview of the literature; more information about an institutional approach to the process of accounting harmonization, and articles concerning research performed in developing nations. Final section provides conclusions and suggestions for further investigation.

2. Research methodology

Our study contribution is expanding knowledge on the adoption of IFRS in developing countries. This raises some methodological issues related to emerging economies. Reviewing IFRS research in developing nations (Boolaky et.al. (2020). The Internet's Library of Science archives have been utilized in this research for both article reviews and search procedures.

In order to choose pertinent articles on the implementation and utilization of (IFRS) in developing nations from the standpoint of institutional theory approach, a methodical research a systematic review was performed. One of the most essential processes in developing research is recognizing the body of knowledge in a subject of institutional theory, which is aided by a comprehensive literature evaluation. (Antônio & Luciane, 2022). Using an organized review of literature helps to provide an overview of the area by considering key points, the area's current direction, potential problems, and the path for further study.

These were the particular objectives of this research:

- to determine how academic studies influenced the adoption of IFRS in emerging countries, from the perspective of institutional theory;
- to be aware of the types of institutional theory that functioned;
- to be aware of the potential benefits that an analysis of institutional theory could provide to the library of literature.

3. Review of Literature

3.1. The institutional theory (definition and approaches)

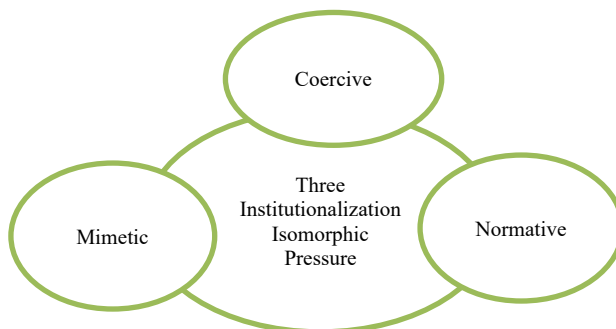
Institutional theory has its origins in the authority and approval of specific organizational procedures, which are consequently embraced to deal with the environmental challenges of competition. This means that it forecasts that organizations will often copy the conduct standards of other businesses in the sector (Cardona et.al 2020). At the foundation of institutional theory is the concept of institutionalism that looks for the reasons behind why organizations do what they do, includes methods and techniques that are outlined by the ideas that are prevalent in the workplace and have been institutionalized in society. An

effective and well-liked explanatory technique for examining organizational behavior and development is institutional theory. The new institutionalism lays a strong focus on the formative function of institutions, while classic views emphasize the assumption that individuals, rational agents, and their own preferences and interests govern organizations.

The institutional theory possesses two approaches – old institutional theory, and new institutional theory – it can be predicted that, in an environment where isomorphism exists, institutions will typically adhere to the same standards and practices when it comes to recording and disclosing accounting information. With its integrated emphasis on the external force of the environment by isomorphic forces and social legitimacy regarding compliance, institutional theory has been the most widely employed theoretical foundation (Guerreiro et al., 2020).

The concept known as organizational isomorphism refers to the efficient process by which organizations undergo institutionalization. The uniformity of techniques, procedures, and management employed by organizations is the cause of these phenomena. Three different forms of institutional isomorphism are shown in figure 1. These can either greatly benefit enterprises or lead to isomorphic dilemmas that obstruct their growth. Specifically, their name is: coercive, mimicking, or standard. (Vailson and Marco. 2021)

Figure 1. *Institutional Isomorphism Mechanisms*



Source: Che Zuriana et.al 2015.

Thus, the first category of isomorphism is coercive isomorphism, which describes the power that laws, conventions, and governmental bodies have on organizations; the outcomes of official or informal pressures give rise to the pressures primarily associated with concerns of political power and legitimacy. Mimetic isomorphism is the second form of isomorphism. It happens when an entity seeks outside itself for instances of prudence because it feels that it lack certain suitable characteristics inside itself. The creature then tries to internalize the traits it sees in the other entity. Conversely, normative isomorphism, the third kind of isomorphism, is typically employed by those with an interest in the organization, both internal and external, with the goal of achieving maximum efficiency and professionalization. (Nguyen 2022)

3.2. The implications of institutional theory upon IFRS

Understanding how IFRS have evolved into the world's accounting standard is made easier by the institutional theory framework. As a result, the requirements of financial statements' major users are going to be better met. (Mantzari et.al 2017)

Regardless of their true value, institutional practices like IFRS-based accounting structures may be embraced in order to gain external credibility. Improved social acceptance and legitimacy from other nations, as well as enhanced reputation of domestic enterprises, are significant anticipated effects of IFRS. It is believed that concerns about social legitimacy and the desire to realise significant economic gains are what drive institutional reform. Therefore, resistant techniques are likely to be used when it is anticipated that complying with institutional constraints would have positive effects on the economy and legitimacy. On the other hand, organisations are more likely to compromise on conformity requirements or manipulate the criteria or conditions of conformity when adhering to institutional practices is thought to yield minimal benefits in terms of money and legitimacy. It is in this regard that the adoption of IFRS by numerous countries and organisations has been encouraged. (Ana Paula, 2023)

by the anticipated gains in legitimacy and economy. Economic and efficiency themes were central to the reasoning behind the introduction of IFRS. Remarkably, the market orientation of IFRS drives its purported economic (ideological) benefits, satisfying the information needs of capital market players. Economic rationale and the belief that more relevant, comparable, and transparent financial reporting will result from stricter quality-usefulness requirements are what motivate the adoption of IFRS. More access and lower capital costs, as well as improved integration of the domestic and global financial markets, are among the financial advantages of implementing IFRS that are frequently mentioned in the literature. reduced expenses associated with processing financial data for the world's capital markets, increased foreign investment (Akisik, 2020), and encouragement of faster economic expansion.

Subsequent contributions to institutional theory introduced the notion of institutional logics, in addition to surpassing the notion of organizational passivity (Abramson et al., 2023). Consequently, the significance of institutional logics – broader cultural practices and ideas that influence individual and organizational behavior – is used for clarification of resistance to change and offers insights into the emergence of organizational heterogeneity and disconnection.

Several institutional studies on international accounting research. For example, Nguyen 2022, In his PhD thesis, he explored the effects of change, particularly the implementation of IFRS in Vietnam in 2025, and provide practical strategies for facilitating this transition within the context of Vietnamese Higher Education of Accounting. For this study, the researcher used a mixed-method approach, combining interviews that were semi-structured along with content evaluation as two qualitative methodologies. the researcher relies on the

Institutional Theory in order to understand whether the IFRS became beneficial for foreign-headquartered firms. When assessing the effectiveness of university-level IFRS learning and preparation techniques. The main conclusions of this research were:

- The content analysis result indicated that a smaller number of the courses under "IFRS" or Worldwide Accounting Standards had a greater degree of emphasis.; Furthermore, in response to the impending IFRS job market, students become familiar with how to employ certain international accounting standards for particular company situations – a skill that most students find daunting.
- The interview data indicates that the adoption of IFRS happens continuously, beginning with particular company categories. More likely bigger organization's first, such those that are publicly traded or have foreign investment. The participants stated that IAS are helpful for controlling accounting procedures and boosting transparency.

4. The employing of institutional theory and its effects on (IFRS) in developing nations

International accounting holds that any country has distinctive regulatory structures that set its accounting procedures apart from those of other nations. Accounting procedures are developed on the foundation of institutional considerations (Tahat et al. 2018). Organizational behavior concept has compelled businesses to use new tactics that are required to bridge the gaps between businesses that are attempting to meet these criteria and to reduce the performance gap. Simply saying that something has been practiced is not enough to persuade experts in other domains. Consequently, there is a requirement for logical change that makes it easier for accountants to persuade and comprehend one another.

According to Hassan and Marston (2019), the country's institutional and legitimate variables have a crucial role in shaping the evolution of accounting methods. This research has two main goals: first, it will examine how multiple essential variables (such as the economy, politics, culturally, specific to a nation and accounting regulatory scheme) affect the formation of accounting behaviors; second, it will use institutional theory to demonstrate which these elements affect the results of firms in developing nations.

Developing countries require a system of accounting which can gather all financial data and be used to several levels of economic decision-making. Investors may find it difficult and costly to evaluate and report financial statements that were properly created in compliance with various accounting standards. In an attempt to prove their legitimacy and win acceptance, nations frequently adopt the lowest possible level of formal structures when interacting with other countries.

Adopting the IFRS doesn't improve a country's economic performance; rather, it gives it credibility. Given that nations often follow current regulations and standards, this is identical with the institutional theory. This promotes the broad implementation of internationally recognized systems and practices. (Albu, Albu & Gray 2020). Because of

this, the institutional theory proposes that there is a structural isomorphism, wherein countries begin imitating one another's behavior's without necessarily helping their own economies grow.

A comparative analysis study made by Andrzej and Sarhad, 2022, The purpose of this study aimed to explore the financial effects of IFRS implementation on inflows of foreign direct investment. Over the years 1996–2019, the researchers examined 22 economies comprising the Middle East and North Africa. The Eclectic Perspective technique is used in the study, and it is expanded to incorporate a number of institutional quality measurements. The study demonstrated statistically significant evidence that foreign direct investment (FDI) is positively related to IFRS adoption; When comparing the results of the study to the countries in the Middle East and North Africa countries indicated a strong positive and statistically substantial relationship. Furthermore, the results demonstrated that, in the Middle East and North African nations, institutional quality characteristics including political stability and government efficacy have played an essential part in determining foreign direct investment.

Leah and Ryan (2018), examining the impact of making the adoption of IFRS mandatory for publicly traded enterprises within certain developing nations. The study adopts an innovative method to look at how business executives observe financial reporting quality and market availability following the implementation of IFRS. Eight nations from Asia, Africa, and Latin America are included in the study's sample. The study found that the adoption of IFRS had a beneficial impact on three survey factors linked to accounting across eight different developing nations. The variables represent how executives and business leaders view the financial reporting situation in each nation.

In Africa; Boolaky et.al. (2020), explore the institutional forces (coercive, mimetic, and normative) supporting the International Financial Reporting Standards (IFRS); this investigation included 54 African nations between 2010 and 2015.

According to the results of the study. the following neo-institutional theoretical forecasts were noticed: (coercive, mimetic, and normative isomorphism) The impact on Africa's adoption of IFRS, even though the isomorphic pressure connections are different from those found in earlier research on adoption in developing nations and globally. Particularly, the supporting evidence of the Global Bank's and the IMF's effect on African nations that was included in the evaluation program for the Report on The Compliance of Standards and Codes-Accounting and Auditing. Additionally, the study discovered that a nation's choice to embrace IFRS is highly correlated with the existence of worldwide audit firms and the length of time that a member has been a member of the International Federation of Accountants; nations that have more organized and successful professional accounting organizations have higher adoption rates for IFRS.

5. Conclusions

A considerable amount of researches on institutional theory and IFRS has provided substantial understanding through the significance of claims for authority, creative techniques, strategic approaches and especially emerging nations, appreciate IFRS because of its significant economic advantages.

Two approaches for IFRS adoption research were reviewed in this study: the first covers IFRS adoption in developing nations, and the second discusses institutional theory review with regard the isomorphism and logical concepts, that's are primarily employed for clarifying the modifications in global financial reporting.

It is observed that the link between the adoption of IFRS and institutional theory is at a significant point. However, the findings of the literature presently in publication demonstrate that institutional theory and interpretations maintain institutions using collaborative opinions, and creativity, using an analytical and pragmatic approach, recognizes the adoption of isomorphic ways to acquire legitimacy. Additionally, it has been shown that the majority of articles with an effect factor were produced in Europe and emerging nations, and that institutional theory is important for appreciating advancements. Because of the appropriate societal forces, the IFRS requirements will enhance the financial reports' quality, similarity, and accessibility. In addition, the new principles aim to provide benefit. The Institutional Theory framework illustrates how norms regulated by being institutionalized and integrity express the interactions between institutions.

Finally, this paper reviewed the major developments in the field of institutional theory and the implementation of IFRS in countries that are evolving in order to provide new viewpoints and a convincing theoretical base. Based on the legitimacy assumption, the implementation of IFRS has been thoroughly researched, with isomorphism and institutional forces serving as the primary academic tools. To aid in the comprehension of principles. As future research, the author offer theoretical insights on how to distinguish formal from informal institutions as well as culturally oriented sorts of organizations.

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Analyzing the impact of oil price fluctuations on economic growth in Algeria: an empirical study

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Abstract. *This study examines the effect of oil price fluctuations on economic growth in Algeria from 1973 to 2023. Using the Autoregressive Distributed Lag (ARDL) model and the Zivot-Andrews (ZA) structural break test for unit roots, the results confirm a long-run relationship between the variables. A 1% increase in oil prices is associated with a significant 1.05% rise in economic growth. However, the model also reveals a delayed negative impact from lagged oil price changes, indicating that price volatility can lead to economic instability. These findings underscore the critical importance of oil price stability for sustainable economic development in Algeria.*

Keywords: Oil Prices, Economic Growth, Zivot-Andrews Test, ARDL Cointegration, Algeria.

JEL Classification: Q43, O13, F43.

1. Introduction

The impact of oil price fluctuations on economic growth has been a topic of extensive study, as oil is a critical input for modern economies. The relationship between oil prices and economic growth is complex and multifaceted, encompassing various theories and empirical observations. This narrative will delve into the theoretical frameworks, channels of influence, the distinction between oil-exporting and oil-importing countries, and a comprehensive literature review that synthesizes findings from numerous significant studies. The study of oil price fluctuations and their impact on economic growth is grounded in several theoretical frameworks. One prominent theory is the supply-side economics perspective, which posits that changes in oil prices directly affect production costs. According to this view, an increase in oil prices raises the cost of production, leading to higher prices for goods and services, and ultimately dampening economic growth. Contrarily, a decrease in oil prices can lower production costs, stimulate economic activity, and boost growth (Agboola, Chowdhury and Yang, 2024). Another foundational theory is the demand-side perspective, which focuses on how oil price changes influence consumer and investment demand. Higher oil prices can reduce disposable income and increase the cost of energy and transportation, thereby lowering consumption and investment (Gadea, Gómez-Loscos, and Montañés, 2016; Akinsola and Odhiambo, 2020).

Oil price fluctuations can affect economic growth through various channels. One such channel is the production cost channel, where changes in oil prices influence the cost structure of firms, particularly those heavily reliant on energy inputs. This, in turn, affects their output, pricing strategies, and profitability (Taghizadeh-Hesary and Yoshino, 2015). Inflation is another critical channel, as oil price increases can lead to higher overall price levels, affecting purchasing power and consumption patterns. Additionally, oil price volatility can lead to uncertainty and affect investment decisions, with businesses potentially delaying or canceling planned investments due to unpredictable future costs. Furthermore, oil price changes can impact government budgets, particularly in oil-exporting countries where oil revenues constitute a significant portion of public revenue. Fluctuations in these revenues can lead to fiscal instability and affect public investment and spending (Idrisov, Kazakova and Polbin, 2015). The distinction between oil-exporting and oil-importing countries is crucial in understanding the differential impact of oil price fluctuations. In oil-exporting countries, higher oil prices typically boost economic growth by increasing export revenues and improving trade balances. These revenues can be used to fund public spending and investment, further stimulating the economy. Conversely, oil-importing countries often experience a negative impact from rising oil prices, as these increase import bills and can lead to trade deficits (Akinsola and Odhiambo, 2020; Deyshappriya, Rukshan, and Padmakanthi, 2023). The differential impact underscores the importance of considering the specific economic context of each country when analyzing the effects of oil price changes.

The literature on the relationship between oil prices and economic growth is extensive and diverse. The seminal work by Hamilton (1983) was one of the first to document the significant impact of oil price shocks on the US economy, highlighting that oil price increases were followed by recessions (Charfeddine, Klein and Walther, 2020b). This study

laid the groundwork for numerous subsequent analyses. For instance, the work of Barsky and Kilian (2004) explored the historical role of oil price shocks in economic fluctuations, concluding that such shocks had significant macroeconomic consequences. Similarly, Blanchard and Gali (2007) examined the changing impact of oil price shocks over time, noting that while the impact had diminished in recent decades, it remained non-trivial (Akinsola and Odhiambo, 2020).

Empirical analyses have further elucidated the nuanced effects of oil price changes. Studies like those by Lee, Ni, and Ratti (1995) and Bernanke, Gertler, and Watson (1997) have quantified the effects of oil price volatility on economic activity, finding that volatility often exacerbates the negative impacts of oil price increases (Deyshappriya, Rukshan and Padmakanthi, 2023). Research by Jimenez-Rodriguez and Sanchez (2005) compared the impact of oil price shocks on different countries, concluding that the effects varied significantly based on the structural characteristics of each economy. More recently, studies by Kilian and Park (2009) have incorporated advanced econometric techniques to distinguish between different types of oil price shocks and their distinct effects on economic growth. The asymmetric effects of oil price changes have also been a focus of many studies. Mork (1989) was among the first to suggest that oil price increases and decreases might have different impacts on economic growth (Jiménez-Rodríguez and Sánchez, 2005). This hypothesis has been supported by subsequent research, such as the work of Lardic and Mignon (2006), which found evidence of asymmetry in the oil price-growth relationship in both developed and developing countries (Abdelsalam, 2023). Furthermore, studies by Hamilton (2003) and Kilian (2008) have refined our understanding of the dynamics at play, suggesting that the response of economies to oil price shocks depends on various factors, including the underlying cause of the price change.

The impact of oil price fluctuations is also mediated by the institutional and policy environment. Research by Ramey and Shapiro (1998) indicated that the strategic responses of firms and policymakers could mitigate or amplify the effects of oil price changes (Abdelsalam, 2023). For instance, countries with strong monetary policy frameworks and flexible exchange rates may be better equipped to absorb oil price shocks without severe economic disruption. Additionally, the presence of energy subsidies, as examined by Coady et al. (2017), can alter the transmission mechanism of oil price changes, particularly in developing countries. The role of financial markets in transmitting the effects of oil price changes has been explored by studies like those of Sadorsky (1999) and Hamilton and Herrera (2004). These works found that oil price fluctuations could significantly affect stock and bond markets, influencing wealth and investment decisions. Moreover, recent research by Basher and Sadorsky (2006) has highlighted the spillover effects of oil price shocks on emerging markets, illustrating the global interconnectedness of financial and commodity markets. The impact of oil price fluctuations on inflation and monetary policy has also been extensively analyzed. Studies by Hooker (2002) and Blanchard and Gali (2010) have shown that oil price shocks can influence inflation expectations, complicating the task of central banks. The work by Bjørnland (2009) and others has further demonstrated that the monetary policy response to oil price shocks can significantly influence their ultimate impact on economic growth.

The heterogeneity of the impact across different sectors of the economy has been another area of interest. Kilian and Murphy (2014) found that while some industries, such as transportation and manufacturing, are highly sensitive to oil price changes, others like the service sector are less affected. This sectoral variation suggests that the overall economic impact of oil price fluctuations depends on the structural composition of the economy (Farhad Taghizadeh-Hesary, 2016). The relationship between oil prices and economic growth has also been explored from a geopolitical perspective. Studies by Berument, Ceylan, and Dogan (2010) examined how geopolitical events that affect oil supply can lead to price spikes and economic disruptions. The work of Baumeister and Peersman (2013) further highlighted the role of geopolitical tensions in driving oil market volatility and its economic consequences. More recently, the focus has shifted towards understanding the long-term implications of oil price fluctuations. Studies by Aastveit, Bjørnland, and Thorsrud (2015) have suggested that sustained high oil prices can lead to structural adjustments in the economy, such as increased investment in energy efficiency and alternative energy sources. This perspective aligns with the findings of Van de Ven and Fouquet (2017), who argued that prolonged periods of high oil prices could accelerate the transition towards a more sustainable energy system (Gadea, Gómez-Loscos and Montañés, 2016).

In conclusion, the extensive body of literature on the impact of oil price fluctuations on economic growth underscores the complexity of this relationship. While the theoretical frameworks provide a foundation for understanding the various channels of influence, empirical studies highlight the nuanced and context-dependent nature of these effects. The differential impact on oil-exporting and oil-importing countries, the asymmetric effects of price changes, and the role of institutional and policy environments are all critical factors that shape this relationship.

In the context of the Algerian economy, the impact of oil price fluctuations on economic growth is pivotal due to the country's heavy reliance on hydrocarbon revenues. Algeria's economy is predominantly driven by its oil and gas sector, historically constituting about 60% of government revenues and 95% of export earnings (World Bank, 2023). From 1970 to 2023, the hydrocarbons sector contributed an average of 30% to the country's GDP, underscoring its significant role in shaping macroeconomic indicators (OPEC, 2022). Throughout this period, Algeria has navigated through various oil price cycles, each leaving a profound impact on its economic trajectory. The oil boom of the 1970s, characterized by prices rising to approximately \$12-25 per barrel, fueled substantial economic expansion and ambitious public investment programs (IEA, 2021). Conversely, the 1986 oil price collapse, with prices plummeting below \$10 per barrel, triggered severe fiscal deficits and economic contraction, highlighting the vulnerability of Algeria's economy to external shocks. Another surge in oil prices during the 2000s significantly bolstered Algeria's fiscal position, leading to the accumulation of substantial foreign reserves, which peaked at \$194 billion in 2013 (IMF, 2013). However, the subsequent downturn in oil prices after 2014, dropping to around \$30 per barrel, exposed structural weaknesses, resulting in a slowdown in GDP growth from 4.0% in 2014 to 1.4% in 2019 (World Bank, 2019). This period also witnessed increased inflation rates and rising unemployment, particularly among the youth, reaching 29.5% by 2019 (ILO, 2019). Despite efforts at economic diversification, Algeria's

economy remains vulnerable to oil price volatility. The COVID-19 pandemic in 2020 exacerbated these challenges as global oil demand plummeted, causing Algerian oil revenues to decline by approximately 30% (OPEC, 2020), and GDP contracted by 5.5%, highlighting the profound impact of global oil market dynamics on national economic performance (World Bank, 2021).

The nexus between oil price fluctuations and economic growth in Algeria has been extensively examined through a multitude of econometric approaches, consistently revealing the profound influence of petroleum market dynamics on the country's macroeconomic performance. A preponderance of studies employs Vector Autoregressive (VAR) models to elucidate this relationship, with Benbouziane et al. (2022) and Benramdane (2017) demonstrating Algeria's acute susceptibility to global oil price volatility. Benramdane's findings are particularly salient, suggesting that the deleterious growth effects of oil price volatility have effectively neutralized the putative benefits of the oil boom, thereby elucidating the "resource curse" paradox in the Algerian context. This vulnerability is further corroborated by Bensafta (2022), who, through a more granular analysis, delineates the asymmetric impact of oil price shocks on various sectors of the Algerian economy. The study's revelation of the hydrocarbon sector's rapid response to price shocks (within 1-2 quarters) juxtaposed against the lagged effect on other sectors (5-7 quarters) underscores the pervasive influence of oil price fluctuations throughout the economic fabric of Algeria. Complementing these findings, Guechari (2018) and Dahmani et al. (2022) employ non-linear models to capture the nuanced, asymmetric nature of oil price effects. Their research collectively suggests that while the direct impact of oil price shocks on macroeconomic variables may be relatively constrained, the economy exhibits a heightened sensitivity to positive oil shocks, manifesting in both short-term volatility and long-term growth patterns.

The long-term ramifications of oil price fluctuations on Algeria's economic trajectory are further elucidated through cointegration analyses and global comparative studies. Laourari and Gasmi (2016), utilizing the Johansen multivariate cointegration approach, uncover a negative long-run impact of unexpected oil revenue shifts on Algeria's economic and industrial growth. This finding is contextualized within a broader regional framework by Olayungbo and Umechukwu (2022), whose global vector autoregression model highlights the asymmetric effects of oil price shocks across oil-exporting African nations, with Algeria exhibiting particularly pronounced sensitivity to positive price shocks. The heterogeneity of responses among oil-exporting economies is further emphasized by Monesa and Qazi (2013) and Berument and Ceylan (2010), whose comparative analyses underscore the idiosyncratic nature of Algeria's oil price-growth dynamics within the MENA and OPEC contexts. Abdelsalam's (2023) panel quantile regression approach offers additional granularity, delineating the dichotomous effects of oil price changes and volatility on oil-exporting versus oil-importing MENA countries, with Algeria's growth positively correlating with price increases but negatively impacted by volatility.

The literature also provides insights into the transmission mechanisms and policy implications of oil price fluctuations in Algeria. Amroun and Smaali (2022) and Lacheheb and Sirag (2019) examine the inflationary consequences of oil price shocks, revealing

asymmetric pass-through effects that necessitate nuanced policy responses. Chelghoum, Boumimez, and Alsamara (2023) elucidate the role of money demand as a conduit for oil price shocks, highlighting the imperative for monetary policy calibration in light of asymmetric oil price-money demand dynamics. Sadeghi (2017) and Rotimi and Ngalawa (2017) underscore the significance of fiscal policy and government size in modulating the economy's response to oil price shocks, while Bouchaour and Al-Zeaud (2012) provide a long-term perspective on the multifaceted impacts of oil price distortions on various macroeconomic indicators. Collectively, these studies underscore the critical need for economic diversification, as articulated by Moawad Ahmed (2016), to mitigate Algeria's vulnerability to oil price volatility and achieve sustainable economic growth. The consensus emerging from this corpus of research is clear: Algeria's heavy reliance on hydrocarbon revenues engenders significant macroeconomic instability, necessitating a comprehensive strategy of economic diversification and judicious fiscal and monetary policies to navigate the vicissitudes of global oil markets.

From a historical perspective, studies have shown that fluctuations in oil prices between 1970-2023 were linked to significant disruptions in Algeria's GDP growth rate, highlighting the strong correlation between the country's economic performance and global energy markets. This historical sensitivity to oil price volatility continues to be relevant, as indicated by recent economic data and future projections. The World Bank's Spring 2024 Algeria Economic Update reported a robust 4.1% GDP growth in 2023, driven by strong performances across both hydrocarbon and non-hydrocarbon sectors, with record-high natural gas production mitigating the impact of declining crude oil production due to voluntary OPEC quota reductions (World Bank Group, 2024). However, despite this positive performance, Fitch Solutions has projected a slowdown in economic growth from 2.9% in 2023 to 1.8% in 2024, primarily due to anticipated reductions in hydrocarbon production resulting from OPEC+ quotas, aging oil fields, and insufficient investment in new capacity (Fitch Solutions, 2024). This contrast between recent growth and future projections underscores a key challenge for Algeria: while the country has demonstrated resilience and growth, particularly within its hydrocarbon sector, it remains highly vulnerable to external factors, particularly fluctuations in global oil prices. This ongoing vulnerability accentuates the urgent need for economic diversification and structural reforms to ensure sustainable growth amidst the volatility of global energy markets.

Collectively, these studies present a multifaceted view of how oil price volatility affects Algeria's economic landscape. The incorporation of both historical and contemporary analyses offers a comprehensive understanding of the complex interdependencies between oil prices and economic growth in Algeria, underscoring the necessity for strategic economic diversification and robust fiscal policies to cushion against global oil market fluctuations. The remainder of this paper is structured as follows: Section 2 elaborates on the research methodology, while Section 3 presents the empirical results accompanied by a thorough discussion.

2. Research Methodology

2.1. Model Specification

For this study, an econometric model has been developed to examine the impact of oil price fluctuations on economic growth in Algeria. The model employs the logarithm of GDP per capita (LNGDPPC) as the dependent variable, reflecting economic growth. The independent variables include the logarithm of nominal oil prices (LNOP), Broad Money to GDP Ratio (LNM2), inflation rate (LNIR), nominal exchange rate of the Algerian dinar against the US dollar (LNER), and trade openness (LNT0). The model is specified as follows:

$$LNGDPPC_t = \beta_0 + \beta_1 LNOP_t + \beta_2 LNM2_t + \beta_3 LNIR_t + \beta_4 LNER_t + \beta_5 LNT0_t + \varepsilon_t$$

where: $LNGDPPC_t$ is the natural logarithm of GDP per capita at time t , $LNOP_t$ is the natural logarithm of oil prices at time t , $LNM2_t$ is the natural logarithm of money supply at time t , $LNIR_t$ is the natural logarithm of the inflation rate at time t , $LNER_t$ is the natural logarithm of the exchange rate at time t , $LNT0_t$ is the natural logarithm of trade openness at time t , β_0 is the intercept term, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ are the coefficients of the independent variables, ε_t represents the error term.

2.2. Data

The study utilizes annual time series data spanning from 1970 to 2023. The data for all variables, except oil prices, have been sourced from the World Bank database. The data on oil prices has been obtained from the OPEC database. The use of a comprehensive dataset over an extended period facilitates a robust analysis of long-term trends and relationships.

2.3. Estimation Technique

The Autoregressive Distributed Lag (ARDL) bounds testing approach will be employed to examine the cointegration relationship among the variables. This method is suitable given the mixed order of integration of the variables ($I(0)$ and $I(1)$). The ARDL model specification will allow for the assessment of both short-term dynamics and long-term equilibrium relationships.

2.4. Unit Root Test

To ensure the reliability of our econometric analysis, we begin by examining the stationarity of the time series data using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. These tests are crucial for identifying the presence of a unit root in the series, which indicates non-stationarity. The ADF test, an extension of the Dickey-Fuller test, accounts for higher-order autocorrelation by adding lagged difference terms of the dependent variable, thereby stabilizing the error term. Complementing this, the PP test addresses serial correlation and heteroskedasticity in the error terms by employing a non-parametric correction, making it robust to a broader range of issues encountered in real-world data. Both tests are applied to the series in levels and first differences to determine whether the series are integrated of order zero, $I(0)$, or one, $I(1)$. The outcomes of these tests form the foundation for further analysis, guiding us toward appropriate modeling techniques.

While the ADF and PP tests provide initial insights into the stationarity properties of the data, they may be limited in their ability to detect structural breaks, which are common in macroeconomic time series due to events like oil price shocks or policy changes. To address this, we incorporate the Zivot-Andrews test, which allows for an endogenous determination of a single structural break in the series. This test enhances the robustness of our analysis by acknowledging potential shifts in the underlying data-generating process. By integrating the Zivot-Andrews test, we ensure a more comprehensive understanding of the stationarity characteristics of our time series, thereby refining the econometric modeling of the relationship between oil price fluctuations and economic growth in Algeria.

2.5. ARDL Approach

The Autoregressive Distributed Lag (ARDL) model, introduced by Pesaran and Shin (1997) and later expanded by Pesaran, Shin, and Smith (2001), has been widely employed in econometric analyses to explore both short and long-run dynamics among variables irrespective of whether the underlying variables are $I(0)$, $I(1)$, or fractionally integrated (Narayan, 2005). This flexibility makes the ARDL model particularly suitable for our study on the impact of oil price fluctuations on economic growth in Algeria. In our research, the dependent variable is the natural log of GDP per capita (LNGDPPC). The independent variables include oil prices along with several control variables. These comprise the natural logarithms of oil prices (LNOP), money supply (LNM2 - proxied as M2), inflation rates (LNIR), nominal exchange rates (LNER), and trade openness (LNTO). These variables are selected based on their theoretical and empirical relevance to economic growth, particularly in an oil-dependent economy such as Algeria. The functional form of the ARDL model can be expressed as:

$$\begin{aligned} \Delta LNGDPPC_t = & \alpha_0 + \sum_{i=1}^p \alpha_i LNGDPPC_{t-i} + \sum_{j=0}^{Q_1} \beta_j \Delta LNOP_{t-j} + \sum_{k=0}^{Q_2} \gamma_k \Delta LNM2_{t-k} \\ & + \sum_{n=0}^{Q_3} \delta_n \Delta LNIR_{t-n} + \sum_{m=0}^{Q_4} \vartheta_m \Delta LNER_{t-m} + \sum_{\rho=0}^{Q_5} \theta_\rho \Delta LNTO_{t-\rho} \\ & + \varphi_1 LNGDPPC_{t-1} + \varphi_2 OP + \varphi_3 LNM2_{t-1} + \varphi_4 LNIR_{t-1} + \varphi_5 LNER_t \\ & + \varphi_6 LNTO_t + \varepsilon_t \end{aligned}$$

where Δ denotes the first difference operator, and $(p, Q_1, Q_2, Q_3, Q_4, Q_5)$ are the optimal lag lengths determined by information criteria such as AIC or BIC.

The ARDL bounds testing approach encompasses several key steps: First, the unrestricted error correction model (UECM) is estimated using ordinary least squares (OLS). Next, a bound test for cointegration is conducted using an F-test to determine the joint significance of the lagged level variables (i.e., Q_1, Q_2, Q_3, Q_4, Q_5). The null hypothesis ($H_0: Q_1 = Q_2 = Q_3 = Q_4 = Q_5 = 0$) of no long-run relationship is tested against the alternative hypothesis ($H_1: Q_1 \neq Q_2 \neq Q_3 \neq Q_4 \neq Q_5 \neq 0$). The computed F-statistic is then compared with critical value bounds provided by Pesaran et al. (2001) to determine the presence of a cointegrating relationship. If the F-statistic exceeds the upper bound, we reject the null hypothesis, confirming the presence of a cointegrating relationship (Narayan, 2004). If it

falls below the lower bound, we fail to reject the null hypothesis. If it lies between the bounds, the test is inconclusive. If cointegration is established, the analysis proceeds in two key steps. First, the long-run equation is derived by extracting the long-run coefficients from the specified ARDL model, normalizing on LNGDPPC (the natural log of GDP per capita). This equation reveals the long-term relationships between the dependent variable and the independent variables. Second, the short-run dynamics are examined, which are captured by the coefficients of the first-differenced variables in the ARDL model. Crucially, this short-run model includes an error correction term (ECT), which represents the speed at which the system adjusts to restore long-run equilibrium following a short-term shock. The ECT coefficient indicates how quickly deviations from the long-run equilibrium are corrected, providing insight into the stability and adjustment process of the economic system under study.

The ARDL model's strength lies in its ability to handle variables integrated of different orders ($I(0)$ and $I(1)$), thereby avoiding the pre-testing problems associated with traditional cointegration techniques. This ensures the robustness and reliability of the inferred relationships between oil prices, monetary variables, interest rates, exchange rates, trade openness, and economic growth. On the other hand, the ARDL approach provides a comprehensive framework to analyze the dynamic interactions between oil price fluctuations and economic growth in Algeria, capturing both short-term adjustments and long-term equilibrium relationships, thereby enhancing the empirical robustness of our study.

2.6. Diagnostic Tests

For ensuring the robustness of the econometric model, several diagnostic tests will be conducted, including tests for serial correlation (Breusch-Godfrey Serial Correlation LM Test), heteroskedasticity (Breusch-Pagan test), and normality of residuals (Jarque-Bera test). Additionally, the stability of the long-run coefficients will be tested using the CUSUM and CUSUMSQ tests as outlined in Pesaran et al. (2001).

3. Empirical results and discussion

Table 1. Descriptive Statistics of Study Variables

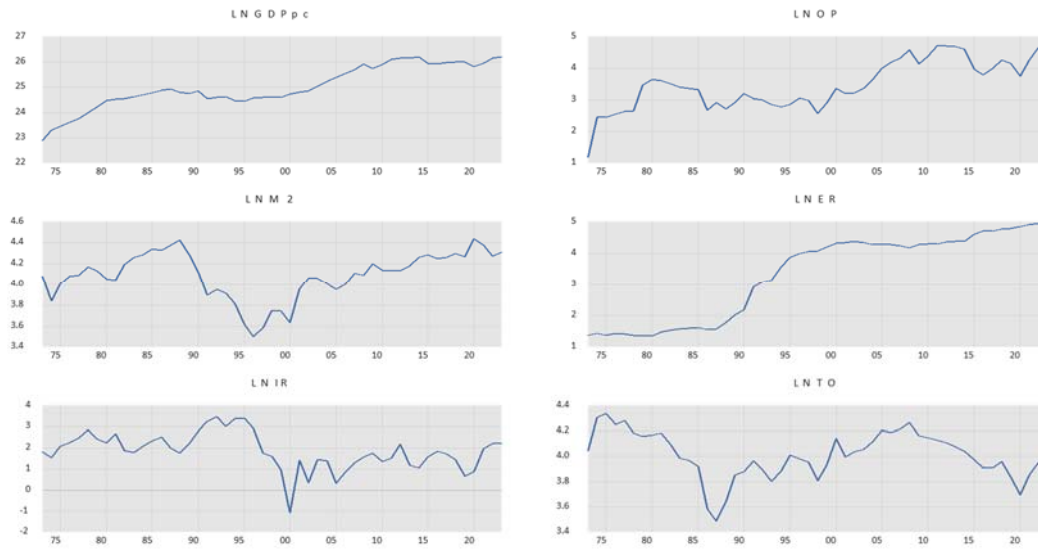
	LNGDPPC	LNOP	LN2	LNIR	LNTO
Mean	25.01038	3.471777	4.089401	3.308472	1.859691
Median	24.80779	3.359264	4.123436	4.073103	1.820159
Maximum	26.20349	4.726680	4.441142	4.955792	3.455359
Minimum	22.88749	1.190888	3.496684	1.344808	-1.081274
Std. Dev.	0.840611	0.769083	0.224925	1.374080	0.859680
Skewness	-0.292769	-0.199840	-0.778561	-0.421154	-0.580137
Kurtosis	2.482512	2.876144	3.088871	1.416740	4.414350
Jarque-Bera	1.297629	0.372056	5.169125	6.834410	7.111566
Observations	51	51	51	51	51

Source: Authors' Calculation.

Analyzing the statistical data on oil price fluctuations and economic growth in Algeria reveals that the Algerian economy experiences significant volatility due to its heavy reliance on oil revenues. The data indicates that oil prices vary greatly, with a range between 1.190888 and 4.726680, reflecting drastic fluctuations driven by geopolitical

tensions and global economic changes. Concurrently, the GDP growth rate per capita ranges between 22.88749 and 26.20349, suggesting that while economic growth in Algeria is notably influenced by these fluctuations, it demonstrates some resilience. A crucial measure in understanding this volatility is the standard deviation, which quantifies the extent of dispersion in the data. High standard deviation in oil prices signifies substantial volatility, and this directly impacts the overall economic stability. For instance, the standard deviation of oil prices and GDP growth rates highlights the irregularity and unpredictability in these metrics, underscoring the economic vulnerability tied to oil dependency.

Figure 1. Annual Trends of Study Variables



Source: Authors' Calculation.

Furthermore, Table 2 presents the correlation matrix, which delineates the nature and strength of the relationships between the variables under investigation, as detailed in the subsequent table.

Table 2. Correlation Matrix of Economic Variables

	LNGDPPC	LNOP	LNM2	LNER	LNIR	LNTD
LNGDPPC	1					
LNOP	0.9109	1				
LNM2	0.4194	0.3483	1			
LNER	0.7709	0.6405	-0.0922	1		
LNIR	-0.3268	-0.3254	-0.0479	-0.4340	1	
LNTD	-0.2102	0.1317	-0.3148	-0.0886	-0.1630	1

Source: Authors' Calculation.

The correlation analysis reveals crucial dynamics affecting economic growth (LNGDPPC) in Algeria. A strong positive correlation (0.91) between oil prices (LNOP) and per capita GDP highlights the essential role of oil revenues in driving economic performance. Additionally, a moderate positive correlation (0.77) with the money supply to GDP ratio (LNM2) underscores the importance of liquidity in supporting growth. Conversely, the

negative correlation with the nominal exchange rate (LNER) (-0.33) suggests that a stronger dinar may impede competitiveness, while the negative relationship with the inflation rate (LNIR) (-0.21) points to the adverse effects of rising inflation on economic stability. Lastly, a weak negative correlation with total trade to GDP ratio (LNT0) (-0.16) indicates potential vulnerabilities linked to external trade reliance. Collectively, these insights emphasize the intricate relationships between oil prices, monetary policy, exchange rates, and inflation, underscoring the need for targeted policy interventions to promote sustainable economic growth in Algeria.

Table 3. ADF and PP Unit Root Tests

Variable	Augmented Dickey-Fuller (ADF) Test			Phillips-Perron (PP) test			Conclusion
	M(5)	M(6)	M(4)	M(5)	M(6)	M(4)	
LNGDPPC	0.0714	0.2370	0.9997	0.1544	0.2013	0.9961	Nanstationary
D (LNGDPPC)	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000	Stationary
LNOP	0.0459	0.0534	0.8743	0.0463	0.0397	0.8850	Stationary
D (LNOP)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-
LN2M	0.5076	0.7524	0.7483	0.5076	0.7524	0.7480	Nanstationary
D (LN2M)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	Stationary
LNER	0.7757	0.4900	0.9605	0.7994	0.8485	0.9743	Nanstationary
D (LNER)	0.0000	0.0046	0.0977	0.0004	0.0029	0.0002	Stationary
LNIR	0.0386	0.0755	0.2359	0.0375	0.0687	0.2359	Stationary
D (LNIR)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-
LNT0	0.2882	0.5481	0.5477	0.2548	0.4520	0.5387	Nanstationary
D (LNT0)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	Stationary

Note **M(6)**: refers to the model with a constant and trend; **M(5)**: refers to the model with a constant; **M(4)**: refers to the model without a constant and trend; **D** denotes the first difference.

Source: Authors' Calculation.

The results of both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for unit roots indicate that the variables LNOP and LNIR are stationary at level (I(0)), while the remaining variables, namely LNRGDPPC, LNM2, LNIER, and LNT0, become stationary after differencing, suggesting they are integrated of order one (I(1)). This consistent finding across both tests highlights that further analysis, such as cointegration tests, is necessary to understand the long-term relationships between these variables. Given these results, employing the Autoregressive Distributed Lag (ARDL) methodology would be appropriate to analyze the impact of oil price fluctuations on economic growth in Algeria and to capture the short and long-term relationships between the model variables.

Table 4. Zivot-Andrews Test for Unit Roots with One Structural Break

Variable	Break Year	Test Statistic	5% Critical Value	p-Value	Lags (k)	Stationarity
lnGDPPC	2003	-4.352	-4.93	0.0003	4	Stable with structural break
lnOP	2004	-5.014	-5.08	0.001	3	Trend-stationary
lnM2	1990	-5.019	-4.93	0.0009	2	Trend-stationary
lnER	1991	-5.217	-4.93	0.0002	1	Trend-stationary
lnIR	1997	-5.966	-5.08	0.0005	3	Trend-stationary
lnTO	1999	-2.535	-5.08	0.058189	2	Non-stationar

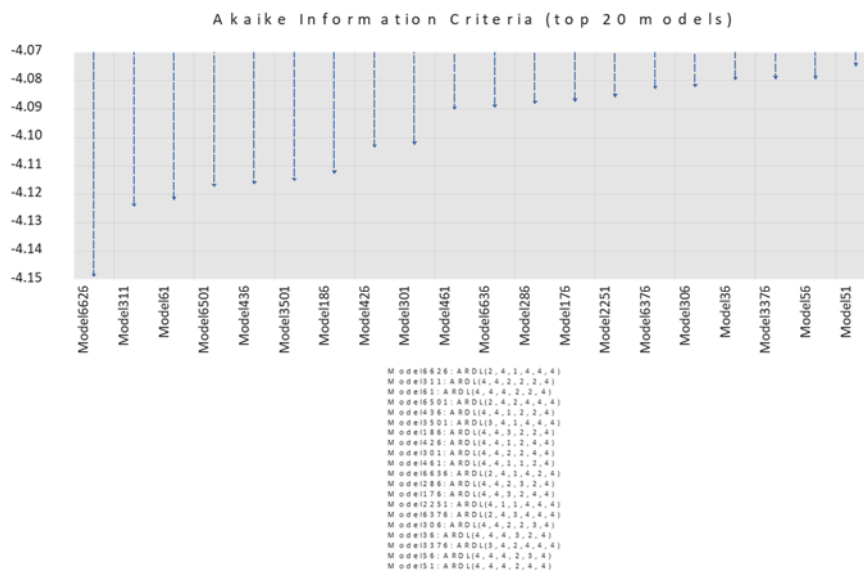
Source: Authors' Calculation.

The Zivot-Andrews tests for Algeria's economic indicators reveal varying degrees of stability. The log per capita GDP shows stability with a structural break in 2003, while the log oil price series (LNOP) is trend-stationary with a break in 2004. The log money supply (LNM2) is trend-stationary with a structural break in 1990, and the nominal exchange rate

(LNER) against the USD is trend-stationary with a break in 1991. The inflation rate (LNIR) is also trend-stationary with a structural break in 1997. However, the trade openness index (LNTO) fails to reject the null hypothesis of a unit root with a structural break in 1999, indicating non-stationarity.

The Zivot-Andrews test results for various economic indicators of Algeria reveal important structural breaks that align with significant economic and political events. The test identifies a structural break in Algeria's log per capita GDP in 2003, likely due to major economic reforms, increased oil revenues, and macroeconomic policies focused on infrastructure and diversification. For the log oil price series (LNOP), a structural break in 2004 corresponds to substantial oil market fluctuations and geopolitical events, alongside government efforts to better manage oil revenues. The log money supply (LNM2) shows a structural break in 1990, reflecting critical economic adjustments and policy shifts during Algeria's transition towards a market economy amidst high inflation. The nominal exchange rate (LNER) against the USD breaks structurally in 1991, in response to the liberalization of exchange rates and significant political changes. The Zivot-Andrews test for Algeria's inflation rate (LNIR) indicates a structural break in 1997, associated with important policy changes and economic events impacting inflation dynamics. Lastly, the 1999 break in trade openness suggests changes in trade policies linked to the rise in oil prices and oil exports, highlighting the significance of the oil sector in the national economy and its impact on governmental trade policies. This notable shift in trade openness in 1999 indicates a reevaluation of the country's official trade policies during that period. The government responded to the substantial impact of high oil prices and exports by revising its trade policies to enhance Algeria's benefits from these economic strengths. However, the series remains non-stationary, indicating persistent effects from external shocks.

Figure 2. Results of the Optimal ARDL Model Selection



Source: Authors' Calculation.

The model selection criteria table reveals that the ARDL(2, 4, 1, 4, 4, 4) model stands out as the best fit for the LNGDPPC data from 1973 to 2023, evidenced by its lowest AIC (-4.148410) and BIC (-3.164289) values. This indicates that this model strikes the optimal balance between goodness-of-fit and complexity, outperforming other tested models. The significantly lower AIC and BIC values suggest superior predictive performance and suitability for capturing the underlying economic dynamics in the given dataset. Consequently, Model (ARDL(2, 4, 1, 4, 4, 4)) is identified as the most effective model for capturing the relationship between oil price fluctuations and economic growth in Algeria, ensuring reliability and precision in the analysis.

Table 5. *Bounds test results*

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Significance	Lower bound value	Upper bound value
F-statistic	14.70086	10%	2.08	3
		5%	2.39	3.38
		2.5%	2.7	3.73
k	5	1%	3.06	4.15

Source: Authors' Calculation.

Additionally, the ARDL bound test for cointegration among these variables is conducted. The results of the F-Bounds Test indicate a strong evidence of a long-run relationship among the variables under consideration. The computed F-statistic is 14.70086, which significantly exceeds the upper critical value of 3.38 at the 5% significance level and also exceeds the critical values at the 1% level (4.15).

Table 6. *Estimated Long-Run Coefficients of ARDL (2, 4, 1, 4, 4, 4) Model*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNOP	1.046863	0.115607	9.055392	0.0000
LNLM2	-1.086112	0.522436	-2.078937	0.0495
LNLER	-0.081623	0.090524	-0.901665	0.3770
LNIR	-0.048831	0.091616	-0.532998	0.5994
LNTOT	-1.472959	0.334445	-4.404186	0.0002
C	32.94698	3.344128	9.852189	0.0000

Source: Authors' Calculation.

The long-term estimation results of the ARDL model reveal significant interactions between various economic determinants and the economic growth (LNGDPPC) in Algeria. The findings indicate that oil prices (LNOP) exhibit a robust positive correlation with economic growth, evidenced by a coefficient of 1.0469. This observation is congruent with established research, including seminal works by Hamilton (1983) and Kilian (2009). Such alignment underscores the considerable influence of oil price fluctuations on the Algerian economy, which is predominantly oil-dependent. Conversely, the coefficient for money supply (LNLM2), recorded at -1.0861, suggests a strong negative relationship, implying that expansions in money supply may adversely impact economic growth. This may reflect the challenges inherent in the Algerian monetary policy framework and its efficacy in fostering economic growth. Additionally, trade openness (LNTOT) demonstrates a significant negative correlation with economic growth, with a coefficient of -1.4730. This negative association points to underlying structural weaknesses within the Algerian trade sector that hinder growth prospects. Moreover, the analysis indicates that inflation rates (LNIR) and

the exchange rate (LNER) do not exhibit statistical significance, implying a negligible or non-existent direct impact on economic growth. These outcomes are consistent with the broader economic literature, which emphasizes the high sensitivity of economies heavily reliant on oil exports to fluctuations in oil prices.

In summary, the ARDL model's long-term estimates elucidate the pivotal role of oil prices in shaping Algeria's economic trajectory, while also highlighting the complex dynamics between monetary supply, trade openness, and economic growth.

Table 7. *Estimated Short-Run Coefficients of ARDL (2, 4, 1, 4, 4, 4) Model*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$\Delta(\text{LN}GDP\text{PC}(-1))$	-0.267487	0.105045	-2.546405	0.0184
$\Delta(\text{LN}OP)$	0.236561	0.022980	10.29428	0.0000
$\Delta(\text{LN}OP(-1))$	-0.014030	0.029400	-0.477224	0.6379
$\Delta(\text{LN}OP(-2))$	-0.053155	0.021686	-2.451131	0.0227
$\Delta(\text{LN}OP(-3))$	-0.070588	0.019223	-3.672127	0.0013
$\Delta(\text{LN}M2)$	-0.381936	0.059179	-6.453941	0.0000
$\Delta(\text{L}NER)$	-0.727783	0.050147	-14.51303	0.0000
$\Delta(\text{L}NER(-1))$	-0.228073	0.090245	-2.527271	0.0192
$\Delta(\text{L}NER(-2))$	-0.024668	0.039423	-0.625738	0.5379
$\Delta(\text{L}NER(-3))$	-0.109026	0.036850	-2.958647	0.0073
$\Delta(\text{L}NIR)$	0.033323	0.005623	5.926661	0.0000
$\Delta(\text{L}NIR(-1))$	0.033272	0.008083	4.116127	0.0005
$\Delta(\text{L}NIR(-2))$	0.012887	0.007542	1.708613	0.1016
$\Delta(\text{L}NIR(-3))$	0.015414	0.006446	2.391233	0.0258
$\Delta(\text{L}NTO)$	-0.192595	0.074872	-2.572322	0.0174
$\Delta(\text{L}NTO(-1))$	0.272932	0.078284	3.486415	0.0021
$\Delta(\text{L}NTO(-2))$	0.050989	0.068966	0.739331	0.4675
$\Delta(\text{L}NTO(-3))$	0.342712	0.063103	5.431005	0.0000
ECT	-0.180137	0.015740	-11.44427	0.0000
R^2	0.979328	Mean dependent var		0.055427
Adj. R^2	0.966039	S.D. dependent var		0.125580
Std. Error	0.023142	Akaike info criterion		-4.403730
Sum squared resid	0.014996	Schwarz criterion		-3.655798
Log likelihood	122.4876	Hannan-Quinn criter.		-4.122278
Durbin-Watson stat	2.149484			

Note: ECT refers to the Error Correction Term, and Δ denotes the first difference

Source: Authors' Calculation.

The analysis of the ARDL Error Correction Model (ECM) reveals the intricate dynamics between oil price fluctuations and economic growth in Algeria. The immediate positive impact of oil price increases on GDP per capita growth is evident from the statistically significant coefficient of the contemporaneous change in oil prices ($D(\text{LN}OP)$). This positive effect underscores Algeria's heavy reliance on hydrocarbon exports as an economic driver. However, the model also uncovers a more nuanced, delayed negative impact from lagged oil price changes. Specifically, the negative coefficients for the second and third lags of oil price changes ($D(\text{LN}OP(-2))$ and $D(\text{LN}OP(-3))$) suggest that price volatility leads to economic instability in subsequent periods. This phenomenon can be attributed to the uncertainty and investment hesitancy caused by fluctuating oil revenues, which aligns with the findings of Cashin et al. (2014) and Ghalayini (2011), who have documented similar delayed adverse effects in other oil-exporting nations.

The ARDL Error Correction Model (ECM) thoroughly elucidates the short-term dynamics of oil price fluctuations on Algeria's economic growth, with GDP per capita as the dependent variable. The significant positive coefficient for contemporaneous oil price changes ($D(LNOP)$) corroborates the immediate stimulative effect of rising oil prices on growth, reflecting Algeria's acute reliance on hydrocarbon exports. This finding is consistent with the resource-based growth hypothesis posited by Auty (1993) and Sachs and Warner (1997), who have established the critical role of natural resources in propelling economic expansion in resource-rich nations. However, the observed negative coefficients for the two- and three-period lags of oil price changes ($D(LNOP(-2))$ and $D(LNOP(-3))$) illustrate the adverse lagged effects of oil price volatility, highlighting an inherent economic instability. This is in line with Hamilton (2003) and Kilian (2008), who have documented similar delayed negative impacts of oil price shocks on macroeconomic performance due to the resultant uncertainty and reduced investment.

Moreover, the model reveals significant negative impacts from other macroeconomic variables such as money supply ($D(LNM2)$) and exchange rates ($D(LNER)$ and $D(LNER(-1))$). The negative relationship between money supply increases and GDP per capita growth suggests potential inflationary pressures or inefficient capital allocation within the economy. Concurrently, the adverse effects of exchange rate depreciation on economic growth resonate with the broader literature on the Dutch disease phenomenon, as highlighted by studies from economists like Sachs and Warner (1995). The model's findings are consistent with the theoretical underpinnings of resource-dependent economies, illustrating how short-term gains from oil price increases can be offset by longer-term economic vulnerabilities. These results highlight the critical need for Algeria to diversify its economic base and stabilize macroeconomic policies to mitigate the adverse impacts of oil price volatility.

Additionally, the model provides insights into the roles of inflation ($D(LNIR)$) and trade openness ($D(LNTO)$) in affecting economic growth. The positive and highly significant coefficients for both current and lagged inflation rates ($D(LNIR)$ and $D(LNIR(-1))$) suggest that moderate inflation can stimulate economic growth by enhancing short-term consumer spending, a phenomenon supported by Barro (1995). In contrast, the effects of trade openness are mixed; the immediate negative impact ($D(LNTO)$) indicates that an initial increase in trade openness might induce competitive pressures that harm domestic industries, which is a short-term adjustment cost. Over time, however, the positive significance of lagged trade openness variables ($D(LNTO(-1))$ and $D(LNTO(-3))$) underscores the long-term benefits of global market integration, leading to enhanced efficiency and sustained growth, aligning with Frankel and Romer (1999).

The significantly negative coefficient of the error correction term (-0.180137) indicates a robust adjustment mechanism, ensuring that short-term deviations from equilibrium are corrected over time, indicating a significant speed of adjustment towards long-term equilibrium at a rate of approximately 18% per period, which is both statistically significant and indicative of a relatively swift correction mechanism in the face of disequilibrium. These results resonate with Sachs and Warner's (1995) findings on the complexities of

resource-dependent economies, emphasizing the intricate balance required in policy-making to mitigate short-term volatilities while fostering sustainable long-term growth.

Table 8. *Breusch-Godfrey Serial Correlation LM Test*

Null hypothesis: No serial correlation at up to 2 lags			
F-statistic	0.959901	Prob. F(2,20)	0.3999
Obs*R-squared	4.116401	Prob. Chi-Square(2)	0.1277

Source: Authors' Calculation.

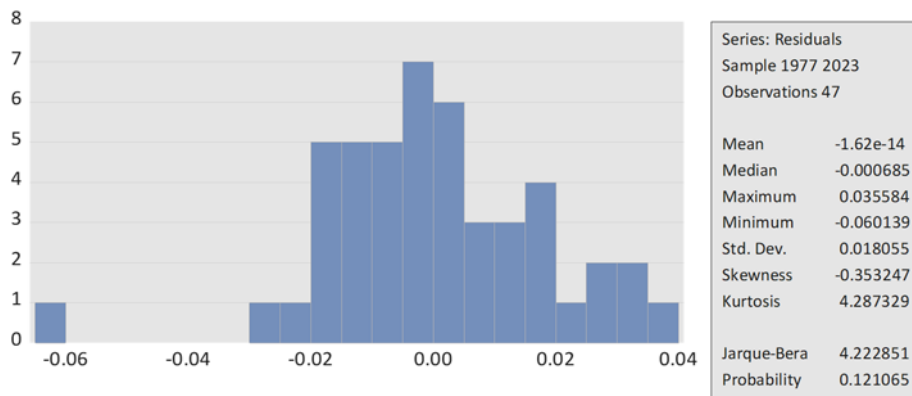
Table 9. *Heteroskedasticity Test: Breusch-Pagan-Godfrey*

Null hypothesis: Homoskedasticity			
F-statistic	0.836956	Prob. F(24,22)	0.6657
Obs*R-squared	22.43181	Prob. Chi-Square(24)	0.5535
Scaled explained SS	8.078432	Prob. Chi-Square(24)	0.9990

Source: Authors' Calculation.

The diagnostic tests for the ARDL model analyzing the impact of oil price fluctuations on Algeria's economic growth indicate a robust framework free from econometric issues. The absence of serial correlation, confirmed by the Breusch-Godfrey test, alongside the validation of homoskedasticity and normality of residuals through the Breusch-Pagan and Jarque-Bera tests, underscores the model's reliability. These findings affirm the model's suitability for accurately capturing the complex relationships at play, thereby providing a solid foundation for informed policy decisions.

Figure 3. *Histogram for Normality*



Source: Authors' Calculation.

The results of the Jarque-Bera test confirm the normality of the residuals in the ARDL model used to analyze the impact of oil price fluctuations on Algeria's economic growth. The test statistic was found to be insignificant, indicating that the residuals closely follow a normal distribution and, thus, validating one of the key assumptions underlying the model. These results are consistent with the findings of Jarque and Bera (1980), who emphasized the importance of normality in econometric modeling to maintain the integrity of hypothesis testing and confidence intervals.

The analysis of cumulative sums of recursive residuals (CUSUM) and CUSUM Squared provides a comprehensive assessment of the stability of the ARDL model examining the impact of oil price fluctuations on Algeria's economic growth.

Figure 4. Cumulative sum of recursive residual (CUSUM) model

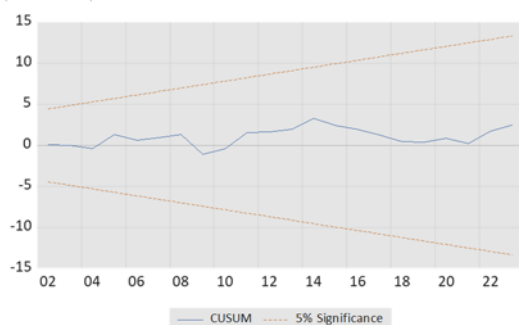
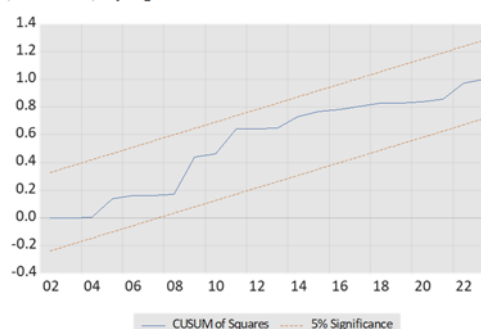


Figure 5. Cumulative sum of recursive residual (CUSUM) of squares model



Source: Authors' Calculation.

The application of the CUSUM and CUSUM of Squares tests confirms the stability of the autoregressive distributed lag (ARDL) model utilized to assess the short-term impact of oil price fluctuations on Algeria's economic growth. The results indicate that the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) statistics remain within the critical bounds throughout the sample period, thus validating the robustness and reliability of the model parameters over time. This empirical evidence suggests that there are no structural breaks or significant deviations, affirming the constancy of the relationship between the independent variables and economic growth. Such findings are crucial, as they underscore the model's capacity to provide consistent and accurate insights, aligning with classical stability diagnostics recommended by Brown, Durbin, and Evans (1975). Consequently, policymakers can confidently rely on the model's projections to inform economic strategies and mitigate the adverse effects of oil price volatility, ensuring sustainable economic growth.

4. Conclusion

This study rigorously examines the impact of oil price fluctuations on Algeria's economic growth using the Autoregressive Distributed Lag (ARDL) bounds testing approach. Empirical evidence from the F-Bounds Test substantiates a significant long-run relationship among the key macroeconomic variables under examination. This provides a solid foundation for further analysis of the dynamic interactions at play. The long-term ARDL model estimation reveals a robust positive correlation between oil prices and Algeria's economic growth, corroborating the extensive body of research in this domain. This observation reinforces the pivotal role of the hydrocarbon sector as a primary driver of economic progress in Algeria. The ARDL Error Correction Model (ECM) elucidates complex interactions between oil prices and economic growth.

The ARDL Error Correction Model (ECM) elucidates complex interactions between oil prices and economic growth. While immediate oil price increases positively impact GDP per capita growth, the model also unveils a more nuanced, delayed negative impact from lagged oil price changes, suggesting that price volatility can lead to economic instability in subsequent periods. The error correction model's estimates reveal an intriguing adjustment mechanism, with a statistically significant speed of adjustment towards long-term equilibrium at a rate of approximately 18% per period. This relatively swift correction process underscores the economy's inherent resilience in the face of disequilibrium, as it strives to realign its trajectory in line with the long-run equilibrium.

Conclusively, this study enriches the understanding of the intricate relationship between oil price volatility and economic growth in resource-rich nations. The insights underscore the necessity for Algeria to diversify its economic base, mitigate dependency on hydrocarbon revenues, and enhance resilience against global oil price fluctuations. This research provides a foundational analysis critical for evaluating Algeria's economic strategies and addressing its dependency on hydrocarbon revenues, thereby contributing to the broader discourse on sustainable economic development.

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Impact of population cycle on income sharing pattern of a capitalistic society

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Abstract. *In this paper, we have tried to explore how the fundamental structure of a capitalistic society affects income sharing within the society and widens the vertical disparity in income distribution. We argue that a capitalist in a free market uses various elements of an economy to continuously improve their profitability. Initial rising population is used as a tool to enhance profit and once the population starts declining, international trade is used as a substitute for population growth to further enhance their profit. Our empirical analysis was divided into two parts; (i) the correlation between income inequality (Gini coefficient) and population (total population & population growth rate) was investigated for closed economies namely Brazil, Moldova, Morocco, & Ukraine (ii) a multivariate OLS was run with Gini coefficient as the dependent variable while the ratio of CPI (Consumer Price Index) and Wage Rate, Export as a percentage of GDP (Gross Domestic Product), and population growth rate was used as regressors to understand how income sharing evolves in an open economy and subject of the study was U.S. The result was confirmatory to the theoretical framework and alternative hypothesis represented in the paper that income inequality is positively associated with population for a closed economy while two variables negatively correlated for an open economy. Further, a positive association was found between income inequality and the ratio of CPI and Wage Rate, and Export for an open economy.*

Keywords: income inequality, inflation, wage rate, international trade, population.

JEL Classification: D31, F1, J23, J3, E31.

1. Introduction

The mode of production is a very debatable concept among economists, while some consider the free market as the way for economic development others are skeptical about it as it ushers the exploitation of weaker and working sections. According, to Marx the mode of production can be of six types which are hunting and gathering, slavery, feudalism, capitalism, socialism, and Asia. The current era is defined by the struggle between capitalism and socialism, lately, it seems that capitalism has already won on the global stage. As big as the rift between the ideology of the two societies, ultimate suffering belongs to the weaker and labor sections of the two societal structures. Though socialism is charged with corruption and instability within the economy, capitalism is not also unimpeachable. The sole motive of making a continuous incremental profit has resulted in various global crises (The housing bubble of 2008) and the exploitation of the labor class is eternally associated with it.

The capitalism as successor of feudalism in England was a silver line as it was considered as a cure for anomalies of the existing system. It took nearly five hundred years for capitalism to disperse around every corner of Europe. The first industrial revolution (1780-1850) plays a crucial role in letting free market ideology strangle the economics of Great Britain. The period is marked by the outstanding work of various economists from Adam Smith to Malthus. While Adam Smith is considered the father of capitalism, we would like to focus on the contribution of Malthus, who propagated a theory that the population grows at geometrical progression whereas the food production growth rate follows arithmetical progression. This theory might not hold weightage alone, but incorporating the theory with technological change brought in by the Industrial Revolution gives us insight into how capitalism can flourish. The basic nourishment for the free market is a growing consumption rate which is a result of a growing population. As the population grows the availability of labor at low cost acts as a second stimulus, and the economy starts growing.

According to Kuznets Hypothesis (1955), economic growth and income inequality have a nonlinear relationship that is inequalities increase as economic growth takes place till a certain point and then declines again. The successive studies provided no conclusive evidence as the results obtained were mixed. Paukert (1973) & Ahluwalia (1976) found evidence of an inverted U-shape relationship between income inequality and economic growth, whereas no such association was established by other scholars (Deininger and Squire, 1998: pp. 259-287; Bruno, 1999; and Ram, 1997). The disparity of results continued in the twenty-first century among researchers because of the statistical irregularity of the Kuznets hypothesis (Thornton, 2001: pp. 449-465). A U-shaped relationship was discovered by Gallup (2012) and a similar conclusion was derived by Kiatrungwilaikun & Suriya (2015), Castells-Quintana et al. (2015), and Raitano (2016).

Over the years many methodologies have been developed to measure income inequality out of which two are most common in use; (a) Percentile ratio, and (b) Gini Coefficient.

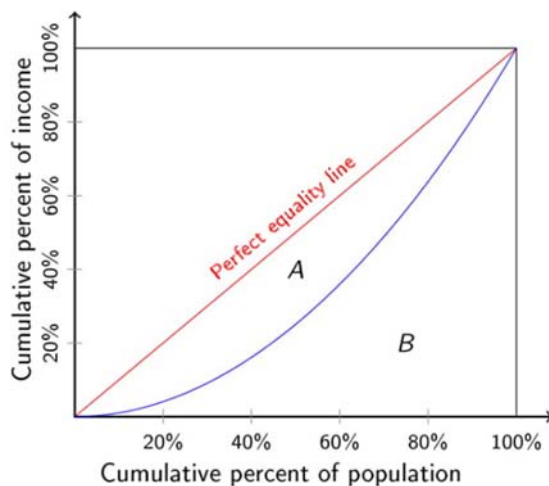
a) Percentile Ratio: The basic classification of income inequality is constructed on the basic ratio. The ratio measures the income of one section of the population against another

section. It gives near about perfect understanding of the rift between the two sections. The basic implied ratio that is used in literature is as follows:

- 50/10 ratio – used for measuring disparity between the middle and the bottom level of earnings.
- 90/10 – used for measuring disparity between the top and the bottom.
- 90/50 – used for measuring disparity between the top and the middle.
- 99/90 – used for measuring disparity between the very top and the top.

b) Gini coefficient: It is a mathematical derivation of income inequality within an economy developed by statistician Corrado Gini (Gini, 1912: pp. 1-30). The basic notion is that it calculates the area between 45° degrees (perfect equality of income distribution) and the Lorenz curve which indicates the actual distribution of income across the population that is area of A. And calculated area of A is divided by the total (A+B). A graphical presentation of the Gini coefficient is shown in Figure 1 below:

Figure 1. Gini index graphical presentation



For our study, we tried to distinguish between income inequalities based on direction and cause. We have divided inequality under three heads which are; Horizontal Inequality, Diagonal Inequality, and Vertical Inequality.

Horizontal income inequalities: This kind of inequality persists when the market is inefficient. The market is not well equipped with the transmission of information, thus unequal pay exists for similar kinds of jobs. For example, unskilled workers having different pay slips for similar jobs may be unaware. This is also true for skilled workers. This kind of inequality will get eluded as development takes place flow of information will get smooth and transmission will get even across the economy. Thus, the unskilled worker will shift to a higher-paying employer, forcing other employers to increase their pay. In case of skilled workers this horizontal disparity can occur because of misinformation or superior skills. Development within the economy will solve the problem of misinformation but superior skill will be a differentiator among the skilled worker. Even opting for the most sort-out education course will not be able to nullify this differentiator completely, as

the skill is a mixture of inherent and learned skills. Though some skills can be learned to some extent inherent will be an obvious divider. Entrepreneur-level horizontal inequality is surely because of the skill possessed by one entrepreneur over the other.

Diagonal income inequalities: When the difference in income is a measure between two sections of the working population say skilled worker and unskilled worker or skilled worker and employer such inequalities fall in diagonal inequalities.

Vertical Income inequalities: This kind of inequality measures the straight-up difference between employee and employer (entrepreneur). We will build a broad understanding of vertical inequalities in the coming section, how an employer used various elements of the economy to widen this gap.

The recent studies on income disparities are mainly concerned with horizontal or diagonal income inequalities. The stepping stone was the Stolper-Samuelson (Heckscher-Ohlin) mechanism which argues that two countries with educated and uneducated labor will result in a widening wage gap in the country with educated labor whereas narrowing gap in the country with less educated labor as they start trading. Bonvin (1996), Harrison and Hanson (1999), Wood (1997) & Goldberg and Pavcnik (2007) observed an increase in wage dispersion developing against the prediction of Stolper-Samuelson (1941). Further, the model predicted that the demand for skilled labor would increase across the industries, whereas subsequent studies found contrary results, the increase in demand was mainly from within industries (Lawrence & Slaughter, 1993; Katz & Autor, 1999; Berman et al., 1998). Krugman (2008) proposed that the increased wage disparity is attributed to international trade because of low-cost imports from China, as opposed by Irwin et al. (2008) & Katz (2008). Owing to the contradicting results a counterargument of skilled-based technology changes (SBTC) was made by Berman et al. (1998) & Katz and Autor (1999).

The majority of the research in the twenty-first century has focused on how exogenous variables of economy affect the income inequality such as technology change, automation, education, globalization, and to a certain extent environmental degradation etc. Thus, the pivot has shifted from society structure to the class of labor (skilled and unskilled) and replacement employment generated by technology change and automation. While some of the research has also used the geographical location of the nation to decipher the level of income inequalities (see Frankel & Romer, 1999: pp. 379-399; Aradhyula et al., 2007). In this article, we tried to divert attention toward the fundamental structure of the society and the process of production for increasing trends in income inequality. We build a narrative of how a capitalistic society with the motive of profit maximization uses various elements of the domestic economy and the global economy to exploit their way to reach the top tier of income distribution.

2. Literature Review

The profit-making motive of a capitalist society is backed by the ideology of having private ownership of the income-generating asset and it was reported in 2010 huge disparity in investment assets was observed in the U.S. where 1% of the population held ownership

over 50.4% of assets and 90% population possessed just 12% (Wolff, 2012; Thalassinos, et al., 2012: pp. 449-465; Thalassinos & Politis, 2012: pp. 137-146; Miller & Choi, 2014). Ravallion (2014) reported rising income inequality since the first century but at a slower rate as compared to the twentieth century. Countries with abundant capital resources (land & money) are supposed to have dispersion in income distribution as compared to countries with large reservoirs of skilled labor (Spilimbergo et al., 1999: pp. 77-101). The openness of an economy has added a new dimension to the study of income inequalities, where Duncan (2000) claimed that the level of poverty and trade liberalization are negatively correlated for small and poor countries. It was found that globalization might have an inverse relationship with inter-country inequality but a positive association with intra-country & regional inequality (Cornia, 2003; Wan, 2004: pp.348-363). According to Kahai and Simmon (2001), trade openness resulted in inequalities except for countries that are in their developing phase. Poor countries (low GDP per capita) experience less income inequality as compared to countries with high GDP per capita and skilled labor (Gourdon et al., 2008: pp. 343-378). The technological-driven economy is more susceptible to disparity than liberal trade policies (Richardson, 1995: pp. 33-55). The rising demand for goods from foreign countries positively impacts the income from exporting while the rising demand for foreign goods has a negative impact (Zhang & Ordreich, 2004). Importing low-wage goods is the main culprit for rising inequality in an economy with a high GDP per capita (Ebenstein et al., 2015; Roser & Cuaresma 2016: pp. 1-27). The covet of earning higher expected returns not only ushered the way for export and import but financial liberalization, for some researcher capital openness can be a connection knot in explaining rising dispersion in income distribution in the recent past, the outcome of such study showed that trade globalization results in reduction income inequality where financial openness is the main culprit for rising disparity (Jaumotte et al., 2013: pp. 271-309; Asteriou et al., 2014: pp. 592-599; Munir & Bukhari, 2019: pp. 44-57). A distinctive result of previous literature by Celik and Basdas (2010) is that trade in goods resulted in income inequality however, financial integration (FDI inflow & outflow) is positively correlated with income inequality for Miracle countries while improving the income inequality in developed and developing countries. A certain section of research also focused on the “equality hypothesis” by Boyce (1994) according to which inequality is associated with environmental degradation. Grunewald (2017) reported that an economy with a higher GDP per capita had a positive association between carbon dioxide and income inequality and an economy with low GDP per capita had a negative association between those variables. In a similar context, Muhammad et al., (2022) found that the replacement of nonrenewable with renewable energy causes a rise in in income inequality.

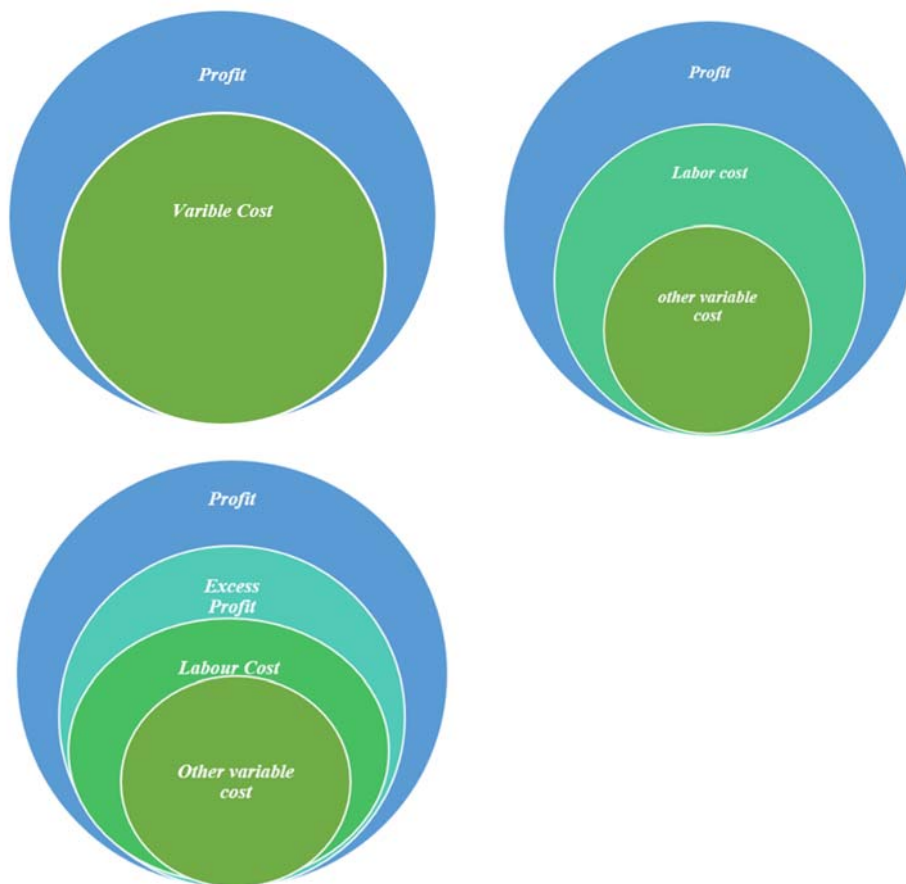
3. Theoretical Framework

3.1. Marginal Cost, Inflation & Wage Rate

The driving force for the business class in a capitalistic society is to continue the production process till $MR=MC$ beyond this point production is not feasible as they will incur a loss. Therefore, we can understand the importance of inflation and wage rates for the business classes. Many economists have bestowed their view on the impact of inflation on business

which is nothing but an inflated rate of marginal revenue (future price level) about cash flows (Alchain & Kessel, 1959: pp. 535-539). Marginal cost, which is synonymous with labor cost (wage rate) plays a crucial role in executing the production process, not lately concept of the global village has taken center positioning in the global economy because of uneven growth in wage rates at different parts of the globe due to differences in population. The success story of China is attributed to this global phenomenon.

Figure 2. Graphical presentation of how the disparity between inflation and wage rate affects income sharing of a society



Source: Author(s).

The revenue is constituted of two components cost incurred and profit. While cost can be split into various headings and subheadings, for the theme of our study we will ponder around labor cost or more precisely wage rate. Now considering that with inflation the revenue of an organization will also increase thus, the hike in marginal revenue must be offset by an increment in wage rate to maintain the existing pattern within the economy. If by any mean rate of change in inflation and wage is not proportionate income sharing will take a toll.

3.2. Population Cycle, Inflation and Wage Rate

The past has been filled with enormous studies of the population and how it affected the economy. Malthus was the first person to put stress on the growing population, more certainly he focused on the growth of food and population. According, to him, the growth rate of food follows an arithmetic progression whereas the human population grows at a geometric progression. The major implication of the theory was that it helped to build an understanding of the condition and socio-structure of society of that era. The gap between the growth rate of food and population would have led to an enormous rise in price while at the same time cutting down the wage rate to the minimalistic level. Thus, the population cycle must have a certain affiliation with inflation and wage rates. The population has a positive and negative relationship with inflation and wage rate respectively.

3.3. Closed Economy

An economy with no trade relationship with other economies will depend on home consumption for economic growth. The population cycle plays a major role in such an economy as its direct relationship to consumption, with a rising population demand for consumption also increases, and with rising demand price levels also hit new heights, at the same time availability of an enormous workforce causes a downward fluctuation in wage rate.

The effect of the declining phase of population is contrary, with a shrinking population the contraction of the demand function is obvious which will create a deflation effect in an economy. And wage rate will also go up with a declining workforce.

3.4. Open Economy

The behavior of income-sharing patterns in an open economy is complex as compared to a closed economy. A capitalistic economy with a trade relationship with another global economy may create an illusion of economic growth in hindsight income sharing patterns also get distorted. In comparison to a closed economy, an open economy keeps on finding new stimuli for the expansion of production. We have already discussed the episode of a closed economy, so with a declining population the wage rate will increase and deflation will hit the economy. In this situation, an economy has two options, either let the economy shrink with a declining population or search new markets for surplus production. Once a new market is identified dumping of goods starts, and these new markets act as a perfect substitution for population growth. As we know population growth will result in more demand, and the price level start increasing again. Capitalistic societies with the ultimate goal of profit maximization still suffer from increasing wage rates, that is income sharing pattern is still shaping in favor of the labor class. The concluding solution to this problem is import or outsourcing thus, hiring low-cost labor from the world economy. This income-sharing pattern again starts tilting toward business class. Thus, we can say that “Export and Import is a perfect substitution for Population Growth”.

4. Objective

Keeping in mind the theoretical framework that we had provided in section 3, the objectives of our study are as follows.

- a) *To analyze the association between population and income inequality in a closed economy.*
- b) *To identify the variable those, have a significant association with income inequality in an open economy.*

5. Hypothesis

- a) H_{A1} : *Income inequality and population are positively correlated in a closed economy.*
- b) H_{A2} : *Income inequality and the ratio of the price level and wage rate are positively correlated in an open economy.*
- c) H_{A3} : *Income inequality and export are positively correlated in an open economy.*
- d) H_{A4} : *Income inequality and population are negatively correlated in an open economy.*

6. Methodology

The purpose of the study was to identify the macroeconomic variables that affect the income-sharing pattern over the year so, the causal research with a multivariate time-series methodology was been embraced. The empirical testing was conducted in two parts. The first part was dedicated to identifying the association between income inequality and population for the closed economy. In the later part, the analysis was focused on an open economy and the variables that cause income inequality.

6.1. Closed Economy

Four countries were used as subjects of our study which were Ukraine, Morocco, Brazil, and Moldova (Shakti, 2022). The selection of the countries was done based on the availability of data and how close is the economy. It is needless to say that in today's world, no country is detached from the global economy. However, these countries fulfill the maximum criteria of being called a closed economy with a limited amount of oil import or export. There were more qualified countries for the title mainly from East Africa but the availability of data was a major issue for these countries. We have used the Gini coefficient as a proxy for income inequality whereas we have used two proxies for population variables which are total population and population growth rate per year. The Karl Pearson coefficient of correlation was used to establish an association between two variables. Again, the availability of data plays an important role in the selection of statistical tools. Since data on all the variables were unavailable, we have shifted from multivariate regression to correlation. The dataset of all the variables was collected from the World Bank database and the range of the dataset varies from country to country. For Brazil dataset ranges from 1981 to 2020; Moldova from 1997 to 2019; Morocco from 1984 to 2013; and Ukraine from 1993 to 2020. Further linear interpolation was used for missing data since all countries were in under developed category at some point in time accessibility of economic variables was not that rigorous.

6.2. Open Economy

In the case of open economy, we have used multivariate OLS (Ordinary Least Square) regression to test the hypothesis. The test consists of one dependent variable which is the Gini coefficient and three independent variables which are the ratio of CPI (Consumer Price Index) and Wage Rate, Export as a percentage of GDP (Gross Domestic Product), and population growth rate. We initiated the empirical analysis with four independent variables, the fourth one being import but due to collinearity (with export) we have to eliminate it as the fourth variable. The subject of the study is the U.S. and data were collected from 1960 to 2020. There are three main reasons for selecting the U.S. for analysis which are (i) the availability of data about the concerned study, almost all the country's information on such variables is missing, (ii) accessibility of well-constructed longitudinal data for research, and (iii) finally the U.S. is the flag bearer of global economy. The various pre- and post-regression tests were conducted to see the feasibility of using regression as a statistical tool for understanding the association between dependent and explanatory variables. The Jarque Bera was used to test the normality of variables and residual series. The Elliot Rothenberg Stock (ERS) point optimal was used to test the stationarity of variable series. The ARCH (Autoregressive Conditional Heteroskedasticity) was used to test the homoskedasticity of residual series while Breusch Godfrey was used to test the Serial correlation of residual series. Lastly, to test whether the coefficient of the variable is collinear or not we have used VIF (Variance Inflation Factor).

Thus, the regression model used is presented below,

$$Gini = \alpha + \beta_1 CPI/Wage + \beta_2 Export + \beta_3 Pop + u_t$$

Where, CPI/Wage, Export, & Pop represent the ratio of CPI (Consumer Price Index) and Wage Rate, Export as a percentage of GDP (Gross Domestic Product), and population growth rate respectively. The u_t in the equation is an error term while α is intercept or drift. Finally, the Gini on the left-hand side represents the Gini coefficient.

7. Result & Discussion

7.1. Closed Economy

The correlation was majorly in favor of the theory that we have proposed in the early section, positive associations of 0.82, 0.66, & 0.81 were found between the Gini coefficient and population for Moldova, Morocco, and Ukraine and in the case of Brazil to variable were negatively correlated (-0.73). When the population growth rate was taken into consideration positive correlations of 0.73, & 0.61 were found for Brazil, and Moldova, and negative correlations of -0.82, & -0.50 for Morocco, and Ukraine. It was astounding to find such varied results for two proxies of the same variable but, we also have to understand that the true characteristic of the population of these countries are not being able to be explained by either one of the proxies. In the case of Brazil, the population is increasing at a decreasing rate which means the total population will still show an upward trend while the growth rate will exhibit a downward trend, thus true characteristic of population is disguised in the number game, therefore even though population is declining different

result was obtained. The opposite can be observed for Morocco, and Ukraine where the population is decreasing at an increasing rate thus, the total population is showing in downward trend while the population growth rate is showing an upward trend. Moldova is a unique case where both the proxy present true attributes of the population of the country. This is the primary reason that we have used two proxies for the population. Consequently, we can claim that H_{A1} is accepted. The result of the correlation test is presented below in Table 1.

Table 1. *Correlation between Income Inequality and Population and Population Growth Rate*

Variables	Population	Population Growth Rate	Country
Gini Coefficient	-0.73	0.73	Brazil
	0.82	0.61	Moldova
	0.66	-0.82	Morocco
	0.81	-0.5	Ukraine

Source: Author(s).

7.2. Open Economy

7.2.1. Normality of Variable

A normally distributed series must possess the basic properties that are mean, & standard deviation must be 0, & 1 respectively. A linear combination of normally distributed variables itself is normally distributed and it also provides minimum variance property thus, impetus us to continue with regression analysis and test hypothesis. The result of Jarque Bera is tabulated below in Table 2.

Table 2. *Jarque Bera test of Variables*

Variables	Calculate Value	Prob
Gini Coefficient	3.86	0.144
CPI/Wage Rate	3.78	0.15
Export	2.37	0.3
Population Growth Rate	8.1	0.02

Source: Author(s)

The H_0 of Jarque Bera test is that the series is normally distributed thus, conferring P value Gini coefficient, CPI/Wage Rate, & Export as a percentage of GDP are insignificant at the level of 10% with P value of 0.14, 0.15, and 0.3 respectively. The result for the population growth rate was a little skeptical as it qualifies with a rear margin of 0.02 P value.

7.2.2. Unit Root Test

The stationarity of the variable was tested using Elliot Rothenberg Stock (ERS) Point-Optimal methodology as it provides an advantage against the anomalies of Augmented Dicky Fuller (ADF) regarding power of test and size distortion (see Elliot et al., 1996: p. 813). The test was conducted with drift, drift, and trend. In the first scenario, all the variables were significant at levels of 1%, 5%, & 10% with P statistics of 207.24, 8.48, 18.07, & 45.03 for Gini coefficient, CPI/Wage rate, Export as a percentage of GDP, and Population growth rate respectively. Table 3 represents the result of the unit root test with drift.

Table 3. *Unit Root Test with drift*

Test	Level of significant	Critical Value	Gini Coefficient	CPI/Wage Rate	Export	POP_G
ERS Point Optimal	1%	1.88	207.24	8.48	18.07	45.03
	5%	3				
	10%	3.96				

Source: Author(s).

When trend along with drift was used to understand the stochastic process of variables except for Export (significant at the level of 1%) all other variables were stationary at the level of 1%, 5%, & 10%. The P statistic of the Gini coefficient, CPI/Wage rate, Export as a percentage of GDP, and Population growth rate were 8.49, 9.90, 4.34, & 22.35.

Table 4. *Unit Root Test with drift & trend*

Test	Level of significant	Critical Value	Gini Coefficient	CPI/Wage Rate	Export	POP_G
ERS Point Optimal	1%	4.22	8.49	9.9	4.34	22.35
	5%	5.7				
	10%	6.77				

Source: Author(s).

Thus, all the variables used for time series regression analysis were stationary at level or integrated at zero order. So simple OLS (Ordinary Least Square) can be used for our regression analysis.

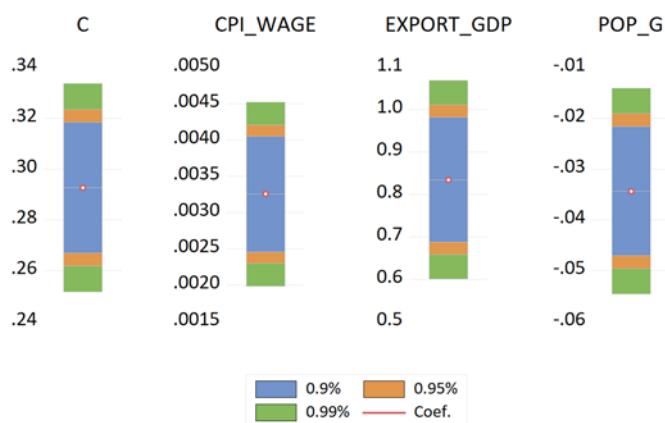
7.2.3. Regression Analysis

In Table 5 below; the outcome of regression is presented where three explanatory variables which are CPI/Wage rate, export as a percentage of GDP, and population growth are regressed on the GINI coefficient. The regression model was significant at the level of 0.1% (F statistic of 198.74) with R squared of 0.91 and adjusted R squared of 0.90 indicating a highly significant model. The estimators including intercept were also significant at the level of 0.1%. CPI/ Wage brings about 0.0032 unit change in the GINI coefficient while the estimation error was 0.000475 with a t statistic of 6.85. Export brings about 0.83 units of change in the GINI coefficient with an estimation error was 0.087 and a t statistic was 9.48. Population growth was negatively correlated with a coefficient of -0.034 and the estimation error was 0.007 with a t statistic of -4.52. Thus, H_{A2} , H_{A3} , & H_{A4} accepted that an open economy population cycle has a negative relation with income inequality while the ratio of inflation and wage rate and export have a positive relation as it was explained through the theoretical framework in section 3. In Figure 3 a graphical presentation of the coefficient is given along with the confidence interval, while the detailed outcome of OLS is presented in Table 5 given below.

Table 5. *Result of regression analysis*

Variables	Constant (α)	CPI/Wage Rate (β_1)	Export as Percentage of GDP (β_2)	Population Growth Rate (β_3)
Coefficient	0.29	0.0032	0.83	-0.034
Standard Error	0.015	0.000475	0.087	0.007
t statistic	19.07	6.85	9.48	-4.52
P (value)	0.000	0.000	0.000	0.000
R-squared				0.91
Adjusted R-squared				0.9
F statistic				198.74
P (F-statistic)				0.000

Source: Author(s).

Figure 3. Graphical presentation coefficient and confidence interval

Source: Author(s).

7.2.4. Post-Regression Test

The validation of OLS regression analysis mainly depends on four conditions which are no collinearity among the regressors, no correlation among the successive value of residual series, no correlation among residual and regressors, no heteroskedasticity in residual series, and residual series should normality distributed.

In Table 6 two measures of collinearity have been presented Variance Inflation Factor (VIF) & tolerance. In this case, the VIF value should not be more than 5 (Hair, 2010), for the tolerance value should not be less than 0.20 (Menard, 1995: p. 192).

Table 6. The measure of collinearity among regressors

Variables	VIF	Tolerance
CPI/Wage	1.71	0.58
Export	2.26	0.44
Population growth rate	1.46	0.68

Source: Author(s).

In Table 7; results of three residual diagnostic tests have been shown, where Jarque Bera, Autoregressive conditional Heteroskedasticity (ARCH), and Breusch Godfrey were conducted for testing normality, homoskedasticity, and autocorrelation & serial correlation of residual series respectively. The outcome of the test confirmed that the series is normally distributed and has no presence of heteroskedasticity, autocorrelation & serial correlation. Thus, it can be concluded that the result of OLS regression is robust and free from any anomalies.

Table 7. Residual Diagnostic

Test	Calculated value	Prob
Jarque Bera	0.34	0.84
ARCH	0.83	0.61
Breusch Godfrey	1.44	0.18

Source: Author(s).

8. Conclusion

The investigation plethora of literature concomitant to income inequality discovered that literature can be divided into two sections; one tries to expand the literature by studying the disparity between skilled and unskilled labor using education and technological change as an explaining factor and other focuses on elements of economic growth and globalization more in the line of Kuznets. In contrast, we avoided commenting income disparity of labor and tried to build a narrative rather than just using certain elements of the economy as an explanatory variable of income inequality. We through our theoretical framework elucidated how the motive of continuously improving profit is impetus by the societal structure of a capitalistic economy to the point that they used various elements of the domestic economy and after that world economy to achieve their motive. Initially, they capitalized on the growing population for the creation of wealth by using low labor costs against rising prices. Once the population starts declining, they use international trade as a perfect substitute for population growth. We also show that a closed economy with a capitalistic ideology will experience a decline in income inequality within the declining population which is very much similar Kuznet hypothesis. Thus, the framework has the potential to explain the irregularity of the Kuznets curve.

The economist might have found a way to stimulate the growth rate, but morally might not be good for everyone. The pity is that, being a failed system capitalism will keep on flourishing as there is no better alternative in the present era.

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Understanding users' behavioral intention to use artificial intelligence for personal financial management: an innovation diffusion theory approach

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Abstract. *The purpose of this study is to investigate the factors that influence users' behavioral intentions to adopt Artificial Intelligence for personal financial management using an Innovation Diffusion Theory (IDT) framework. An analysis of empirical data collected from 246 users is conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM). Findings reveal that users' intentions to embrace AI in financial management are influenced by a variety of factors, including relative advantage, compatibility, and observability. As a result of this study, we offer insights into the intricate interplay of factors affecting the adoption of artificial intelligence in personal finance.*

Keywords: Artificial Intelligence, Fintech, Personal Financial Management, Innovation Diffusion Theory.

JEL Classification: O16, O33, N75.

1. Introduction

In the contemporary technological landscape, Artificial Intelligence (AI) has ushered in transformative changes, particularly in the area of personal financial management (PFM) (Anshari et al., 2022). AI-driven applications for personal financial management represent an important departure from conventional financial tools. Using advanced algorithms, machine learning, and predictive analytics, these applications provide users with personalized insights, real-time data analysis, and proactive recommendations (Chang & Wang, 2023). By enabling individuals to gain a deeper understanding of financial matters and make informed decisions, these tools aim to redefine how individuals approach and navigate their financial landscapes (Nain & Rajan, 2023).

An important aspect of AI-PFM applications is their potential to democratize access to sophisticated financial advice. The applications cater to a diverse range of individuals regardless of their level of financial literacy, providing tailored solutions that adapt to changing economic conditions (Lin-Jiang et al., 2023). Increasing financial complexity and uncertainty have made AI-PFM tools a crucial tool for creating wealth, reducing risk, and reaching goals.

The literature regarding the factors that influence users' intentions to adopt AI-PFM applications in India is noticeably lacking, despite the increasing importance of AI-PFM applications. Studying the Indian market as a case study, this study examines the nuanced sociocultural and economic factors that influence user perceptions. In this study, the primary objective is to understand the behavioral intentions of users in regards to AI-PFM adoption, in line with the need to understand the unique dynamics in the Indian financial market.

The purpose of this study is to provide a deeper understanding of the adoption dynamics of AI-driven PFM applications in India based on the aforementioned gaps in the literature. As a conceptual framework for the research, the Innovation Diffusion Theory (IDT) is employed, which was first proposed by Rogers (1962). The theory provides a framework for analyzing the adoption and diffusion of innovations within social systems, providing a holistic understanding of the complexities involved in the adoption of AI. Using IDT in the context of AI-PFM in India, this study provides insight and practical recommendations for financial institutions, policymakers, and developers to enhance the adoption and effectiveness of AI-driven financial management solutions in the Indian market.

2. Literature Review and Theoretical Framework

Rogers' Innovation Diffusion Theory (IDT), first introduced in 1962 and refined in subsequent editions, provides a fundamental framework for understanding how innovations are spread within social networks. IDT's relevance in diverse fields is evident, with intrinsic attributes such as relative advantage, compatibility, complexity, trialability, and observability influencing adoption of innovations (Rogers, 1962). IDT has been applied to a number of contexts, ranging from healthcare and technology to agriculture and education, as it has evolved (Alyoussef, 2023).

Literature on Artificial Intelligence (AI) applications for Personal Financial Management (PFM) has illustrated the transformative potential of these innovations in the area of technology. AI-driven PFM applications, leveraging machine learning and predictive analytics, offer personalized insights and real-time analysis, reshaping traditional financial tools (Anshari et al., 2022). In spite of their potential benefits, little is known about the factors that influence the adoption of these technologies in contexts such as India.

It is in this context that the predictive power of IDT is crucial in anticipating adoption intentions. IDT's framework enables a systematic analysis of AI-driven PFM innovations based on their perceived attributes. Relative advantage, reflecting the perceived improvement over existing financial tools, compatibility with user values and practices, trialability, and observability of benefits, all play a pivotal role in shaping users' intentions to adopt these innovations (Rogers, 1962). Additionally, communication channels and social systems influence how information about AI-PFM applications is disseminated and how adoption behavior is influenced by social networks.

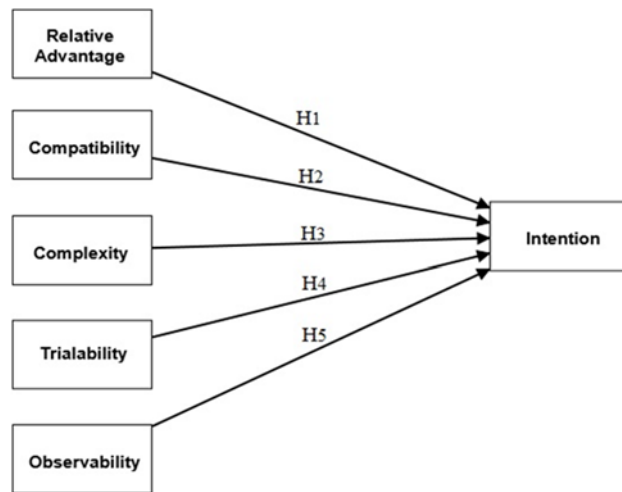
The application of IDT to the adoption dynamics of AI-driven PFM applications in India becomes an essential avenue for exploration as scholars and practitioners continue to draw upon IDT. Through the use of IDT, this study aims to gain insight into the factors that influence users' intentions in order to inform the development, implementation, and diffusion of AI-PFM technologies in the dynamic socio-economic landscape of India. The integration of AI into personal financial management represents a significant innovation, and IDT offers a structured lens to understand and predict the adoption patterns of these transformative technologies.

3. Hypothesis Development

In the context of Artificial Intelligence-driven Personal Financial Management (AI-PFM) applications, several key variables derived from the Innovation Diffusion Theory (IDT) influence users' intentions to adopt these innovations. The concept of "Relative Advantage" speaks to users' perceptions of the superiority of AI-PFM applications over traditional financial tools, emphasizing efficiency, accuracy, and overall utility. The variable "Compatibility" delves into the alignment between AI-PFM applications and users' existing financial practices and preferences. Perceived "Complexity" focuses on the ease of use and user interface, highlighting that a less complex system enhances adoption likelihood. "Trialability" reflects the opportunity for users to experiment with AI-PFM applications before full commitment, reducing perceived risk. Lastly, "Observability" centres on the visibility of benefits, emphasizing tangible and observable improvements in financial management. Previous studies have consistently found positive relationships between these variables and adoption intention in various technological contexts, reinforcing the theoretical underpinnings of IDT and highlighting their significance in shaping users' attitudes toward the adoption of AI-PFM applications (Al-Bashayreh et al., 2022; Jeong et al., 2021; Ntsiful et al., 2022). These variables collectively provide a robust framework for understanding the multifaceted dynamics influencing the adoption of innovative financial technologies.

- H1: Relative advantage positively affecting Adoption Intention.
 H2: Compatibility positively affecting Adoption Intention
 H3: Complexity positively affecting Adoption Intention
 H4: Trialability positively affecting Adoption Intention
 H5: Observability positively affecting Adoption Intention

Figure 1. Research Model



4. Research Design and Methods

A quantitative research design is used in this study in order to investigate the factors that influence the adoption of Artificial Intelligence-driven Personal Financial Management (AI-PFM) applications. The primary aim is to gather empirical data on users' perceptions and behavioral intentions. A structured survey instrument is administered through Google Forms in a cross-sectional study, allowing data to be collected at a single point in time. Participants in this study are those who actively use AI-PFM applications in the state of Tamil Nadu, India. The convenience sampling method is employed due to practical constraints, targeting users who are able to access online platforms. In total, 253 respondents are included in the sample, representing a diverse cross-section of AI-PFM users in the region. The questionnaire is structured with a five-point Likert-scale items. There were a total of 253 samples obtained at the end of the survey, which met the minimum sample size requirement of 200 for the SEM analysis (Kline, 2011).

5. Data Analysis and Results

The data collected for this study is analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) through the software SmartPLS4. PLS-SEM is particularly well-suited for complex models and exploratory research, making it an appropriate choice for investigating the relationships between variables in the context of AI-driven Personal Financial Management (AI-PFM) adoption.

6. Assessment of Measurement Model

The assessment of the measurement model in this study ensures the reliability and validity of latent constructs derived from Innovation Diffusion Theory as shown in Table 1. High Cronbach's alpha coefficients (ranging from .892 to .902) indicate strong internal consistency, affirming the reliability of items within each construct (Henseler et al., 2009). Additionally, composite reliability values ranging from .825 to .831 reinforce the stability of the measurement model, indicating high internal consistency and reliability across latent constructs (Henseler et al., 2009). The examination of Average Variance Extracted (AVE) values, all exceeding .7, underscores the convergent validity of the measurement model, indicating that the latent constructs effectively represent the measured variables (Hair et al., 2022). These results collectively affirm the robustness of the measurement model, establishing a solid foundation for subsequent analyses exploring relationships between variables in the context of AI-driven Personal Financial Management adoption. Further, Using the Fornell-Larcker criterion, discriminant validity was confirmed. Table 2 showing that the square root of the Average Variance Extracted (AVE) for each construct exceeded its correlation with other constructs (Fornell & Larcker, 1981). This robustly establishes the distinctiveness of each construct, ensuring confidence in the measurement model's ability to capture unique facets of the theoretical framework.

Table 1. Construct validity and reliability

Construct	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Compatibility (COMP)	0.901	0.831	0.771
Complexity	0.902	0.832	0.773
Intention (INT)	0.899	0.830	0.767
Observability (OB)	0.892	0.825	0.755
Relative Advantage (RA)	0.894	0.827	0.760
Trialability (TR)	0.893	0.825	0.756

Source: Primary Data.

Table 2. Discriminant validity - Fornell-larcker criterion

	COMP	CPX	INT	OB	RA	TR
COMP	0.878					
CPX	0.812	0.879				
INT	0.814	0.807	0.876			
OB	0.831	0.807	0.825	0.869		
RA	0.821	0.760	0.768	0.786	0.872	
TR	0.868	0.791	0.778	0.822	0.786	0.870

Source: Primary Data.

7. Assessment of Structural Model

The structural model analysis reveals significant positive effects for Compatibility ($\beta = .208$, $p < 0.1$), Relative Advantage ($\beta = .265$, $p < 0.01$), and Observability ($\beta = .317$, $p < 0.01$) on Adoption Intention in the context of AI-driven Personal Financial Management applications. However, the relationship between Relative Complexity and Adoption Intention is not statistically significant ($\beta = .122$, $p = 0.116$), nor is there a significant relationship between Trialability and Adoption Intention ($\beta = .030$, $p = 0.759$). These nuanced findings emphasize the critical impact of compatibility, relative advantage, and observability in influencing positive adoption intentions, while highlighting areas where perceived complexity and trialability may have less pronounced effects.

Table 3. *Hypotheses Testing Results*

Hypotheses	Path	β	T statistics	P values	Decision
H1	RA-> INT	0.265	2.921	0.004	Supported
H2	COMP -> INT	0.208	2.206	0.027	Supported
H3	CPX-> INT	0.122	1.573	0.116	Not Supported
H4	TR-> INT	0.030	0.307	0.759	Not Supported
H5	OB-> INT	0.317	2.983	0.003	Supported

Source: Primary Data.

8. Discussions

The findings of the study shedding light on the factors influencing the adoption of Artificial Intelligence-driven Personal Financial Management (AI-PFM) applications. In line with the findings of extant research studies (Almaiah et al., 2022; Lin, 2011; Liu et al., 2022; Sudarsono et al., 2022), the present study observed positive and significant effects for Compatibility, Relative Advantage, and Observability on Adoption Intention substantiate the primary objective of understanding the drivers of AI-PFM adoption.

The positive relationship between Compatibility and Adoption Intention ($\beta = .208$, $p < 0.1$) underscores the importance of aligning AI-PFM applications with users' existing financial practices, validating the findings of extant research on adoption intentions. Similarly, in line with the extant research, the positive effect of Relative Advantage on Adoption Intention ($\beta = .265$, $p < 0.01$) supports the hypothesis that users perceiving superior advantages in AI-PFM are more likely to express positive adoption intentions. Furthermore, the significant positive effect of Observability on Adoption Intention ($\beta = .317$, $p < 0.01$) reinforces the findings of previous studies, that users who can visibly observe the benefits of technological applications are more inclined to adopt. This finding underscores the practical significance of making the advantages of AI-PFM technologies tangible and visible to users.

However, the non-significant relationship between Relative Complexity and Adoption Intention ($\beta = .122$, $p = 0.116$) suggests that, in this context, perceived complexity may not be a decisive factor in users' adoption intentions. This nuanced result challenges the hypothesis, emphasising the need to consider other factors that may weigh more heavily in users' decision-making processes. Similarly, the lack of a significant relationship between Trialability and Adoption Intention ($\beta = .030$, $p = 0.759$) indicates that the ease of experimentation with AI-PFM applications before full adoption may not strongly influence users' intentions. This result prompts a reevaluation of the hypothesized impact of trialability in the AI-PFM context.

In summary, the discussion based on the proposed research model underscores the critical role of Compatibility, Relative Advantage, and Observability in shaping positive AI-PFM adoption intentions. The non-significant relationships with Relative Complexity and Trialability highlight areas where user perceptions may deviate from conventional expectations, offering avenues for future research and refining strategies to enhance AI-PFM adoption.

9. Theoretical and Practical Implications

By enhancing the understanding of technology adoption, this study emphasizes the relevance of Compatibility, Relative Advantage, and Observability in the context of Artificial Intelligence-driven Personal Financial Management (AI-PFM). It is noteworthy that there are no significant relationships between Relative Complexity and Trialability, which challenges conventional assumptions, prompting a reconsideration of factors influencing user decisions. Stakeholders, including developers, financial institutions, policymakers, and users, can benefit from these insights. By prioritizing user-centric design, emphasizing the relative advantage, and promoting observable benefits, developers can generate greater value. By educating their users, financial institutions can address complexity concerns, while policymakers may encourage the implementation of AI-PFM solutions that are user-friendly. Increased awareness and familiarity among users contribute to the successful integration of AI-PFM technologies into everyday financial practices.

10. Conclusion

In conclusion, this study has delved into the intricacies of Artificial Intelligence-driven Personal Financial Management (AI-PFM) adoption in Tamil Nadu, India. The purpose of this study was to identify the factors that shape users' intentions to adopt AI-PFM technologies, and the results were closely aligned with the proposed research model. A key influencer was compatibility, emphasizing the importance of aligning AI-PFM applications with the existing financial practices of users. Additionally, Relative Advantage demonstrated that users gravitate towards AI-PFM technologies when they perceive superior benefits. Observability played a crucial role, indicating that users are more likely to adopt when they can visibly observe the benefits of AI-PFM applications.

However, the study concluded that Relative Complexity and Trialability did not significantly influence adoption intentions, indicating that users may consider other factors as part of their decision-making process. Even though this study offers valuable insights, it acknowledges limitations, such as potential selection bias caused by convenience sampling and the cross-sectional nature of the study. Research on AI-PFM adoption could be conducted using a variety of sampling methods and longitudinal designs in the future.

In summary, this research offers practical implications for developers, financial institutions, and policymakers navigating the landscape of AI-PFM adoption. Understanding the nuanced dynamics revealed in this study may enable stakeholders to refine strategies to enhance the acceptance and effectiveness of AI-PFM technologies. This can contribute to the evolving field of personal financial management in the age of artificial intelligence.

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Financial stability and monetary policy rules: evidence from Tunisia

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Abstract. *This paper aims to identify the role of monetary policy in ensuring not only price stability but also financial stability for the central bank of Tunisia. We employ the generalized method of moments on quarterly data during the period 2000-2020 for the Tunisian context to estimate various types of monetary policy rules. We compare the standard Taylor rule with the augmented version that incorporates non-performing loans as a financial variable. Our findings indicate a significant and positive impact of this variable on the monetary policy reaction function. Furthermore, our analysis highlights the ability of monetary policy to effectively balance the trade-off between its dual objectives of price and financial stability.*

Keywords: monetary policy, financial stability, Taylor rule, GMM model.

JEL Classification: E52, E58.

1. Introduction

The global financial crisis of 2008 has raised challenges regarding the role of monetary policy in ensuring low inflation and maintaining financial stability. In this context, it is essential to understand whether the objective of financial stability will be placed in the existing monetary policy framework.

Since the 1980s, price stability has been the fundamental objective of most central banks, with interest rates seen as the main instrument of the monetary policy to achieve it. Theoretically, this objective represents a significant contribution of monetary policy to macroeconomic stability. Following the financial imbalances experienced by the global crisis, this perspective has been challenged. Significant financial crises occurred in time of low and stable inflation, indicating that price stability cannot be sufficient to maintain financial stability. Historical evidence suggests that price stability is a necessary, but insufficient condition for ensuring financial stability. Consequently, the stability of the financial system has become a major concern for monetary authorities, alongside ensuring price stability. Recently, many central banks have expanded their mandate to explicitly include financial stability as a mandate of their monetary policy.

The Tunisian monetary policy has undergone several changes. In order to eliminate ambiguity surrounding the mission of the Central Bank of Tunisia (CBT), the principal objective explicitly assigned since 2006 to maintain price stability, by adopting interest rate as an operational objective. While focusing on maintaining this objective, the CBT has worked on developing and modernizing its monetary policy which is enriched by a diverse range of indicators such as the inflation and output gap.

According to the recent status of April 2016, the CBT has extended its mandates by explicitly incorporating the financial stability objective into its monetary policy in addition to price stability. This novel approach enhances our understanding of the dynamics between monetary policy and financial stability, providing the impact of financial variable on the conduct of monetary policy.

The contribution of this paper, in contrast to previous studies in Tunisia (Amiri and Talbi, 2013; Lajnaf, 2014; Mna and Kilani, 2023) is to integrate non-performing loans as a financial variable in the Taylor rule. We propose an empirical estimation of various specifications of the Taylor rule reaction functions for the Tunisian monetary authorities, using the GMM model with instrumental variables for quarterly data during 2000 to 2020.

The rest of the paper was organized as follows: Section 2 provides a brief empirical literature review. Section 3 describes the data set and model specifications used in the empirical analysis. Section 4 presents the empirical findings.

2. Empirical literature review

Financial stability is a concept that remains difficult to be defined (Allen and Wood, 2006). Generally, it is defined by its opposite, as the absence of financial instability, but the causes of instability are not yet fully specified. It can be identified across a multitude of observable and measurable variables (Schinasi, 2004).

Several studies examine the interaction between monetary policy and financial stability. Some authors estimate an augmented Taylor rule including asset prices and test the response of a monetary policy to this variable (Cecchetti et al., 2000; Chadha et al., 2004; Siklos et al., 2004). All of these papers suggest that financial imbalances accumulate even in a low inflation environment, which is typically favorable to financial stability. Indeed, the side effect of low inflation is that excess demand pressures may initially appear in credit aggregates and asset prices. Moreover, the authors emphasize that asset prices represent an important aspect of monetary policy and observe a significant impact of the stock prices during the period of estimation. Consequently, monetary authorities use asset prices not only to enhance their inflation and growth forecasts but also to set the interest rate.

Martin and Milas (2010) estimated a monetary policy rule augmented by the gap between policy rates and the three-month base rate using monthly data in order to analyze the impact of this indicator on the United Kingdom monetary policy. They found that the rise in this spread is due to unsecured credit risk, suggesting that the perceived risk of these loans in the interbank market was the primary source of credit.

Other authors examined the reaction of central banks to the credit gap (Borio and Lowe, 2004; Cúrdia and Woodford, 2010). According to Käfer (2014), the study of Borio and Lowe (2004) is probably the most influential empirical study concerning the role of credit in the monetary policy. The authors estimated an augmented Taylor rule with credit gaps for the United States, Australia, Japan, and Germany. They analyzed the response of the four central banks to financial imbalances measured against the credit of the private sector to GDP. The results vary among these countries, with the clearest evidence of some considerations for financial stability found in the case of the United States. Additionally, central banks response to financial imbalances. The analysis of this study suggests that credit is an important indicator of the accumulation of financial risks and can also reduce fluctuations in output and inflation.

In the Tunisian context, several authors have examined the conduct of monetary policy using the Taylor rule. Some of them estimated this rule in its original form (Boughrara, 2007; Mansour, 2009) showing that CBT employs the Taylor rule with different weights on the inflation and output gap. Others have estimated different specifications of the Taylor rule including the exchange rate as an additional variable (Amiri and Talbi, 2013; Chaouech, 2015). Furthermore, Ben Tahar and Rahmani (2006) evaluated the behavior of the Tunisian monetary authorities towards the asset prices and the exchange rate by estimating a Taylor rule. Their results indicate that the CBT does not react to either the evolutions of the stock market index or the exchange rate.

3. Model

According to the literature, the most appropriate response function for monetary policy is the Taylor rule.

3.1. Standard version of Taylor rule

The traditional version of this rule was proposed by Taylor (1993), which depends on the inflation and output gap. Monetary authorities adjust their interest rate according to the following equation Taylor (1999):

$$r_t = \bar{r} + \pi^* + \gamma_1(\pi_t - \pi^*) + \gamma_2(y_t - \hat{y}) \quad (1)$$

Where:

r_t is the short-term interest rate, $\bar{r}$ is the equilibrium interest rate, π_t is the inflation rate, π^* represents its target level and $(y_t - \hat{y})$ represents the deviation of current output from its potential level.

3.2. Dynamic Taylor rule

Some studies added an interest rate smoothing in the traditional Taylor rule (Clarida et al., 1998). The equation is represented as the following form:

$$r_t = \rho r_{t-4} + (1 - \rho) \times [\alpha_0 + \gamma_1(\pi_t - \pi^*) + \gamma_2(y_t - \hat{y})] \quad (2)$$

Which ρ is the smoothing parameter of the interest rate and the constant α_0 represents $\bar{r} + \pi^*$.

3.3. Forward-looking Taylor rule

Therefore, we introduced an anticipated inflation and assumed that the CBT reacts to π_{t+4} . The forward-looking dynamic Taylor rule is represented as the following form (Clarida et al. 1998, 2000; Kozicki, 1999):

$$r_t = \rho r_{t-4} + (1 - \rho) \times [\alpha_0 + \gamma_1(E(\pi_{t+4}) - \pi^*) + \gamma_2(y_t - \hat{y})] \quad (3)$$

E is the expectation operator.

3.4. Augmented Taylor rule

Many studies have modified the structure of this rule by including additional variables, aiming to evaluate the behavior of the monetary authority. In this context, the CBT has explicitly included the financial stability objective into its monetary policy framework. Consequently, we examine whether a variable indicating financial instability could influence the decision-making process of Tunisian monetary authorities when adjusting policy rates.

The contribution of this study is to integrate the non-performing loans (NPL) into an augmented Taylor rule as presented in the following equation:

$$r_t = \rho r_{t-4} + (1 - \rho) \times [\alpha_0 + \gamma_1(E(\pi_{t+4}) - \pi^*) + \gamma_2(y_t - \hat{y}) + \gamma_3 \hat{S}_t] \quad (4)$$

Where:

$\hat{S}_t = NPL_t - NPL_{t-4}$ represents the gap of NPL_t and its lagged level by 4 periods.

4. Data and methodology

The data used in this study correspond to quarterly data for the period ranging from 2000 to 2020 from the World Bank and CBT databases.

The Money Market Rate (MMR) is used as a proxy for the interest rate. As for the inflation gap, we use an annual target inflation rate equal to 3% determined implicitly by the change in the Consumer Price Index (CPI). The output gap was measured, as the percentage deviation of the observed GDP from the potential trend. We adopted the filtering method of Hodrick and Prescott to extract the trend component from time series data recommended a degree of smoothing λ equal to 1600 for quarterly data (Ravn and Uhlig, 2002).

To estimate the central bank's reaction function, presented in our model by the Taylor rule, we employed the GMM technique (Hansen, 1982). This method is particularly useful when analyzing time series, since an exercise can allow for heteroscedasticity and autocorrelation between the regressors and the error term. It also used to overcome potential endogeneity bias in the empirical investigations (Clarida et al., 1998, 2000). The application of this method necessitates an effective choice of the instrumental variables that must satisfy the orthogonality conditions. To realize the best choice for these instruments, we refer to the literature that estimates this type of function. In our model the instrument set includes 1 to 6 lagged values of the interest rates, inflation and output gap.

In order to assess the validity of our specification, we test the Hansen J-test of overidentifying restrictions. Also, The Durbin Watson (DW) statistic is a test for autocorrelation in the residuals from a statistical regression analysis.

5. Results

The results obtained by estimating the standard Taylor rule are shown in Table 1.

Table 1. Estimation of the Standard Taylor rule (Eq.1)

Variables	Coefficients	Standard.Errors	P-values
α_0	4.095	0.378	0.000
γ_1	0.234**	0.093	0.012
γ_2	-0.120	0.103	0.243
J-statistic	42.6743	-	0.000
D-W statistic	0.2643	-	-

***, **, * indicate the significance level at 1%, 5% and 10%, respectively. The set of instruments: 6 lags of inflation, output gap and interest rate.

These results indicate that the coefficient $\gamma_1 = 0.234$ associated with the inflation gap is positively related to the interest rate, while the negative coefficient ($\gamma_2 = -0.120$) of the output gap, appears unsatisfactory. Consequently, this equation does not align with the behavior of the CBT. J-statistics indicates the validity of the instruments.

We proceeded to modify the model by introducing a smoothing interest rate coefficient (ρ). This parameter leads to certain modification in the estimated parameters.

Table 2. Estimation of the dynamic Taylor rule (Eq.2)

Variables	Coefficients	Standard.Errors	P-Values
α_0	0.3477	0.551	0.528
ρ	0.885***	0.0955	0.000
γ_1	0.117**	0.057	0.041
γ_2	0.263***	0.068	0.000
J-statistic	30.1948	-	0.011
D-W statistic	1.0139	-	-

***, **, * indicate the significance level at 1%, 5% and 10%, respectively. The set of instruments: 6 lags of inflation, output gap and interest rate.

The results shown in Table 2 indicate that the smoothing coefficient $\rho = 0.88$ is close to unity, which shows that the CBT tend to determine the current interest rate with reference to that of the previous year. The coefficients of the inflation gap $\gamma_1 = 0.117$, while the output gap $\gamma_2 = 0.263$, both showing significance and a positive correlation with the interest rate. Therefore, the coefficient γ_2 is more important than γ_1 . This contradicts the hierarchical mandate of the CBT, which prioritizes inflation stability foremost.

In order to overcome this deficiency, we proceed to estimate a forward-looking Taylor rule.

Table 3. Estimation of the Forward-Looking Taylor rule (Eq.3)

Variables	Coefficients	Standard.Errors	P-Values
α_0	0.424	0.494	0.390
ρ	0.933***	0.080	0.000
γ_1	0.274***	0.053	0.000
γ_2	0.164***	0.044	0.000
J-statistic	26.665	-	0.031
D-W statistic	0.3494	-	-

***, **, * indicate the significance level at 1%, 5% and 10%, respectively. The set of instruments: 6 lags of inflation, output gap and interest rate.

The results presented in Table 3 indicate that the smoothing coefficient is 0.933. The coefficients associated with the gap between the expected inflation in one year and the implicit target of inflation is more important $\gamma_1 = 0.274$ than that related to the output gap $\gamma_2 = 0.16$. Additionally, the results demonstrate that the inflation and the output gap are statistically significant at 5% and 1% levels respectively.

In the light of these results, the coefficients seem to be more satisfactory with a remarkable significance and confirm the overriding objective of the monetary policy, namely inflation stability. Considering the case of the traditional central bank objectives, Equation (3) can conform to the behavior of the Tunisian monetary authority.

Table 4. Estimation of the augmented Taylor rule (Eq.4)

Variables	Coefficients	Standard.Errors	P-values
α_0	1.350	0.569	0.017
ρ	0.562***	0.080	0.000
γ_1	0.372***	0.056	0.000
γ_2	0.367***	0.050	0.000
γ_3	0.144***	0.0253	0.000
J-statistic	31.863	-	0.044
D-W statistic	0.5331	-	-

***, **, * indicate the significance level at 1%, 5% and 10%, respectively. The set of instruments: 6 lags of inflation, output gap and interest rate.

Based on Table 4, the coefficients for both the inflation and production gaps, standing at 0.37 and 0.36 respectively, are statistically significant and positively signed. J-statistics indicates that the validity of the instruments is not rejected.

Furthermore, the results show that the interest rate is positively sensitive to the non-performing loans $\gamma_3=0.144$. In other words, the Tunisian monetary authorities took into account this variable when adjusting the interest rate. Although the coefficient of credit gap seems to be low, financial stability can be considered as another mandate for the CBT in addition to the traditional objective of price stability.

These results validate the recent decision of the CBT to formally declare financial stability as an explicit objective of their monetary policy. Although the monetary authorities took into account the financial imbalance into their behavior, they are claiming it in a formal way, recently. In fact, most central banks have focused on financial stability in the conduct of monetary policy only after the subprime crisis.

Therefore, the adjusting of the interest rate by the CBT appears related to the smoothing interest rate, anticipated inflation rate, output gap and credit spread.

6. Conclusion

This paper investigates the relationship between monetary policy and financial stability within the Tunisian context. We estimated Taylor rules by Generalized Method of Moments (GMM) model over the period of 2000-2020 to compare various types of Taylor rules.

The obtained results imply that the coefficients responses of dynamic Forward-looking Taylor rule are notably more satisfactory than those of standard and dynamic versions. The findings reveal that the CBT incorporates inflation expectations into interest rate adjustments. Furthermore, we examine the response of non-performing loans, considered as an indicator of financial instability in the augmented Taylor rule. The empirical results show that this indicator is statistically significant and affects positively the interest rate, improving the response of the other variables.

This study justifies that policy rate can be common instrument to ensure price stability and to contain financial instabilities.

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The transfer between the spending habits of different generations-a debate between retail and E-commerce

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Abstract. *This study presents the transition from retail to E-commerce and the impact of this change on the global market, influenced by the advancement of technology, evolving human needs and the change in the mindset of the current generations activating in the field of trade for goods and services. Evaluating the shift of needs a consumer has over a prolonged period it can be observed how the big retailers won market share and how the trends in consumer spending were influenced by the advancement of technology from online marketing to fast shipping from any part of the world and where this movement is going.*

Keywords: retail, E-commerce, generations, mindset, global market.

JEL Classification: J11, E24, F16.

1. Introduction

The transition between generations can be observed in many aspects of daily life and consumer spending it is not excluded. Different patterns can be observed around the world depending on the season but mostly based on the day-to-day habits, influenced by age and culture and are reflected in the change of people that have the most purchasing power and with them of mindsets that are shifting. It is the first time in history when five generations work together, which results in a wide range of needs and wants from the people that interact in the same environment. Gen X is known to have the biggest purchasing power but a part of them is now supporting both their aging parents and children who are not financially independent yet. The second category of income is occupied by Millennials followed by Boomers and Gen Z. These changes in consumer categories are reflected also in the transition from retail to E-commerce, the digital natives being prone to an easier shopping method while others prefer an in-person experience. These points of view are supported by the desire for quality or option of a store with a wide variety of products tailored by each person's lifestyle. One of the main factors that separates Gen Z from the preceding generations is the popularity of social media within their lifetime. These platforms have connected individuals and became a vital source of information for this generation of buyers, in this way, E-commerce being more popular. Digital word-of-mouth holds a significant role in this transition and recommendations from trusted influencers can lead the consumers to online purchases, these being easier and more accessible worldwide than in-store products, becoming a source of bands and products discovery. Retail stores are more popular in the sector of Gen X and Boomers consumers even if most of the people who are part of any generation favor in-store experience, but this alternative is time-consuming and can be replaced by using a site or an app for the brand.

Since remote work emerged as a dominant trend, traditional workspaces had undergone a radical shift, when the Covid pandemic had emerged. This important change in lifestyle of many people shifted the shopping experience for good in terms of basic needs and extra purchases. One in five people who are part of the work force is working remotely reflecting a significant adaption in corporate structure and daily lifestyle of a significant part of the population. This evolution in the workforce suggests a different definition for the traditional work environment and the objects and habits that correspond to it. An astonishing number of 98% of workers want to work remote at least a part of the time which reflect the workforce growing affinity towards flexibility and freedom from the traditional corporate standard, inducing a more relaxed, work-life orientated way of living. The patterns of spending generated by this shift in life habits showed that people spent more on groceries rather than in-restaurant experiences, which led to the development of home-delivery services for this category of food and an increase in home-delivery services in general, accessed mostly by the digital natives, spending more on the home department in order to make a more suitable environment, lowered the demand for new clothes and the increase in demand for sportswear and comfort in general and the reduced need for planning in some sectors such as vacation time due to the flexibility of different kinds of jobs.

2. How is influenced the transfer from retail to E-commerce by the undertaking of more important roles by Millennials and Gen Z

Age is a key factor which influence the way a consumer is spending on a variety of products and services. In the transfer of generations, the needs of every individual are different, and the income is in distinct stages of life. While Gen X and Millennials have advanced in their career because they spent a longer time in their jobs or overall professional path, a part of the members of Gen Z are still undertaking their studies or starting new careers. This movement is reflected in the power of consumption and patterns determined by each stage of life. The ones that have spent a longer time building themselves may have a stronger financial stability and can afford to splurge on something that they want, while the younger ones need to think about the future while building a foundation for daily needs, letting unnecessary things with a second thought. According to the Amazon spending in the United States, Millennials and Gen X spend the most while Boomers and Gen Z are almost the same beneath them.

While taking into consideration any significant purchase, the labor market stability is a meaningful aspect. Europe is suffering from a major labor market imbalance. While there are widespread staff shortages in many industries, in others, there is a surplus of skilled workers and too few jobs. A report by EURES, the European employment services network found that the EU's 27 member states plus Norway and Switzerland experienced labor shortages in the second and third quarter of 2022 while 24 of these countries experienced labor surpluses. In the US the labor market is tight, with a 3,8% in March 2023, but according to Michael Feroli, J.P. Morgan's Chief U.S. economist, the 'normal' level is around 4%, the current rate being close to equilibrium. According to a variety of estimates, the US immigration has surged in the last two to three years with the most immediate implication being an increase in potential workforce, as well as a higher pace of jobs growth.

Over the last two decades, online shopping has increased rapidly to purchasing groceries and apparel to books and gifts. Currently, approximately 70% of Americans shop online monthly, and this number is expected to increase. Across the European continent, E-commerce platforms benefited from increased revenues along with an expanding user base, with a wide range of people looking for convenience and variety of products. For instance, E-commerce revenue in Germany grew by more than twenty billion euros between 2019 and 2021. France experienced an online sales increase during the pandemic, with e-commerce sales revenue increasing from 103 billion euros to more than 146 billion euros in 2022.

As far as the European countries are concerned, they share a common trade market, so it is normal for EU consumers to buy from E-commerce companies that are not located in their country. On average, just over one-fourth of the EU's E-commerce revenue is generated from cross-border e-retail. In Austria, eight in ten online shoppers have made a cross-border E-commerce purchase in 2022, versus around five in ten Swedish e-shoppers. In Netherlands, cross-border E-commerce spending has almost doubled, hitting the one-billion-euros mark in the first quarter of 2023, up from only 564 million euros in the third quarter of 2020. Belgium showed a fair cross-border shopping as well, with nearly 70

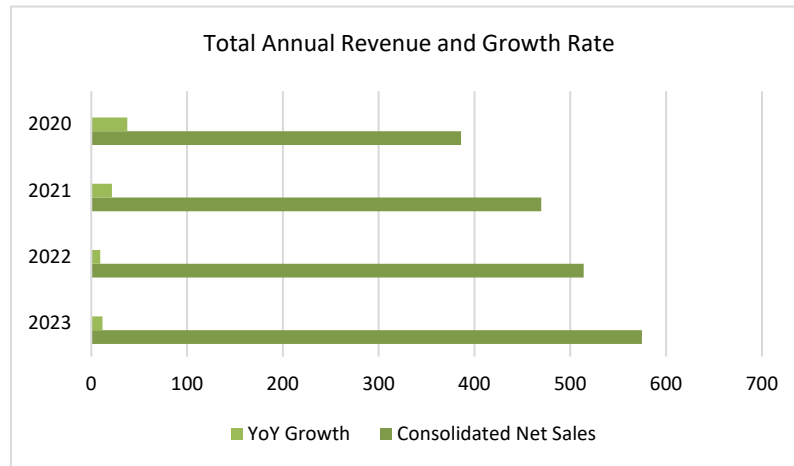
percent of the shoppers purchasing goods online from international sellers. The median age in Austria is 42.6 years, in Sweden 41.9 years, in the Netherlands is 42.5 years and in Belgium 40.8 years demonstrating the fact that Gen X and Millennials have the biggest purchasing power and are using both retail and E-commerce with a tendency towards E-commerce for balancing the day-to-day life.

By 2027, 23% of retail purchases are expected to take place online, the increase in digital orders not being just a trend. The transition to E-commerce is here to stay, as 22.6% of the total retail will be conducted online in 2027. The E-commerce market is expected to total over 7.9 trillion dollars, this movement showcasing the need for adaptability of retailers if they want to stay relevant to the shift of habits displayed by older generations and the increasing in people with stable purchasing power who are entering the market.

Amazon, eBay and AliExpress are the most visited E-commerce websites, with a wide range of clients of almost any age. 49% of the Amazon costumers are between the age of 18 and 34 outlining the fact that Gen Z is more prone to online alternatives. A survey from 2020 investigated the impact of Amazon Prime delivery services on shopping habits of the Gen Z and it showed that in the United States 55% of Gen Z consumers were more likely to increase their total order in case of same-day delivery, which demonstrates the tendency for easy and fast solutions.

Amazon is marketing a variety of products and services, which include everything a consumer need to a huge selection of products that a person can buy from retail stores with no string to each other, all in one place and able to be delivered within days. Amazon main strings of income are the online stores, Amazon Marketplace, cloud services, subscriptions and physical stores. For over twenty years, Amazon has set the standard in E-commerce with almost unrivaled product inventory and competitive prices, combining the brand and customer experience and keeping the people coming back. The free shipping is available after spending at least 35 dollars for customers who don't have the Prime option, a concept introduced as a subscription which allows the costumer to have access at music, movies and free shipping all over the year, movement that promotes the convenience and a fast response to change when faced with the demand for innovation by the global retailer. Retail stores have made an appearance, accommodating even the most skeptical consumer with Amazon Bookstores and Amazon Go, a check-out less grocery store, which is another step for the future accepted by an important number of people. In this process technology plays a key role and the acceptance of the need for rapid change should be considered fast by a wide variety of brands to survive.

Returns are one of the most important aspects of any online shopping experience, because the client couldn't see or touch the product like in a retail store, so to make the whole experience better is important to consider how the costumers prefer to return the items. Most of the big E-commerce companies make it easy to return the products. These packages come with a prepaid, printed return label, even if those labels are accessible through the returns portal in the app or on the online site.

Figure 1. Total revenue and growth rate of Amazon.com

Note: The graph above presents the resource net sales represented in billions of dollars and the year over year growth represented in percentage points.

Source: CapitalOne Shopping.

Gen Z online shopping data reveals that fashion and electronics rank among the most frequently purchased categories. Still, their participation in these segments remains lower than Millennials and Gen X. This could be attribute to their bringing uncertain economic times and limited financial resources due to their young age. They are mindful of their expenses because they can compare the prices as the main advantage of online stores beyond mere convenience and entertainment. They specifically choose E-commerce to capitalize on lower prices. This trend extends to emerging online shopping methods like live commerce, which offers inspiration and access to exclusive discounts to its users. Gen Z shoppers prioritize value and affordability when purchasing online, making sales and discounts particularly appealing. The availability of discounts can prompt an impulsive purchase among this generation, while their absence could determine them to postpone these purchases until better prices are available.

While Amazon was the top of the list in January 2024, with a significant market share, around 50%, eBay was trailing behind with a market share of around 13%, establishing an auction-style platform for sales, eBay expanded its horizons and became a global marketplace.

Another E-commerce website that made a significant difference is Alibaba, where the main consumers are Gen Z, followed by Millennials and Gen X. This company has linked its main method of making an appearance the organic search, but its using also the help of social media, with Facebook being the main platform of distribution for the ads.

3. The impact of social media platforms on the consumer spending habits

Brands should be mindful about the social media impact on every generation and their distinct way of looking for information. They can reach the Gen Z and Millennials through

social media and align with their progressive way of thinking. Brands that are engaging with them online are Nike and Duolingo. Nike is one of the most popular brands in the world, manufacturing good for every generation that can be worn in almost every situation, so that makes them a strong player in terms of utility. They don't struggle with reaching consumers, but they continue to engage with the younger audience online. Another brand that is doing a uniquely job of reaching Gen Z is Duolingo, an easy-to-use language learning platform. Duolingo is leading the charge for TikTok advertising. They aren't necessarily promoting their brand in the videos, but they use their mascot in participating in the platform's trends to become relatable to the consumers. They now have a huge following of 4.4 million because they are engaging with two generations through humorous 15 seconds videos, in order to keep the attention of the consumer while expressing their message and them to connect and remember their name.

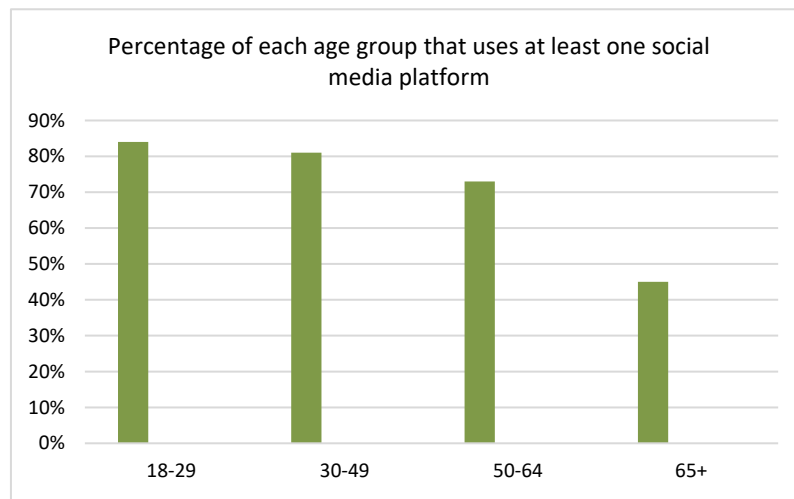
A notably part of Gen Z's life is social media, specifically with the rise of TikTok in the last years. Over 60% of TikTok users are Gen Z, with the other 40% being divided between the other generations. This generation also makes up around 40% of the current global population which makes it a huge audience.

One of the first platforms to see the opportunity of engaging the consumer directly from social media was Facebook, which first implemented the "buy" call-to-action button on ads and page posts back in 2014. Adopting this feature gives users the opportunity to make a purchase of a product or service without interrupting their scrolling. Many other mediums have followed and other marketplaces like Instagram Shopping gained popularity. Listing products in the dedicated "Shop" tab gives your items exposure to a wide breadth of audiences that were previously inaccessible if you were a brick-and-mortar location that required consumer foot traffic to make a purchase. Consumers seek honesty and rely on other sources such as influencers when it comes to making decisions. Hiring a popular influencer in your brand's niche to put a spotlight on your product or service can make a difference if handled correctly. Just one positive review conducted by a recognizable influencer has the capability of causing an influx in popularity and sales. Many up-scale influencers like mega and macro influencers can be hired through an agency, while nanos can be reached by sending a direct message or email to create a line of communication and begin the process of getting your brand in front of their audiences. Using a more popular influencer can be useful if the brand wants to remind the audience about an already existing product, they are having a broad community but being more expensive. On the other hand, for new products which should be launched to a wide variety of consumers nano influencers can be the best because they have a tight community, in some cases specific on their niche and in this way the brands can have access to different generations and area of interests by marketing their message through tailored voices who speak the same language, but are interpreted differently by any consumer that has contact with it.

Affiliate Marketers have tapped into the potential of social media platforms as lucrative avenues for generating income. The process works by promoting specific products or services through engaging posts, in-depth reviews and compelling narratives. These markets typically embed an affiliate link into their content, which is leading the consumer to the brand's website or to a larger platform like Amazon, where they have an easy access

to buy it, in contrast with the in-store retail where the consumer can be influenced by a much smaller category of factors and in less time to make a purchase. This approach capitalizes on the marketer's follower base and requires an understanding of one's value proposition. The use of analytics tools embedded in most social media platforms can enhance the effectiveness of affiliate marketing.

Figure 2. Percentage of each age group that uses at least one social media platform



Note: This graph represents the evolution of social media popularity and the distribution of its usage towards consumers from different generations.

Source: Forbes Advisor.

4. How is the mentality towards sustainability and social inclusiveness affecting consumer spending?

The morals of a company are for sure an important factor which affects the purchasing of products and services. The consumers, especially the younger ones take seriously the environmental and inclusivity matters, as well as the respect for the labor division and gender equality. If a member of Gen Z doesn't agree with the morals of a company, many of them will boycott the products completely and get their friends to do so as well. What advertisers and brand managers learned in their marketing classes years ago is outdated when a brand is trying to relate to a certain category of consumers, and especially to Millennials and Gen Z. The best way to learn what this category wants is looking far from the business and to ask them.

Gen Z care that the products they purchase are made and handled sustainably, and that the companies that they buy from are committed to positive climate action. If this generation doesn't see their personal values aligning with the brand, there is a smaller chance of them buying anything that they are offering. There is one more important consideration which is the fact that there is no specific group. The preferences of this generation vary depending on the culture, social background and group of friends.

Forecasting experts calculate that the purchasing power of Millennials and Gen Z surpass that of Boomers around the year 2030, with up to 68 trillion dollars in wealth transferring from Boomers to these younger generations by the end of this decade. To earn these younger consumers' trust, it's clear that the brands sustainability efforts must deliver on humanity and transparency. The highest humanity could demonstrate that the organization respects everyone, regardless of background, identity or beliefs and take society and its well-being seriously. Transparency could be underscored by displaying straightforward information about the brands impact on community and nature.

A survey done by Harvard Business Review on US customers from age 18 to 98 measured intent by combining the score of two out of four factors we use to gauge trust: brand's perceived humanity, emphasizing empathy, kindness and fairness, and transparency, emphasizing openness to sharing motives and relevant information in simple terms. The perception of brand's competence was measured using a combination of capability, the quality of offerings, and reliability, which was represented by consistent delivery. Considering the results, if Gen Z and Millennials believe a brand cares about its impact on people and the planet, they are 27% more likely to purchase it than older generations, a clear measure of sustainability's power to drive buying decisions in this group.

When Gen Z and Millennials customers rate a brand highly on humanity, they are 15% more likely than older generations to spend more money with the brand and choose it over the competitors. When the brand displays transparency, there are 30% more chances to spend more money on it than older generations and 20% to choose it over competitors.

This strategy applies to all categories of goods and services, with the mention that every personality is distinct, and it can be influenced by a certain combination of words and images, which in the right order can comprise a good strategy for any brand, tailored to a specific demographic or field of activity.

5. Conclusion

Understanding the consumer is one of the biggest challenges a brand can have. The transition from generations can result in a shift in consumer spending habits that can be induced by the upcoming generations or the result to the adaptation to new routines of the older ones, one thing is for sure, a significant part of the world and life is changing and we can't stop it, but we can embrace the new beginning as something that makes daily operations easier or more accessible and connect parts of the world rather than to divide them. The E-commerce connects in an international level human need, even if we speak about brands or consumers, no matter the age or culture everything is interconnected as something bigger than its own identity and emerges in a unique way of coexisting together in each moment living the present and looking for the future.

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Planning for economic integration: addressing trade challenges posed by the Ukraine-Russia conflict in Europe

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Abstract. *This study aims to establish a connection between Russian-Ukraine's current state of affairs and its impact on trade in the European Union and East Asia-Pacific (EAP) regions. Russia-Ukraine conflict impacts EU and EAP trade openness due to rising military spending. Further, escalating sanctions against Russia would negatively affect trade in these regions. War media coverage may cause temporary trade decline in EU and EAP, but recovery expected in the long run. EU imports and exports flow would be significantly disrupted by conflict, irrespective of country's financial situation. Study findings can aid policymakers in assessing trade threats and developing mitigation strategies.*

Keywords: Russia-Ukraine war, military expenditures, economic sanction, media coverage, trade, Europe-Asia, Panel ARDL approach.

JEL Classification: F14, F51, O52.

1. Introduction

War, defined as a prolonged and intense confrontation between political parties involving assaults or operations, is a complex social phenomenon that has been influenced and influenced ethical philosophy over time (Cox, 2021). While there is no single definition of war, it is widely accepted that violence and conflict are prevalent in all communities, with varying degrees of severity, root causes, and effects (Scherer, 2021). Conflict analysis can be broken down into various categories, such as ideological, political, economic, technical, legal, sociocultural, and psychological approaches, but the actual theories are often mixed, as no single framework can fully capture the intricacies of war (Scherer, 2021). Different schools of thought offer diverse perspectives on the causes and character of conflict. Realists, for instance, emphasize the importance of a single strong central authority in preventing chaos, while Marxists focus on the social class divide as the root cause of conflict (Kucherenko, 2021). In contrast, Constructivism has replaced Marxism as it focuses on the primary causes and grounds of conflict (Kucherenko, 2021). Today's conflicts have evolved, with nations increasingly fighting covertly. Cyberwarfare, which involves assaults on a nation's information resources, is a form of modern conflict that seeks to achieve various objectives, including compelling surrender and sowing doubt and uncertainty (Finnegan, 2020). Civil war, on the other hand, refers to a bloody battle taking place on a nation's soil between a state and one or more organized non-state entities. It is distinct from interstate conflicts, intercommunal conflicts, state repression of people, and similar violence by non-state actors such as terrorism or violent crime (Bara et al., 2021). Proxy wars are the most frequent type of conflict in the modern world. Participants in proxy conflicts are sponsored by an external power in an effort to sway the outcome of a bloody struggle for the external power's own strategic objectives. The external state may use violence to achieve desired political aims while assisting clients on the ground (Rauta, 2021). Finally, biological warfare, also known as chemical war, involves the intentional use of disease-causing biological organisms such as bacteria, viruses, or their toxins to kill or disable people, animals, or plants (Morris & Kedar, 2022).

Ukraine has suffered greatly from the Russia-Ukraine war. The conflict has strained the Ukrainian health system, with active combat zones experiencing a surge in demand for healthcare services even as the capacity to deliver them diminishes. The war has caused damage to medical facilities and left many patients requiring treatment for wounds and trauma related to the conflict (Choudhary et al., 2022). The conflict has also had severe environmental and infrastructure effects. The shelling of residential areas, industrial facilities, transportation systems, and houses, as well as infrastructure for sanitation and waste management, has resulted in extensive and severe environmental damage. Ukraine's rich soils have been affected, and soil deterioration will likely reduce the amount of food produced there, affecting both Ukraine and the wider world (Pereira et al., 2022). The economic impact of the conflict is also significant, with Ukraine's GDP expected to drop by 45.1 percent this year. This drop will require substantial Western assistance to maintain financial stability. Stronger energy ties between Russia and China have helped to mitigate the economic impact of the conflict on Russia, preventing the collapse of the Russian economy, which many had anticipated after Moscow's military intervention in Ukraine six months ago (Astrov et al., 2022). Perhaps the most significant aftereffect of the war is its

impact on social stability in Ukraine. Forced relocation, destroyed homes, and lost income have disrupted the lives of hundreds of people and affected countless livelihoods (Pereira et al., 2022).

1.1. Research Questions

The study aims to answer several research questions, including:

1. Does the ongoing crisis between Russia and Ukraine only impede trade between the two nations, or does it have global effects on trade?
2. To what extent are the economic sectors of Russia and Ukraine affected by unrestricted military spending during this protracted conflict?
3. Given the significant resources devoted to the war effort, how much of an impact will the research field experience?
4. Is the continuous international media coverage, in various forms such as print, social, or electronic, mitigating the conflict or exacerbating it?

1.2. Research Objectives

The study aims to accomplish the following objectives:

1. Assess the impact of the crisis between Russia and Ukraine on trade operations, not only between the two nations but also on global trade flows.
2. Analyze the effect of unrestricted military spending on the economic performance of both countries.
3. Examine the effect of the ongoing conflict on the research sector.
4. Investigate the role played by international media in exacerbating or mitigating the crisis.

To achieve these objectives, this study proposes to employ advanced econometric techniques, specifically Panel ARDL, to analyze panel data from Russia and Ukraine.

2. Literature Review

During times of conflict, economic activity, particularly trade, can be adversely affected, which can significantly impede a nation's development. Hypotheses based on the trade situation during war can be constructed to evaluate such impacts. For instance, Havlik (2014) assessed the costs that the Ukraine crisis would impose on Russia, Ukraine, and Europe. The study analyzed the data between 2012 and 2014 from over seven European countries, including Russia and Ukraine, comparing their levels of trade and economic development. The findings indicated that Ukraine was the primary victim of the conflict, with its GDP falling by 8% in 2014. Russia's GDP was predicted to lose almost 20 billion euros in the same year, and this loss could rise in the future. Furthermore, the effects on various EU nations varied depending on their exposure to Russian and Ukrainian markets. The study's findings provide firm policy recommendations to mitigate the negative impacts of the conflict on economic activity. Similarly, Godzimirski (2014) studied the impact of the Russian-Ukrainian crisis on the energy industry in Europe and the degree to which this sector was exposed to Russian aggression. The study included 38 European nations and used data collected in May 2014. The approach to reaching a conclusion involved

conducting stress tests on all countries that purchased energy from Russia, comparing the results, and then determining Russia's impact. The study found that Europe heavily depends on Russia for its energy needs, and the EU has been compelled to reevaluate its energy trade with Russia and implement strategies to solve short-, medium-, and long-term energy-related challenges due to Russia's actions in Ukraine. However, the report did not offer any specific economic or diplomatic solutions to address the problem. MalmLöf et al. (2014) conducted a study to investigate the impact of the 2014 Russian-Ukrainian crisis on both countries' economies and the European energy industry. The authors gathered data from Russia and Ukraine over the years 2009, 2011, 2013, and 2014. The study concludes that while the Russian population supports Putin's policies regarding Ukraine currently, it is becoming increasingly unlikely that they will do so in the future once the true cost of his policies is understood. The authors suggest applying sanctions against Russia and Ukraine as a possible solution to the conflict. However, the study lacks the depth of knowledge required to make a well-informed conclusion. Horst (2014) examined how the Ukrainian crisis affected business ties between Germany and Russia and assessed the role of sanctions in ending international conflicts. The data was gathered in 2014 from Germany and Russia. The findings suggest that the sanctions against Russia are affecting both the Russian and German economies. The study's conclusion highlights that Germany's sanctions against Russia are damaging both their diplomatic relations and their economic ties. The research covers all the economic problems and provides answers, indicating that there are no research gaps. Mankoff and Kuchins (2015) analyzed the causes of the economic collapse in Ukraine and Russia and its implications for other nations, including the USA. The study is conducted in the context of the 2013 Ukrainian situation. The conclusion explains how this issue has impacted both US-Russian and EU-Russian relations and proposes strategies for undermining Russia's overt aspirations. However, the research presents only one viewpoint and fails to consider Russia's economic well-being.

In their study, Shnyrkov and Chugaiev (2017) investigate the causes and implications of Ukraine's separation from Russia for its affiliation with the European Union (EU). They argue that examining and analyzing the export losses incurred by the rival nations as a result of the economic battle can help achieve this goal. While adhering to the EU-Ukraine Association Agreement is expected to increase economic activity in Ukraine, both the EU and Ukraine did not anticipate the severe economic, governmental, and military reactions from Russia, which present a significant obstacle to the successful implementation of the Association Agreement. The study's final conclusion is that cooperation and integration between countries cannot be restored without changes to Russia's and other parties' diplomacy. However, the study falls short in one aspect, as it suggests that Western nations are the only ones that can help Ukraine attain economic stability. Karolewski and Cross (2017) investigate the role of the EU in the war between Russia and Ukraine. They gather information from Europe, Russia, and Ukraine between 2009 and 2016 and consider five factors, including the primary parties in the conflict, the relevant issue, the strength of these players' influence, the costs that these players must bear, and economic and military resources. The authors conclude that while the EU has some influence in the crisis, its impact is relatively limited in terms of altering power dynamics. However, the study does not address the brief political perspectives and learning processes of various players in

Europe. Zayats et al. (2017) examine the four sectors impacted by the Russian-Ukrainian dispute: infrastructure, institutions, the economy, and society. They gather information from various publicly accessible governmental and private organizations, media outlets, and interviews with members of the general public conducted in January and February of 2016. Depending on the industry assessed, the collected data from 2000 to 2016 is divided into various pockets. The study's findings indicate that infrastructure and institutions suffer the most, while the impact on the social and economic sectors is evident but not irreversible. Finally, the authors provide recommendations for improving relations between Ukraine and Russia. In their study, Stukalo and Simakhova (2018) aimed to investigate the socio-economic effects of the conflict in Ukraine on both Europe and Ukraine. The authors gathered information from publications by scientists in Ukraine and abroad, as well as international organizations, between 2014 and 2017. The results revealed that the conflict in Ukraine has led to various social and economic difficulties, including an increase in criminal activity, migration, unemployment, and trade disruptions. The study recommends that Ukraine implement an integrated strategy to address all of its social and economic challenges. Slukhai (2018) examined how the economy influences international conflicts by using the Russian-Ukrainian conflict as an example. The author gathered information in Ukraine between 2012 and 2017, estimating the results by comparing Ukraine's trade rate from year to year. The study's conclusion is that the commercial disputes between the two countries have become a permanent economic conflict, which Ukraine can best resolve by reducing its trade with Russia and implementing significant economic reforms. The author provides some suggestions to the Ukrainian government on how to handle this conflict with Russia.

War is often associated with physical harm and losses incurred by people, such as death or severe injury. However, it has other implications that require massive efforts and a prolonged recovery period, such as the impact on economies that push countries backward in their development path. To understand the negative effects of war on other social and economic phenomena, this research aims to explore the relationships between several variables. Previous studies have identified several areas that are often overlooked, such as the impact of war on military spending and the direction that mainstream research fields may take. For instance, Kofroň and Stauber (2023) explore the effects of military expenditures on GDP, while Kozinchuk et al. (2022) examine how the war in Ukraine affects academic research and education. Additionally, media bias is another factor to consider, as it can influence the escalation or prevention of a conflict (Zhabotynska & Ryzhova, 2022; Talabi et al., 2022). Economic sanctions and their impact on Russia and Ukraine are also a crucial area of investigation (Blanchard & Pisani-Ferry, 2022; Christie, 2016). Thus, this study aims to establish the relationship between several variables, including the harm done to trade by the crisis between Ukraine and Russia, the potential increase in military spending due to the cost of war, the impact of economic sanctions on global and European commercial activity, the damage inflicted on both countries' research and development, and the potential role of the media in the conflict between Russia and Ukraine. The study intends to bridge the gaps between these different components to provide a comprehensive understanding of the impact of war on various aspects of society and economy. Based on the stated literature, the study's hypotheses are as follows:

H1: The conflict between Ukraine and Russia is expected to impact the trade openness of the European Union and East Asia-Pacific regions

H2: The repercussions of economic sanctions on trade openness are influenced by changes in military spending.

H3: The presence of strong R&D initiatives and positive media coverage during the Russo-Ukrainian Conflict had a positive impact on trade openness between Russia and Ukraine.

3. Materials and Methods

Table 1 shows the study's variables for ready reference.

Table 1. List of Variables

Variables	Symbols	Measurement	Theoretical Expectations
Trade Openness of European Union and East Asia-Pacific	TOP	% of GDP	-----
Military Expenditures of Russia and Ukraine	ME	% of GDP	It is highly probable that there exists a positive correlation between military spending and trade balance.
Research and Development of Russia and Ukraine	R&D	% of GDP	The relationship between trade openness and R&D can vary depending on the context, and it is possible for there to be a positive and mutually beneficial correlation between the two factors.
Economic Sanctions of Russia and Ukraine	ES	The deduction of R&D expenditures in Ukraine attributed to Russia from its corresponding per capita income of the country.(%)	If economic sanctions are targeted towards trade activities, there may be a consequential impact on the relationship between the sanctions and trade openness.
Media Coverage of European Union and East Asia-Pacific	MC	Individuals using internet of EU and EAP (% of population)	Depending on the context, there may exist a positive and mutually reinforcing association between media coverage and trade openness.
War (Dummy Variable) of Russia and Ukraine	WD	Binary values 0 and 1	Depending on the situation and the nature of the conflict, a binary variable called the "war dummy" was assigned a value of 1 after 2014, indicating the onset of the crisis period, while a value of 0 was assigned before 2014 to represent the pre-crisis period.

The primary aim of the study is to investigate the effect of the Russian-Ukrainian War on trade openness. To achieve this goal, the study employs panel analysis and selects six key variables for analysis, namely trade openness, military spending, Research & Development, economic sanctions, media coverage, and war/conflict as a dummy variable. The World Development Indicators (WDI) database of the World Bank (2022) is used as the primary source of data, and the study covers the period from 2000 to 2021 with 22 observations. The data is sourced from Russia, Ukraine, the European Union, and the East Asia-Pacific region.

Since 1991, when Ukraine proclaimed independence from the USSR, the Russian Federation has refused to recognize Ukraine's independence. Tensions worsened as Ukraine appeared to align more closely with the United States, and the announcement of its intention to join NATO further exacerbated the issue. Ukraine and Russian-backed soldiers fought after Russia invaded and seized Crimea in March 2014. Peace efforts

between 2014 and February 2022 were unsuccessful, and on February 24, 2022, Russian forces attacked Ukraine. The war continues to this day, causing damage to all involved nations and the rest of the world, particularly as Russia and Ukraine are significant exporters of goods. The US-Russia crisis might escalate to a bigger European conflict. The war has led to higher energy costs globally due to Russia's oil exports and raised concerns about food shortages given that Ukraine and Russia produce most of the world's wheat and barley. Defense budgets are likely to increase in response to the situation. The study's goal is to measure the harm caused by the war on the global trading environment, with data gathered from the World Bank (2022). The research focuses on the impact on Europe and Central Asia, using a panel analysis to compare the behavior of Russia and Ukraine during selected years. Variables include trade openness, military spending, R&D, economic sanctions, and war(dummy).

In econometrics, the concept of cointegration is utilized to assess and quantify a long-term equilibrium. Cointegration tests produce findings that indicate instances where two or more non-stationary time series are combined in such a manner that they cannot deviate from equilibrium over an extended period (Perman, 1991). When dealing with variables that exhibit different orders of integration, such as $I(0)$, $I(1)$, or a combination of both, the ARDL cointegration technique is a preferred method in econometrics (Pesaran et al. 2001). This approach is particularly reliable in cases where a small sample size results in a single long-term relationship between the underlying variables. ARDL models, which rely on OLS and can be employed for non-stationary and mixed order of integration time series, are used for this purpose (Bahmani-Oskooee & Ng, 2002). The first step in utilizing the ARDL approach is to examine the stationary behavior of the variables. After determining the order of integration, the cointegration step is then applied, followed by an investigation of the causality between the variables (Menegaki, 2019). The ARDL equation is as follow:

$$\begin{aligned} \Delta TOP_t = & \beta_0 + \beta_1 TOP_{t-1} + \beta_2 ME_t + \beta_3 R\&D_t + \beta_4 ES_t + \beta_5 MC_t + \beta_6 WD_t + \\ & \alpha_1 \sum_{i=1}^p \Delta TOP_{t-i} + \alpha_2 \sum_{j=1}^q \Delta ME_{t-j} + \alpha_3 \sum_{k=1}^r \Delta R\&D_{t-k} + \alpha_4 \sum_{il=1}^s \Delta ES_{t-il} + \\ & \alpha_5 \sum_{m=1}^t \Delta MC_{t-m} + \alpha_6 \sum_{n=1}^u \Delta WD_{t-n} + \gamma ECM \end{aligned} \quad (1)$$

Where, ECM shows error correction term.

Causality refers to the relationship between the causes and effects of a phenomenon. It is generally defined as the situation where a variation in one variable leads to a change in another. In the 1960s, the concept of Granger causality was introduced, which employs statistical and mathematical principles to forecast future outcomes. Essentially, Granger causality is used to predict the actions that need to be taken today to achieve better results in the future. As such, Granger causality plays a crucial role in predicting various concepts (Seth, 2007). Granger causality analysis can yield three possible outcomes:

1. Unidirectional causality: This means that there is a causal relationship between two variables, but it is only in one direction.

2. Bidirectional causality: This refers to a situation where two variables are mutually influencing each other.
3. Non-causality or neutrality: This occurs when there is no causal relationship between two variables.

The impulse response function (IRF) is a statistical tool used to analyze the effect of a single shock, impulse, or innovation on a particular dependent variable. The IRF provides insights into the future behavior of the dependent variable, and can be used to forecast its values. Moreover, the IRF enables us to determine which independent variable will have the most significant effect on the dependent variable in the future. This approach is often complemented by the use of variable decomposition analysis (VDA), which helps to identify the potential impact of a variable on itself and other variables over a specified period. Through the combination of these techniques, analysts can gain a better understanding of the behavior of the variables they are studying, and make more accurate predictions about their future performance.

4. Results and Discussion

Table 2 presents the descriptive statistics of the variables under consideration. The mean values for the independent variables, military spending, R&D, economic sanctions, media coverage, and war dummy are 3.052, 0.928, 4.895, 48.667, and 0.363, respectively, while the dependent variable, TOP, has a mean value of 70.442. The maximum value for TOP is 93.339, while the maximum values for ME, R&D, ES, MC, and war are 5.425, 1.286, 15.584, 84.743, and 1, respectively. On the other hand, TOP, ME, R&D, ES, MC, and War have minimum values of 49.774, 1.533, 0.406, 0.323, 5.609, and 0, respectively. The standard deviation of trade openness is 13.407, while that of military spending is 0.976, R&D is 0.238, economic sanctions is 3.307, media coverage is 24.541, and war is 0.483. Research and development and media coverage are the only variables that exhibit negative skewness, while trade openness, military spending, economic sanctions, and war display positive skewness. Furthermore, the kurtosis value of TOP is less than 3, indicating that it is platykurtic, along with ME, R&D, MC, and the War Dummy. In contrast, economic sanctions have a leptokurtic distribution, with kurtosis values exceeding 3. None of the variables have an exact kurtosis value of 3, indicating that none of them have a mesokurtic distribution, and thus, none of them have a normal distribution.

Table 2. *Descriptive Statistics*

Methods	TOP	ME	R&D	ES	MC	WD
Mean	70.442	3.052	0.928	4.895	48.667	0.363
Maximum	93.339	5.425	1.286	15.584	84.743	1.000
Minimum	49.774	1.533	0.406	0.323	5.609	0.000
Standard Deviation	13.407	0.976	0.238	3.307	24.541	0.483
Skewness	0.169	0.116	-0.821	0.956	-0.225	0.566
Kurtosis	1.785	2.248	2.679	3.923	1.799	1.321

Source: Author's estimation.

The results of the unit root test, as shown in Table 3, provide valuable insights into the properties of the time series under investigation. All variables, except for R&D spending

and media coverage, exhibit differenced stationary behavior, whereas the latter two variables display level stationary characteristics. Differenced stationary variables are those whose differences over time are stationary, indicating a constant variance and mean. On the other hand, level stationary variables exhibit a constant mean and variance over time. The identification of the type of stationarity displayed by each variable is important in time series analysis, as it can impact the choice of appropriate econometric models and the accuracy of the analysis results.

Table 3. Unit Root Test (Probability values)

Level				1 st Difference				Decision
Variables	None	Constant	Constant & Trend	Variables	None	Constant	Constant & Trend	
TOP	0.867	0.233	0.072	TOP	0.000	0.005	0.053	I(1)
ME	0.742	0.612	0.117	ME	0.000	0.000	0.000	I(1)
R&D	0.045	0.528	0.287	R&D	0.000	0.000	0.000	I(0)
ES	0.073	0.087	0.095	ES	0.000	0.000	0.000	I(1)
MC	0.522	0.001	0.001	MC	0.007	0.35	0.961	I(0)
WD	0.496	0.735	0.601	WD	0.061	0.086	0.002	I(1)

Source: Author's estimation.

The technique utilized for estimation is Panel ARDL, taking into account the mixed order of integration of variables discovered using unit root test (see, Table 4).

Table 4. Panel ARDL Estimates

Long Run Results		
Variables	Coefficient	Probability
ln(ME)	1.256	0.012
ln(R&D)	1.046	0.001
ln(ES)	-0.352	0.010
ln(MC)	0.263	0.039
WD	-2.807	0.060
Short Run Results		
$\Delta \ln(\text{ME})_t$	-0.777	0.183
$\Delta \ln(\text{ME})_{t-1}$	-0.114	0.651
$\Delta \ln(\text{R\&D})_t$	-0.325	0.000
$\Delta \ln(\text{R\&D})_{t-1}$	-0.159	0.245
$\Delta \ln(\text{ES})_t$	0.060	0.538
$\Delta \ln(\text{ES})_{t-1}$	0.061	0.254
$\Delta \ln(\text{MC})_t$	-0.445	0.000
$\Delta \ln(\text{MC})_{t-1}$	0.302	0.260
$\Delta(\text{WD})_t$	0.130	0.033
$\Delta(\text{WD})_{t-1}$	0.108	0.128
ECM	-0.227	0.519
C	0.742	0.443
Wald F-statistics	6.175	0.001

Source: Author's estimation.

The results obtained from the panel autoregressive distributed lag (ARDL) model indicate a positive correlation between Military Expenditure (ME) of Russia and Ukraine and Trade Openness (TO) of the European Union and East Asia-Pacific in the long run. The ME variable is statistically significant as its probability value is less than 0.05 (0.012) and can explain 1.25% of the variation in the dependent variable TOP, as indicated by its coefficient value of 1.256. The observed positive relationship between ME and TOP suggests that

higher military spending could lead to increased trade activities, a theory proposed by Wang and Su (2021), which is supported by the reliance of military operations on crude oil imports. This relationship between trade and military spending has been previously documented by Khan et al. (2021) in both the short and long runs. They found that, in the short run, both upper-middle and lower-middle income countries exhibit a direct relationship between these two variables, while in the long run, only lower-middle income countries display a favorable relation between them. Furthermore, Olak and Zkaya (2021) have confirmed that countries involved in conflicts may have no other option but to increase their defense spending, which may lead to a substantial increase in their trade with the world. Therefore, the observed positive relationship between ME and TOP in this study supports the existing literature and suggests that higher ME may result in rising TOP, while lower ME could lead to a decline in TOP.

The second controlled variable, Research & Development (R&D), of Russia and Ukraine exhibits both long-run and short-run relationships with Trade Openness (TOP) of the European Union and East Asia-Pacific. In the long run, these two variables have a positive association with a coefficient value of 1.046, indicating that as R&D rises, TOP also rises, and vice versa. Specifically, a one percent change in R&D leads to a 1.05% change in TOP, and the probability value of 0.001 confirms the statistical significance of RD. Khezri et al. (2021) investigated the relationship between R&D and TOP in the context of the production and consumption of renewable energy, and their study demonstrated a direct and favorable relationship between these two variables. Similarly, You et al. (2022) examined the connection between commerce and RD while taking carbon emissions into account, and found that increasing trade activities can raise carbon emissions and necessitate the development of safer, less environmentally harmful technology. Vetsikas and Stamboulis (2023) also analyzed the effects of R&D and economic growth on trade openness, and concluded that both had significant and favorable implications for trade. In the short run, the coefficient value of R&D is -0.325, indicating an inverse relationship between R&D and TOP. Specifically, to increase TOP, R&D must decrease, and vice versa. A one percent change in R&D results in a 0.33% change in TOP, but in the opposite direction. The probability value of 0.000 indicates that R&D is a significant variable in the model. During conflicts, the R&D industries of both Russia and Ukraine may suffer, which can negatively impact trade with Europe and Eastern Asia. Hwang et al. (2018) reported an inverse relationship between trade liberalization and R&D, which is contrary to conventional wisdom regarding these two factors. Additionally, Shu and Steinwender (2019) found that R&D negatively affects the trading operations of most importing nations, while García Fontes and Tansini (1996) claimed that R&D and trade operations, particularly on the importing side of trade, have a detrimental association in developing countries.

The independent variable of economic sanctions on Russia and Ukraine (ES) is found to have a negative coefficient value, indicating an inverse relationship with the Trade Openness (TOP) of the European Union and East Asia-Pacific in the long run. The coefficient value of ES, which is -0.352, implies that a one percent increase in ES results in a 0.35 percent decrease in TOP. ES is a significant variable in the model, with a probability value of 0.010. Studies conducted on Iran by Farzanegan & Fischer (2021) suggest that the country's growth rate significantly improved after trade restrictions were

abolished as a result of the Joint Comprehensive Plan of Action (JCPOA) and sanctions were lifted. However, a country's trade exchange may suffer as a result of economic penalties. Le et al. (2022) found a negative connection between sanctions and export operations on a global scale, particularly for developing nations. Nguyen & Do (2021) established a nexus between trade, economic sanctions against Russia, and counter-sanctions from Russia. The data revealed that sanctions against Russia had a negative effect on its exports, while sanctions by Russia had a detrimental effect on imports. It is evident that economic sanctions have a damaging effect on overall trade activity and would have severe implications. The current crisis between Russia and Ukraine has drawn attention to the relationship between media coverage and trade outcomes (TOP) in the European Union (EU) and East Asia-Pacific regions. Through an analysis of both coefficient and probability values, it has been found that there is a significant and positive relationship between media coverage (MC) and TOP in these regions.

Specifically, the MC coefficient value of 0.263 suggests that a 1% change in MC may result in a 0.2% change in TOP. As MC and TOP are directly related, they are likely to move in the same direction, either rising or falling together. The probability value of 0.039 further emphasizes the significance of MC in the model over the long term. The role of social media, particularly Twitter, in commercial operations has been highlighted by Duz Tan & Tas (2021), who found that it is a powerful tool that businesses can utilize to advertise, grow, and facilitate commerce. Similarly, Infante & Mardikaningsih (2022) have demonstrated how any type of media can bridge the gap between customers and business owners, helping them better understand customer preferences and leading to more effective trading. However, it is important to note that while an increase in MC may be beneficial in the long term, it has the potential to decrease TOP in the short run due to the negative correlation between MC and TOP. The coefficient value of -0.445 suggests that a 1% increase in MC could result in a 0.45% decrease in TOP. The p-value of 0.000 highlights the significant role that MC plays in the model. Finally, in light of the COVID-19 crisis, Atri et al. (2021) investigated the impact of fear-mongering by media on oil prices and commerce in general, while Chawla et al. (2021) found that news manipulation, particularly on Twitter, can negatively affect trade and business opportunities.

The relationship between War Dummy (WD) and Trade Outcome (TOP) in the context of the Russian-Ukraine crisis is examined by evaluating the coefficient and p-value, which are 0.130 and 0.033, respectively. The positive coefficient value indicates that there is a direct association between WD and TOP, meaning that when one variable grows, the other also increases. Furthermore, the probability value indicates the importance of this variable in the model. However, the crisis in Russia and Ukraine will have only a short-term positive impact on trade in the European Union and East Asia-Pacific. If the potential for war increases by one unit, there is a 0.13-unit likelihood that trade will be affected. Nerlinger and Utz (2022) conducted research on the possibility that trade between exporters of warring nations and other nations may increase in the event of conflict between two nations. The example of the Russian-Ukrainian crisis is used to demonstrate this phenomenon, whereby Russia lost its crucial exporting position, and certain North American, European, and Asian companies took its place. Abu Hatab (2022) stated that African countries must find new trading partners in light of the crisis in Russia and Ukraine. This conflict has

provided other nations with an opportunity to expand their commerce activities. Additionally, Ibadoghlu (2021) established a chain in which a nation at war today requires sophisticated military hardware, which must be purchased from nations with effective munitions industries. The Karabakh War is an example of this phenomenon. According to this study, a country at war has more prospects for international trade.

Table 5 presents a diagnostic assessment of all measurement problems, including misspecification error, heteroskedasticity, autocorrelation, and normality issue. The J.B. and LM tests detect normality and autocorrelation, respectively. The heteroskedasticity test checks for uneven residual variance, while the Ramsey Reset test checks for data misspecification.

Table 5. *Diagnostic Test Estimates*

Methods	Value	Probability Value	Decision
Jarque-Bera Test	1.534	0.464	No error term normalcy.
LM Test	2.834	0.071	The issue of autocorrelation does not exist in the data
Heteroskedasticity Test	2.337	0.060	Residual is Homoscedastic
Ramsey RESET Test	1.391	0.245	No data misspecification.

Source: Author's estimation.

Causality implies a cause-and-effect link (see Table 6). Numerous economic rationales might account for the positive and negative correlation between military spending and media coverage during the Russia-Ukraine conflict. When a nation spends much money on military activities, it makes headlines, and the media pays more attention to the government. When a conflict is widely covered in the media, it may significantly impact public opinion, political choices, and international relations, all of which can lead to a rise in military spending. Increases in military expenditure generate more interest from the media, leading to even greater increases in military spending. War/conflict, military spending, and media attention are Granger's causes of increased trade liberalization. However, uncertainty and instability caused by military expenditure, media attention, and war/conflict may harm commercial openness in the afflicted area. Due to potential delays in transportation, supply networks, and investment, trade prospects and openness may decline as military expenditures and war rise. Additionally, media coverage of the conflict can negatively impact international perceptions of the region, which can reduce opportunities for international trade and investment.

Table 6. *Granger Causality*

Causality Inferences	Decision
ME $\leftrightarrow$ MC	Bidirectional
ME $\rightarrow$ TOP	Unidirectional
MC $\rightarrow$ TOP	Unidirectional
WD $\rightarrow$ TOP	Unidirectional
R&D $\rightarrow$ ME	Unidirectional
WD $\rightarrow$ ME	Unidirectional
TOP $\rightarrow$ R&D	Unidirectional
MC $\rightarrow$ R&D	Unidirectional
ES $\rightarrow$ WD	Unidirectional

Source: Author's estimation.

Trade openness and media coverage Granger cause military expenditures and R&D spending causes military expenditures. One probable economic explanation for this correlation is that military expenditures and research & development tend to grow during times of conflict. Therefore, military spending and R&D investment have a positive correlation. Spending on R&D is also essential in developing military technologies and capabilities, which may be pivotal in times of conflict. However, R&D spending can be forecasted by factors such as trade openness and media attention. A country may be more inclined to invest in R&D to maintain competitiveness and innovation if it can more easily access foreign markets. Increased investment and focus on R&D are possible outcomes of greater public awareness and interest in the field thanks to media coverage.

Economic sanctions always lead to increased hostility and violence. Financial restrictions are a standard method of pressuring nations to alter their actions or policies. Russian participation may have been discouraged, and economic sanctions may have prompted a settlement of the conflict between Russia and Ukraine. Russia's actions and decisions throughout the war may have been affected by the prospect of, or actual execution of, economic sanctions. However, the likelihood of greater economic sanctions as a direct result of war or conflict is low. Sanctions against a country's economy are only used once all other options have been exhausted, and their use is usually related to larger political or strategic goals. Economic sanctions may have been imposed on Russia in reaction to Russian actions or policies during the conflict with Ukraine rather than as a direct consequence of the fighting. Table 7 shows the IRF estimates of TOP for ready reference.

Table 7. *IRF Estimates of TOP*

Years	TOP	ME	R&D	ES	MC	WD
2023	3.761	0.000	0.000	0.000	0.000	0.000
2024	1.981	0.449	0.675	0.832	0.880	-0.906
2025	0.842	1.442	0.988	-0.122	1.791	-1.306
2026	1.236	1.335	0.146	-0.525	2.155	-0.689
2027	1.993	0.840	-0.625	-0.666	1.811	-0.277
2028	1.827	0.960	-0.733	-0.389	1.189	-0.450
2029	1.141	1.760	-0.675	-0.164	0.779	-0.565
2030	0.812	2.501	-0.889	-0.294	0.566	-0.367
2031	0.940	2.796	-1.258	-0.627	0.301	-0.188
2032	1.029	2.888	-1.489	-0.763	-0.079	-0.297

Source: Author's estimate.

The fluctuations in TOP lead to a random trend in all five variables, whereby they experience an increase one year followed by a decrease the next year. The TOP demonstrates a significant upward shift until the fifth period, following which it experiences a slight decline but remains relatively stable for the next period. Subsequently, it sharply declines until the eighth period, after which it starts to recover in the final two projected periods. On the other hand, ME demonstrates a generally upward trend, except for the period between the fifth and sixth when it declines. RD increases until the fourth period and then steadily declines until the end. ES experiences an increase in the first period and declines until the fifth period, after which it remains in the same region with occasional periods of improvement and reversals until the end. MC is predicted to grow only during the first four years of the following ten-year period. WD is expected to decrease until the

third period, then experience a significant increase until the fifth period before fluctuating. Table 8 shows the VDA estimations for ready reference.

Table 8. *VDA Estimates of TOP*

Years	S.E.	TO	ME	R&D	ES	MC	WD
2023	3.761	100	0	0	0	0	0
2024	4.585	85.97	0.959	2.172	3.293	3.688	3.910
2025	5.451	63.20	7.674	4.826	2.380	13.40	8.510
2026	6.200	52.83	10.56	3.786	2.557	22.44	7.815
2027	6.879	51.32	10.079	3.904	3.015	25.166	6.512
2028	7.341	51.26	10.563	4.426	2.929	24.722	6.095
2029	7.727	48.45	14.722	4.760	2.689	23.334	6.038
2030	8.244	43.54	22.143	5.347	2.490	20.973	5.503
2031	8.875	38.69	29.033	6.622	2.648	18.211	4.793
2032	9.542	34.62	34.272	8.164	2.930	15.759	4.242

Source: Author's estimate.

The results show that TOP is mostly affected by itself, followed by MC and then ME. Changes in RD, ES, and WD have negligible effects on TOP. ME is mainly influenced by itself, followed by R&D, with almost no impact from TOP and WD. RD is most affected by itself, followed by TO, ME, MC, and ES, with minimal impact from WD. ES is mostly influenced by itself, followed by TOP and then ME and WD with almost equal efficacy. MC is mostly influenced by itself, followed by ME and then TOP. R&D and WD have little impact on MC. Finally, WD is mainly influenced by itself, followed by ME and then ES, with almost no impact from TOP, MC, and R&D.

5. Conclusions

This study aims to investigate the effect of the Russian-Ukrainian conflict on the trade of the European Union and East Asia-Pacific. The study uses panel data from the European Union, Ukraine, Russia, and the East Asia-Pacific region, covering the years 2000 to 2021. The findings suggest that in the long run, increased military spending by Russia and Ukraine would enhance trade between the European Union and East Asia-Pacific. Although war is a devastating situation, it increases the demand for military equipment, which is typically procured from other countries. Economic sanctions on Russia and Ukraine, on the other hand, have a long-term negative impact on trade. The conflict theory and economic theory of war predict that additional economic sanctions would limit trade and potentially lead to social upheaval and civil unrest between nations. Moreover, sanctions could affect resource distribution and markets, leading to economic harm and potentially causing war. In the short term, R&D opportunities in Russia and Ukraine would negatively impact trade, but over time they would have a positive effect on trade in the European Union and East Asia-Pacific. Media coverage of the Russian-Ukrainian war would have a negative impact on trade in the short term, but in the long term, it would start to improve. However, the war itself would have a favorable effect on trade, increasing trade prospects for the European Union and East Asia-Pacific in the near future. According to game theory, countries in Europe and Asia can develop trade strategies in response to Russia and Ukraine's inability to export goods and can fulfill their roles as substitute exporters.

5.1. Policy Recommendations

The following policy recommendations can be implemented to aid in resolving the conflict between Russia and Ukraine without causing additional harm:

1. Instead of imposing extensive sanctions against Russia, which may have trade costs and negatively impact the accessibility of necessary supplies, a shift towards providing economic aid to Ukraine can be made. This approach focuses on providing economic help as a "carrot" rather than using sanctions as a "stick" to deter future hostile actions.
2. Smart sanctions, which target only those parties that have engaged in undesirable behavior, can be employed to resolve disagreements with minimal violence. This approach avoids the negative impacts of broad sanctions and focuses on specific parties responsible for the conflict.
3. Rather than using sanctions as a means of coercion, incentives can be used to foster a more cooperative environment for compromise. These incentives can include financial support, access to technology, loans, investment projects, and political or security cooperation, offered in exchange for specific policy changes or concessions. Such incentives can be more effective in resolving conflicts than the threat of additional sanctions.
4. It is also crucial to involve international organizations to mediate negotiations between Russia and Ukraine. These organizations can provide a neutral ground for discussions and help ensure that the negotiations are fair and equitable for both parties.
5. Another strategy to prevent further conflicts and tension in the region is to promote economic cooperation and integration among the countries in the region. The creation of a regional economic bloc, similar to the European Union, can provide incentives for countries to work together towards common goals and reduce the likelihood of conflict.
6. The media can also play a role in reducing tensions between Russia and Ukraine by promoting dialogue and understanding between the two nations. The media can highlight the benefits of peaceful resolution and encourage leaders to take steps towards reconciliation. It is essential to address the root causes of the conflict, such as historical grievances, territorial disputes, and economic disparities. By addressing these underlying issues, it may be possible to prevent similar conflicts from arising in the future and promote long-term peace and stability in the region.
7. Ukraine can receive assistance from its international allies in three areas: military, financial, and political. Military aid includes the provision of munitions, modern artillery, gasoline for armored vehicles and aircraft, bulletproof vests, and first aid kits for soldiers. Financial aid is necessary due to the damage the war has caused to Ukraine's infrastructure, which requires reconstruction work with funds from other countries. Political aid is also needed, with the key point of contention being whether Ukraine is involved with NATO. For this issue to be resolved, Ukraine must either join NATO or deny any affiliation.
8. The traditional system of enforcing laws and punishing offenders is no longer effective, as demonstrated by the ongoing war in Ukraine. A new geostrategic order is emerging, in which force must be balanced with force. The future may lie in bold diplomatic initiatives that go beyond the conventional methods of protracted discussions, institutional bureaucracy, and financial pressure.

9. The UN Charter emphasizes state sovereignty, peaceful dispute settlement, and the ban on the use of force in international affairs, hence the UN General Assembly must exert pressure on Ukraine. All countries, especially the strongest, must support this rules-based international order.
10. Social media video messaging can be a powerful agent for change, as demonstrated by the 2011 Arab Spring, which was successful due to media intervention. Accurate information disseminated via social media has the potential to compel people in conflict-ridden nations to pressure their governments towards peace.

A desire for a "complete triumph" for either side in the conflict will result in nothing and can be extremely hazardous. Therefore, it is best for all other nations to keep their own aims and engagement in check to prevent further escalation of the situation in Ukraine. Encouraging a settlement between Russia and Ukraine increases the likelihood that the war will not spiral out of control. All non-parties to the conflict should pursue a ceasefire settlement. The current standoff between Russia and Ukraine is a critical issue that needs to be addressed immediately, as it has the potential to escalate into a disastrous situation. The ramifications of this conflict extend beyond the borders of these two countries, with global energy costs escalating and the world's food security being compromised due to Russia's blockade of Ukrainian grain and fertilizer imports. This conflict has resulted in widespread human suffering around the world. Therefore, it is crucial that a quick and effective resolution is achieved for the betterment of humanity.

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Dynamics of the interplay between economic complexity, governance and economic growth in the BRICS countries: a panel GMM approach

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Abstract. *This study tried to understand how economic complexity can unravel economic growth, resisting resource curse phenomena within the dynamics of governance factors in the BRICS countries. We used the panel GMM model for the period 1996 to 2022. We employed Arellano and Bover's (1995) GMM method for dynamic panel data estimation. Further, we used the Wald test to identify endogeneity. The results show that natural resources are a robust driver of economic growth, while the economic complexity index is pivotal in enhancing economic growth in the BRICS countries. Governance quality encompassing political stability, regulatory quality, rule of law, and control of corruption, exerts substantial influence on economic growth. While resource rents can determine economic growth, robust outcomes depend on economic complexity and the quality of governance of an economy in the context of the BRICS economies.*

Keywords: natural resources, economic complexity, economic growth, governance, resource curse.

JEL Classification: O43, O47, O13, Q2, Q3, Q56.

1. Introduction

Why do some countries fail amidst plenty of natural resources, however, some countries prosper with little or no availability of natural resources. Empirical studies reflect a prevailing viewpoint that considers resource availability a conceivable growth catalyst, thus labelling natural resources as advantageous (Robinson et al., 2006; Brunnschweiler and Bulte, 2008; Bhattacharyya and Hodler, 2010; Tsui, 2011; Cavalcanti et al., 2011). However, studies also contradict this resource-driven notion, as numerous resource-rich economies grapple with poverty and low living standards (for example several African countries suffer from acute poverty despite abundant natural resources like gold, and other minerals). For instance, research conducted by Gylfason and Zoega (2006), Papyrakis and Gerlagh (2007), Murshed and Serino (2011), and Badeeb et al. (2017) substantiated the principles of the Dutch disease and resource curse theory. The findings highlighted how natural resource endowment does not guarantee automatic economic advancement, indicating a missing link hindering the effective translation of resource abundance into growth (Xu et al., 2019). In recent years, economists have developed a model called the economic complexity index to examine this complexity of economic development to understand why nations fail amidst an abundance of natural resources and why some countries continue to develop without being endowed with an abundance of natural resources.

Therefore, this study tries to examine the economic complexity influencing BRICS countries' economic growth trajectories, primarily focusing on the potential to overcome the resource curse. Economic complexity is a multi-dimensional concept that encompasses factors such as product diversification and a country's skill in leveraging knowledge and resources to expand its spectrum of exports. The economic complexity of a country is measured through the Economic Complexity Index (ECI)⁽¹⁾. This comprehensive index covers human development, innovation, and trade dynamics. Rooted in Hidalgo and Hausmann's (2009; 2011) seminal works asserted the reliance of economic growth on productive knowledge and skills, enabling diversified productivity. Notably, all BRICS countries have low ECIs, indicating limited productive enhancement. In the 2023 report of the Organization of Economic Complexity, Japan ranks the highest in the ECI (2.48), while China, India, Russia, Brazil, and South Africa score 1.07, 0.60, 0.46, 0.33, and 0.10, respectively (OEC, 2023).

This research aims to uncover the intricate intertwining between resource abundance, economic complexity, and sustainable economic growth within the BRICS countries. Beyond surface analysis, it seeks to unveil patterns crucial for overcoming the resource curse and achieving lasting economic prosperity. We seek to address a gap in the current literature by examining the impact of the interplay between natural resources and economic complexity on economic growth within the dynamics of governance in the BRICS countries. Therefore, it explores whether resources affect growth and whether economic complexity and governance play a role in the economic growth of a nation. And if it (economic complexity) plays, how does it play? These are the questions that are being explored in this study. Therefore, employing data from 1996 to 2022 for the BRICS economies, the study measures the moderating effect of economic complexity on economic growth.

This paper is divided into seven sections. The next section is the background of the study. The third section is the Review of Literature; the fourth section is Data and Methodology; section fifth is Empirical Results; section sixth is Discussion; and section seventh is the conclusion and Policy Implications.

2. Background of the study

The BRICS countries—Brazil, Russia, India, China, and South Africa—constitute a significant portion of the world's population and landmass, and their collective economic influence has grown substantially in recent decades. These countries are richly endowed with diverse natural resources, ranging from Russia's vast mineral reserves and China's manufacturing prowess to Brazil's agricultural output and South Africa's mineral wealth. However, paradoxically, these countries grapple with profound regional disparities, escalating inequalities, alarming levels of unemployment, and pervasive poverty, as documented by Jha et al. (2013). In stark contrast, Asian counterparts such as Japan, Hong Kong, Singapore, and Taiwan, despite their lack of significant natural resources, demonstrate remarkable economic efficiency and boast high per capita GDP, thereby highlighting the presence of the natural resource blessing. This perplexing phenomenon prompts a fundamental inquiry into the reasons behind the paradox of plenty syndrome prevailing in the BRICS countries and the underlying factors that form the elusive link between resource abundance and their economic growth dynamics. Rajiv (2023) cogently attributes the paradoxical situation to the prevailing tendency to consider natural endowments in isolation, neglecting the imperative of diversification. Given the resource advantages, the economic trajectories of these BRICS countries have been marked by complexities. While China's rapid industrialization and export-oriented growth have propelled it to the forefront as a global supply chain hub, Russia's heavy reliance on oil exports has made its economy vulnerable to fluctuations in global oil prices. Brazil faces challenges in sustainable land use and deforestation, while India grapples with issues related to poverty alleviation, income inequality, and bureaucratic hurdles. Trade dynamics within the BRICS bloc significantly fabricated their economic landscapes. Intra-BRICS trade has increased over the years, reflecting their efforts to strengthen economic ties. Among the BRICS countries, China's role as the "world's factory" has trade imbalances, as it exports manufactured goods to other BRICS countries and imports raw materials to sustain its production. This trade pattern underscores the interdependence and complexities of their economic relationships. Governance quality is another crucial factor influencing the utilization of resources and economic growth within the BRICS countries. Transparency, corruption, and regulatory efficiency impact their ability to convert resource wealth into sustainable development. Each nation's approach to governance varies, with implications for resource management, trade negotiations, and investor confidence.

Therefore, the BRICS countries' natural resource endowments, economic complexities, trade dynamics, and governance quality collectively define their paths in the global financial arena. Their efforts to leverage their resource wealth for development while addressing internal challenges and external dynamics showcase the intricate balancing act they navigate. As the BRICS countries continue to evolve, their approaches to resource

utilization, economic diversification, trade cooperation, and governance reforms will shape their roles in the global economy and their ability to tame the existing complexities. Therefore, uncovering intricate connections between resource abundance, economic complexity, and sustainable growth within the BRICS countries is prudent.

3. Review of literature

The discourse on natural resource-led economic growth has yielded mixed empirical findings within the literature. Nevertheless, this study strides ahead by seamlessly integrating economic complexity into the framework of the natural resource-led growth model. The division of the literature review unfolds into dual strands of thought. Primarily, the existing evidence illuminates the advantageous aspects of natural resource endowment. Conversely, a contrasting viewpoint emerges, highlighting the presence of a resource curse exacerbated by the intricate interplay of economic complexity and growth. Eminent scholars such as Cavalcanti et al. (2011), Tsui (2011), Bhattacharyya and Hodler (2010), Brunnschweiler (2008), Mesagan et al. (2019), and Haseeb et al. (2021) have meticulously documented a direct nexus between natural resources and economic growth. For instance, Cavalcanti et al. (2011) unearthed a positive correlation between natural endowment and growth across 53 countries from 1980 to 2006. Tsui (2011) delved into the repercussions of oil-rich economies on both democracy and growth, shedding light on the adverse impact of oil on democracy while also highlighting its positive contribution to growth.

Zall'e (2019) explored the intricate interplay between resources, institutional quality, and human capital in the context of Africa. The study underscores the imperative of investing in human capital and eradicating corruption. Havranek et al. (2016) brought to the fore a nuanced perspective, emphasizing the tenuous link between resources and growth when accounting for factors such as publication bias and approach disparities. This underscores the need for methodological rigour, including considering institutional frameworks, investment patterns, resource categorization, and the distinction between resource dependence and abundance.

Zhu and Li (2019) have taken a proactive approach to predict and explain how economies grow by using the concept of economic complexity. They have shown how economic complexity positively impacts, especially in larger economies, where its long-lasting effects are noticeable. While managing natural resources effectively can kickstart growth, it could act as a catalyst. The connections between economic complexity and the increase in GDP provide examples of how countries with higher incomes handle more complex challenges and responsibilities.

Bhattacharyya and Hodler (2010) thoroughly studied the period from 1980 to 2004 across 124 countries, whereby the analysis pointed to specific conditions necessary for growth driven by resources. These conditions include having high-quality institutions and a thriving democratic framework. In a broad study spanning five diverse regions, Brunnschweiler (2008) supports how natural resources could lead to economic growth. The study found a strong link between abundant resources and maintaining high-quality institutions. Mesagan et al. (2019) carefully examined the influence of resources on growth

in African countries such as Angola, Egypt, Nigeria, and Tanzania, challenging the widely accepted idea of a "resource curse." The study established direct connections between resources and growth.

The complexity of growth also involves the core concepts of trade and economic collaboration among countries. Guo et al. (2019) highlight that well-organized trade agreements and integration can drive resource optimization and economic growth. It relies largely on establishing strong governance systems that ensure fair distribution of these advantages to achieve the benefits.

On the contrary, there exists a body of research by Sachs et al. (1995), Gylfason and Zoega (2006), Papyrakis and Gerlagh (2007), Brückner (2010), Murshed and Serino (2011), Boschini et al. (2013), Ahmed et al. (2016), Badeeb et al. (2017), and P'erez and Claveria (2020) that supports the notion of the resource curse and Dutch disease theory. For instance, Sachs et al. (1995), through a cross-country analysis, established a negative correlation between resource abundance and economic output within the context of an endogenous growth model. Further, Auty (1993) extended this investigation across 85 countries, corroborating the existence of a resource curse phenomenon. The quality of governance plays a pivotal role in shaping economic growth trajectories. Findings from studies such as Kaufmann et al. (2003) and Mauro (1995) underscore that effective governance, encompassing attributes like the rule of law, corruption control, and political stability, creates an environment conducive to sustainable economic advancement—governance of high calibre aids in efficiently utilising resources and acts as a magnet for investments. Brückner (2010), in an examination spanning 39 countries from 1970 to 1990, delved into the impact of institutional instability and governance, attributing the emergence of the resource curse hypothesis to these factors. Investigating trade and growth across 49 economies from 1960 to 2005, Murshed and Serino (2011) found a positive correlation between diversified processed exports and growth that diversified processed exports were correlated with positive growth outcomes, while economies rich in primary product exports experienced detrimental growth effects. Papyrakis and Gerlagh (2007), focusing on the USA between 1986 and 2000, revealed an inverse relationship between resource endowment and indicators like investment, schooling, trade openness, and expenditure on research and development, while corruption exhibited a positive correlation. Brunnschweiler (2008) reinforces the pivotal role of institutional quality in shaping the impact of resources on economic growth. The efficacy of governance mechanisms proves indispensable in translating the wealth derived from resources into sustainable development, underscored by the success of resource-abundant countries such as Norway.

In the exploration of the intricate dynamics surrounding natural resource abundance, Boschini et al. (2013) ventured to dissect minerals, leading them to an insightful revelation. Their analysis unveiled positive growth effects stemming from ore and metal resources, while other types of resources exerted negative impacts. They put forth a compelling argument for institutional quality's pivotal role in countering the resource curse's potential adverse effects. Building upon this foundation, Ahmed et al. (2016) conducted a meticulous investigation applying the Cobb-Douglas function to the Iranian context. The findings aligned with the resource curse hypothesis, as they verified a decline of 4% in growth for

every 1% rise in resources. The reflections of Badeeb et al. (2017) cast a wide net over the landscape of resource curse literature. The study also pointed towards the applicability of the resource curse notion, especially within developing countries characterized by weaker institutions. Eregha and Mesagan (2020) delved into the Next-11 countries by expanding the geographical scope. Through an intricate analysis involving nonlinear panel data spanning from 1960 to 2016, the study uncovered a critical juncture. Specifically, when financial deepening stayed below the 45% threshold, it triggered an inverse relationship between resources and growth. Conversely, crossing the 45% mark paved the way for resource-led growth. Shifting the focus, the investigation into the role of economic complexity in driving growth emerges as another important dimension. Du and O'Connor (2021) harnessed cross-country data to present a compelling argument – entrepreneurship, acting as a catalyst for growth through economic complexity, fuels progress. Further amplifying the significance of economic complexity, Hartmann et al. (2017) embarked on a journey involving 150 countries. The findings established a strong connection between high economic complexity and lower levels of income inequality. Delving deeper into this arena, Zhu and Li (2016) conducted a study across 210 countries, revealing a profound link between economic complexity, human development, and positive economic growth. On the other hand, Ch'avez et al. (2017) unveiled the role of economic complexity in shaping wealth disparities among Mexican states.

In this landscape of research, few studies firmly support the resource curse theory, while others, like Brückner (2010), Boschini et al. (2013), Badeeb et al. (2017), Eregha and Mesagan (2020), and Usman et al. (2022), advocate for a distinct path. They proposed that certain institutions, governance, and financial deepening qualities could act as potent tools to reverse the curse, thereby transforming resources from burdens into blessings. Conversely, an intriguing gap becomes evident in the existing body of research. While some studies have highlighted the role of economic complexity in driving growth—such as Hartmann et al. (2017), Ch'avez et al. (2017), Zhu and Li (2016), and Zhang et al. (2022)—they have yet to connect it as the conduit through which natural resources foster growth. In its innovative approach, the current study steps into this uncharted territory. It expands the horizon by intertwining economic complexity into the interplay between natural resources and economic growth, particularly within the dynamic context of the BRICS countries. This novel perspective seeks to unravel whether the inherent complexities within the BRICS countries could transform natural resources into dynamic sources of growth or amplify their potential to propel economic progress significantly.

4. Data and Methodology

Model and data

The current study examines the interplay among natural resources, economic complexity, and growth in BRICS economies, building on insights from Solow (1956), Hidalgo and Hausmann (2009), and Eregha and Mesagan (2020). These previous works lend support to the chosen model and variables. Solow's growth theory, which underscores the roles of labour and capital, provides the fundamental basis (Solow, 1956). Equation (1)

incorporates these foundational factors and extends its scope to encompass resource rent and other relevant control variables. The significance of knowledge is represented through the economic complexity index, as inspired by Hidalgo and Hausmann (2009), who established a link between complexity and the relationship between natural resources and growth. Consequently, equation (1) can be expressed as follows:

$$PCGDP_{it} = \alpha + \beta_1(NR_{it}) + \beta_2(ECI_{it}) + \beta_3(LFPR_{it}) + \beta_4(CF_{it}) + \beta_5(FDI_{it}) + \beta_6(To_{it}) + \beta_7(PS\&V_{it}) + \beta_8(RQ_{it}) + \beta_9(ROL_{it}) + \beta_{10}(CC_{it}) + \mu_{it} \quad (1)$$

Where per capita GDP (PCGDP) measures economic growth, natural resources are represented by the natural resources rent (NR) and economic complexity is quantified by the economic complexity index (ECI). The growth model incorporates the labour force participation rate (LFPR) and gross capital formation (CF) to account for labour and capital effects. Control variables encompass Foreign Direct Investment (FDI), Trade openness (TO), Political stability and violence (PS&V), Regulation Quality (RQ), Rule of Law (ROL), and corruption control (CC). The model's components include an intercept (α), estimated parameter coefficients ($\beta_1 - \beta_{10}$), stochastic disturbance (μ), and cross-sectional (i) and time-related (t) variations. To assess the combined impact of natural resources and economic complexity on growth, equation (2) is presented.

$$PCGDP_{it} = \alpha + \beta_1(PCGDP_{it-1}) + \beta_2(NR * ECI_{it}) + \beta_3(LFPR_{it}) + \beta_4(CF_{it}) + \beta_5(FDI_{it}) + \beta_6(To_{it}) + \beta_7(PS\&V_{it}) + \beta_8(RQ_{it}) + \beta_9(ROL_{it}) + \beta_{10}(CC_{it}) + \mu_{it} \quad (2)$$

In equation (2), $PCGDP_{it-1}$ is the time lag of PCGDP that could determine the growth and $NR*ECI$ captures the joint ECI impact while other estimators remain constant. Data spans from 1996 to 2022 for 5 BRICS countries selected for data availability. This period reflects substantial growth, trade expansion, and global influence, albeit with varied trajectories due to distinct complexities, internal challenges, external factors, and governance enhancement efforts.

The study employs Arellano and Bover's (1995) GMM method for dynamic panel data estimation. GMM corrects sample biases, addresses endogeneity, curbs over-identification, and controls cross-sectional dependence. It suits scenarios with more cross-sections ($N = 5$) than time series ($T = 26$). Instruments chosen through the Sargan Test (results undisclosed) use lagged explanatory variables. GMM outperforms OLS and fixed effects, tackling issues like serial correlation, multicollinearity, and measurement biases. It handles misspecification and proxy variable errors. Pre-conditions include endogeneity diagnosis. The study employed the Wald test to identify endogeneity; insignificant J-statistics accept instrument validity. Moreover, the Wald test is applied for endogeneity diagnosis. Test results indicate significant ($p \geq 0.05$) correlations between residual terms and explanatory variables, confirming endogeneity issues. This approach aligns with how resource-rich countries leverage resource revenue for economic growth, as observed in studies like Mesagan et al. (2019), Mohamed (2020), and Canh et al. (2020), making it a fitting proxy.

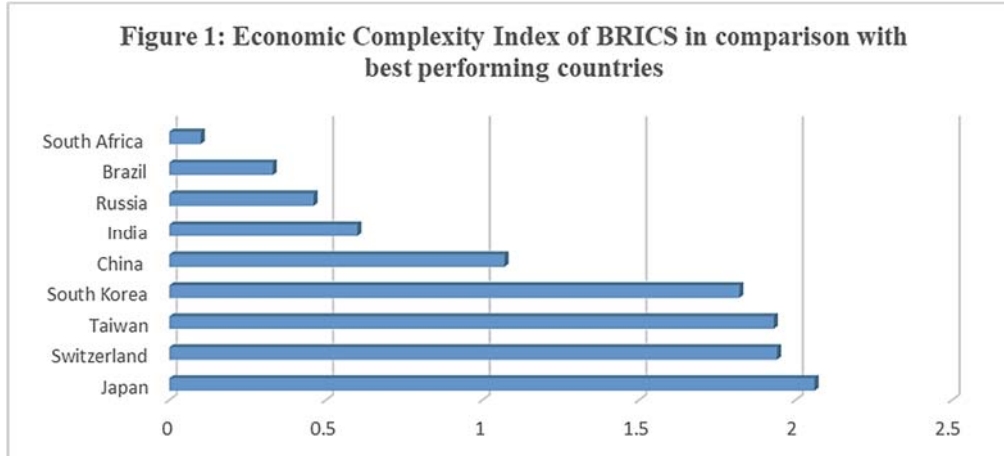
Table 1. *Description of Variables*

Variables	Name	Measurement	Sources
PCGDP	Per Capita GDP (Economic Growth)	Measures the per capita income of people of a country in Real-term	World Bank 2021
NR	Natural Resources	Measures the resource rent as % of GDP	World Development Index 2021
CE	Complex economy	Measures the productive capabilities of economic systems. The Economic Complexity Index has measured it.	Harvard Dataverse 2021
NRCE	Interrelationship of Natural Resources and Complex Economic System	Measures the joint effect of natural resources and complex economic system (Index)	Derived by Author
CF	Capital Formation	It is measured with gross capital formation as % of GDP of a country	World Development Index 2021
LFPR	Labour Force Participation Rate	It is measured from the total labour force	World Development Index 2021
FDI	Foreign Direct Investment	Measured by the inflow of foreign currency and technology in USD	World Governance Indicator 2021
TO	Trade Openness	The ratio of the sum of exports and imports	World Bank/IMF
PS&V	Political Stability and Violence	This index assesses the perceptions regarding the potential for the government to experience destabilization or removal through unconstitutional or violent methods, encompassing politically motivated acts of violence and terrorism.	World Governance Indicator 2021
RQ	Regulatory Quality	This index reflects the perceptions regarding the government's capacity to create and enforce effective policies and regulations that facilitate and encourage the growth of the private sector.	World Governance Indicator 2021
ROL	Rule of Law	This index encompasses the perceptions of how much individuals trust and adhere to societal norms and regulations. It mainly assesses the quality of contract enforcement, property rights, law enforcement, and judicial systems and also considers the potential for criminal activities and violence.	World Governance Indicator 2021
CC	Control on Corruption	This index gauges the perceptions regarding the degree to which governmental authority is wielded for personal benefit, encompassing various forms of corruption, both minor and significant. It also includes instances of the state being influenced or controlled by privileged groups and private interests.	World Governance Indicator 2021

Source: Authors' compilation.

5. Empirical Results

Descriptive analysis is presented in Table II, showcasing variable trends via mean, standard deviation, and minimum and maximum values. For instance, PCGDP has a mean of 7337.7, reflecting the BRICS economies' average trajectory. Similarly, NR (natural resources) averages 2.61, representing rent from diverse natural resources. ECI (economic complexity index) has an average of 0.51, depicting relatively good (not better) ECI state in BRICS countries, with the benchmark ranging between 2 (favourable) and -2 (poorest). Likewise, CC (corruption control) holds a mean of 0.52, reflecting not-so-good conditions in BRICS. The labour force participation rate (LFPR) mean is 58.9, and CF (capital formation) averages 18.21, representing relatively better regional trends. Furthermore, FDI and TO (trade openness) have respective mean values of 18.79 and 21.55, both in logarithmic form, indicating inflow volume and trade openness level. The economic complexity Index among BRICS countries compared to top-performing countries in the ranking is depicted in Figure 1.

Figure 1. *Economic Complexity of BRICS countries compared to other best-performing countries*

Sources: Complexity rankings, "The Observatory of Economic Complexity", OEC, 2023.

In Figure 1, the resource utilization and productive capacity of BRICS countries are compared with top performers like Japan, Switzerland, Taiwan, and South Korea. This highlights BRICS' comparatively weaker performance, indicating less diversification of its productive activities for exports and further lesser competitive pricing capacity of export products for the BRICS economies. Furthermore, this could also give some inference about uneven socio-economic indicators across their populations and substantial inequality across different levels that lead to lower knowledge base economy and innovation in these economies.

Table 2. *Descriptive Statistics*

Variables	Mean	Std. Dev	Max.	Min.	Obs
PCGDP	7337.75	3440.21	10511	1928	111
NR	2.61	2.84	18.5	1.8	111
ECI	0.51	1.2	1.02	-0.98	111
NRCE	-1.89	0.71	0.56	-0.24	111
CF	18.21	1.54	43.8	13.05	111
LFPR	58.9	0.69	63.8	36.2	111
FDI	18.79	0.71	-0.71	-1.89	111
TO	21.55	0.21	-0.89	-2.01	111
PS&V	0.42	0.74	0.59	-1.8	111
RQ	0.51	0.82	-0.25	-1.81	111
ROL	0.39	0.46	-0.32	-1.78	111
CC	0.52	0.85	-0.11	-1.91	111

Sources: Authors' calculation.

Unit root testing

Given the inclusion of numerous macroeconomic variables, assessing their stationarity is crucial. To this end, the unit root tests employed Im, Pesaran, and Shin (2003) and ADF (Dickey and Fuller, 1979) tests. Results, detailed in Table III, demonstrate stationarity at the first difference of all variables. The statistically significant values ($p \geq 0.05$) from both techniques reject the null hypothesis of non-stationarity.

Table 3. *Estimated Results of Unit Root Test*

Variables	IPS (Im, Pesaran and Shin) W-Statistics			
	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
PCGDP	-0.151	0.7284	-5.673	0.0000*
NR	0.731	0.7706	-5.798	0.0000*
CE	0.757	0.9808	-6.236	0.0000*
NRCE	-1.631	0.4006	-14.887	0.0000*
CF	-0.193	0.6124	-10.591	0.0000*
LFPR	0.673	0.6581	-5.019	0.0005**
FDI	0.181	0.9958	-4.487	0.0000*
TO	-1.63	0.992	-12.253	0.0000*
PS&V	-1.66	1.000	-14.262	0.0000*
RQ	3.249	0.5256	-22.410	0.0000*
ROL	0.560	0.0921	-12.928	0.0010**
CC	-1.820	0.0341	-10.113	0.0033**

Note: * 1%, ** 5% level of Significance.

Sources: Authors' calculation.

Endogeneity Test

The endogeneity identification test is designed to determine endogeneity, that is, the existence of a correlation between explanatory variables and the error term in a regression model. These tests help detect potential biases in regression estimates and assess the reliability of the model's results. The results presented in Table IV depict the absence of any endogeneity issue; hence, no relationship exists between explanatory variables and error terms, which may impact coefficients and level of significance.

Table 4. *Endogeneity Identification*

Test	Statistic	Degree of Freedom	Prob.
F-Statistic	3545.162	8, 87	0.0001*
Chi-Square	2981.284	8	0*
Testing H0 = C(n)=0			
Restriction Terms		Value	Std. Error
C(1)		0.261	0.023**
C(2)		0.009	0.0004*
C(3)		0.005	0.005*
C(4)		0.0078	0.012*
C(5)		0.003	0.021**
C(6)		0.002	0.0001*
C(7)		0.0036	0.005*
C(8)		0.0001	0.002*

Note: * 1%, ** 5% level of Significance

Sources: Authors' calculation.

Correlation analysis

In Table V, variable correlation coefficients are displayed. Evidence indicates mild correlations between the series, indicating minimal collinearity and the absence of multicollinearity issues in the model. The only notable strong correlation is 0.959 between NR & ECI, 0.914 between NR & NRCE, and 0.909 between PS&V & ROL. To prevent multicollinearity among regressors, the regression models estimated have been divided accordingly.

Table 5. *Correlation Analysis*

	PCGDP	NR	CE	NRCE	CF	LFPR	FDI	TO	PS&V	RQ	ROL	CC
PCGDP	1.000											
NR	0.065	1.000										
CE	0.079	0.959	1.000									
NRCE	0.070	0.914	0.229	1.000								
CF	0.715	0.123	0.149	0.137	1.000							
LFPR	0.849	0.043	0.008	0.008	0.052	1.000						
FDI	0.730	0.069	0.539	0.126	0.253	0.012	1.000					
TO	0.076	0.211	0.102	0.197	0.067	0.126	0.033	1.000				
PS&V	0.104	0.275	0.077	0.232	0.322	0.124	0.828	0.149	1.000			
RQ	0.049	0.043	0.008	0.008	0.052	0.539	0.126	0.126	0.253	1.000		
ROL	0.130	0.069	0.539	0.126	0.253	0.012	0.891	0.070	0.909	0.229	1.000	
CC	0.076	0.211	0.102	0.197	0.067	0.126	0.033	0.069	0.539	0.126	0.253	1.000

Sources: Authors' calculation.

Regression assessment

Using the GMM (Generalized Method of Moments) technique recommended by Arellano and Bond (1995), the results are presented in Tables VI and VII. This method, commonly called the AB model, is consistent with prior research on similar topics (Canh et al., 2020; Farooq, 2021a). Table VI outlines the step-by-step impact of the main predictors, while Table VII focuses on the moderating effects. In Table VI, the lag of Per capita GDP (PCGDP) stands out significantly at the 1% level, indicating that the current year's PCGDP relies on the previous year's value. This finding reinforces the implication of the system GMM model, which suggests that PCGDP depends on its lag (Farooq et al., 2021). Shifting our attention to the core variables, the coefficient associated with natural resource rents stands at 2.418, significantly impacting economic growth within the BRICS countries at a confidence level of 1%. This implies that a single-unit alteration in natural resource rents corresponds to a notable growth increase of 2.148%. On the contrary, the positive coefficient linked to the economic complexity index (ECI) (1.082) underscores the pivotal role of ECI in bolstering economic growth (GMM Model 2). This coefficient holds statistically significant at 5% level, signifying that a one-unit elevation in ECI corresponds to a substantial growth augmentation of 1.082%.

Table 6. *Estimated results of GMM models*

	System GMM Model 1		System GMM Model 2	
	Coefficients	Std. error	Coefficients	Std. error
Per capita GDP (-1)	1.891***	1.101	1.762***	1.110
Natural resources	2.418***	0.014	-	-
complexity of Economy	-	-	1.082**	0.910
Labour force participation	0.495	3.142	0.375	3.498
Capital-formation	0.841 **	1.891	0.745 **	1.752
FDIs	1.546 **	0.201	-	-
Trade Openness	1.484**	0.010	1.074**	0.854
Pol. Stability and Violence	-	-	-0.454***	0.089
Regulatory Quality	0.807	5.222	0.674	4.852
Rule of Law	0.785**	0.003	-	-
Control of Corruption	-0.838***	1.451	-0.603***	1.036
Adjusted R-square	0.701		0.668	
S.E. of regression	1.022		1.436	
Prob (J-statistic)	0.845		0.731	

Note: ***significant at 1%, **significant at 5%, *significant at 10%.

Source: Authors' calculation.

The labour force participation rate notably displays a positive yet insignificant correlation with economic growth. Capital formation exhibits a positive and significant relationship with economic growth. Findings suggest that a 1% rise in capital formation induces a 0.841% increase in the economic growth of BRICS economies. Further, trade openness emerges as a vital determinant of economic growth within BRICS countries. The estimates reveal a 1% growth in trade openness (trade surplus) corresponds to a 1.484% economic growth increase. These outcomes hold significance at 5% level. Concerning governance quality (control variables), political stability and violence reveal a notably negative relationship with economic growth. The estimates indicate economic growth in the BRICS region responds positively to natural resource utilization and enhanced economic complexities under stable political conditions without violence. However, economic growth could decrease by -0.454% during political instability and violence. A similar scenario applies when regulatory quality and the rule of law thrive. For a 1% improvement in regulatory quality and the rule of law, economic growth increases by 0.807% and 0.785%, respectively. While regulatory quality remains insignificant, the rule of law holds significance at the 5% level.

Furthermore, the control of corruption significantly affects economic growth. Therefore, the estimates demonstrate that a 1% strengthening of corruption control mechanisms results in a 0.838% economic growth increase. This coefficient is statistically significant at the 1% level of significance. The aforementioned findings underscore the substantial impact of resource utilization capacity and economic complexity on economic growth in BRICS countries. Nevertheless, realizing the full potential of their resources and productive capabilities (knowledge, urban centres, income, and economic systems) hinges upon achieving elevated levels of governance quality and economic openness. In the absence of robust governance quality and open economies, BRICS countries may experience constrained and volatile economic growth.

To evaluate the combined or moderating influence of natural resources and economic complexities, we computed equation 2 from the study. As shown in Table VII, the interaction between natural resources and economic complexities directly and significantly affects the economic growth of BRICS countries. The estimations indicate a 1% rise in the combined impact of NR and ECI leads to a 3.458% increase in economic growth (GMM model 1) and a 3.624% increase (GMM model 2). Similarly, the coefficients for governance quality (PS&V, RQ, ROL, and Control of Corruption) and economic openness (FDI and TO) reveal their considerable impact on the economic growth of BRICS countries.

Table 7. *Estimated results of moderating/joint effect equation*

Variables	Panel Generalized Method of Moment (GMM) Model 1 Coefficients	Panel Generalized Method of Moment (GMM) Model 2
Per Capita GDP (-1)	1.566***	1.751***
NR*ECI	3.458***	1.624***
Labor force participation	0.884	0.793
Capital-formation	1.027***	0.952
FDI	2.010***	-
Trade Openness	1.183*	1.009*
Pol. Stability and Violence	-	-0.808**
Regulatory Quality	0.856	0.767
Rule of Law	0.775**	-

Variables	Panel Generalized Method of Moment (GMM) Model 1 Coefficients	Panel Generalized Method of Moment (GMM) Model 2
Control of Corruption	-0.915***	-0.887***
Adjusted R-square	0.655	0.678
S.E. of regression	0.983	1.581
Prob (J-statistic)	0.875	0.795

Note: ***significant at 1%, **significant at 5%, *significant at 10%.

Source: Authors' calculation.

6. Discussion

This study explored how natural resource rents and economic complexity impact countries' economic progress in the BRICS region. On employing a statistical analysis centred around the implications of the system GMM model, the findings unveiled the significance of natural resource rents to foster economic growth, thereby challenging the prevailing notion that resources are inherently detrimental (i.e., resources are a curse). Therefore, it reveals that the judicious harnessing of resources to fuel various ambitious objectives significantly contributes to economic expansion, underscoring the argument that presumes the excess use of resources within a framework of controlled regulatory quality, adherence to the rule of law, and robust corruption control mechanisms bestow a boon upon a country. Consequently, the outcomes derived from this investigation run counter to the conclusions drawn by Ampofo et al. (2020) where it was found the resource curse phenomenon operating in Australia, India and the Democratic Republic of Congo indicating that the availability of natural resources does not determine economic growth in these economies. However, our finding suggests that the combined effects of natural resource rent and economic complexity in BRICS economies has positive impact on economic growth.

The economic performance of the BRICS countries—Brazil, Russia, India, China, and South Africa—has garnered substantial attention and scrutiny due to their collective influence on global GDP, trade, and population (Garcia and Bond, 2017). For instance, the share of BRICS in the Global GDP was 16.9% in 1995, and the latest IMF estimates reveals that the BRICS share to Global GDP in 2023 will go up to 32.1%, which is higher than the G7 countries share of 29.9% (IMF). Factors such as natural resources, demographic trends, technology advancements, and policy choices have all shaped their economic trajectories (Gupta & Nayak, 2018). Despite their resource abundance and population diversity, these countries have exhibited varying levels of growth, challenges, and resilience. China and India have seen rapid industrialization, while Brazil and South Africa have faced inequality and political instability. Energy exports and geopolitical dynamics have swayed Russia's economic performance (Zhao and Ehsan, 2023). The COVID-19 pandemic has introduced multiple challenges and collaborative opportunities, such as joint efforts in vaccine development and economic recovery (Dogen et al., 2022). In totality, the intricate economic performance of BRICS countries results from the interplay between resource use, domestic and global factors, and their evolving role in the world economy.

The progress of BRICS is entangled with unsustainable economic growth and challenges to address multiple socioeconomic inequalities. Studies have advocated that natural

resources and economic capabilities are pivotal in achieving economic ambitions within the BRICS countries (Liu et al., 2023; Adebayo et al., 2023; He et al., 2022; Bai et al., 2022).

Consistent with these perspectives, the estimated outcomes of the GMM model, as presented in Table VI, further underscore the noteworthy and affirmative relationship between the economic complexity index and economic growth (Zhao & Ehsan, 2023). Economic complexity signifies the enhancement of prevailing economic endeavours through a combination of diversification and advancements in production technology and knowledge. Numerous economies amplify trade by focusing on product complexity, boosting economic growth (Guo et al., 2022). A heightened economic complexity index indicates product diversification and a knowledge-driven economy, reflecting a nation's productive capabilities that contribute favourably to economic growth through exports channel. This aligns with Hodey et al.'s (2015) empirical analysis, which illustrated the beneficial effects of export diversification, closely associated with economic complexity, on economic growth.

Apart from individual analyses, this study also investigated the combined impact of economic complexity and natural resource rents on the economy's progress. The statistical results presented in Table VII suggest that a higher level of economic complexity has the potential to amplify the positive influence of natural resource rents on economic growth. The noteworthy coefficient value of the interaction term (NR*ECI) supports this proposition, underscoring a significant and affirmative effect on the economic growth in the BRICS region. Economic complexity enhances efficiency and outcomes in utilising natural resources, boosting trade endeavours. This correlation aligns with empirical findings by Zhao & Ehsan (2023), Liu et al. (2023), Islam and Managi (2019), and Ikram et al. (2021). Furthermore, this empirical examination delves into the dynamic impacts of economic factors such as the total labour force, gross capital formation, FDI inflow, and trade openness on economic growth (which is also studied by Constantinl et al., 2008; Wang et al., 2022; Ma et al., 2022). Conversely, the total labour force has a direct influence on economic growth. A larger pool of human capital, particularly skilled workers, has the potential to uplift economic growth by enhancing production efficiency. However, our analysis indicates insignificant effect in this aspect, which differs from the conclusions drawn by Zhang et al. (2018). Furthermore, gross capital formation positively affects real per capita gross domestic product. The accumulation of fixed capital assets, known as gross capital formation, amplifies production capacity, leading to increased exports and economic growth (Dittrich et al., 2010; Zhang et al., 2022). This could be because, through capital formation, innovative ideas could be put into action to produce varieties of new products and services which help to enhance the economic complexity index. Therefore, the studies suggested that BRICS prioritize infrastructure development and fortification of production sources to accelerate economic growth. Similarly, the positive impact of FDI inflow on economic growth arises from enhanced employment, improved total factor productivity, and increased industrial momentum within the host nation (Ma et al., 2022). FDI inflow facilitates knowledge transfer from developed to developing economies, fostering rapid economic growth (Hartmann et al., 2017; Zhang et al., 2022).

Likewise, the significant effect of trade openness on BRICS's economic growth underscores opportunities for domestic industries to expand by producing export-oriented goods (Zhang et al., 2022; Wang et al., 2022). However, note that less developed BRICS countries (like South Africa and Brazil) might face challenges due to lower product quality, and the export baskets of these economies mainly consist of primary goods, thus, hindering benefits from trade openness policies. As BRICS economies exhibit changing import-export proportions over time, trade openness boosts trade volume and domestic economic growth by reducing trade deficits (Wang et al., 2022; Farooq et al., 2022). Lastly, governance quality positively and substantially impacts BRICS's economic growth. The factor directly linked to economic growth, controlling corruption, is more likely to contribute significantly to production efficiency and institutional efficiency through strict anti-corruption measures (Bhattacharyya & Hodler, 2010). On the other hand, political stability and violence negatively correlate with economic growth. Sound institutional structures can effectively shape and enforce economic regulations, fostering a corruption-free, rule-based society (Biswas et al., 2012; Hosseini & Kaneko, 2013). Similarly, regulatory quality and the rule of law significantly affect economic growth. Favourable citizen behaviour, civil liberties, political rights, and literacy drive economic development, improving quality of life and overall economic growth (Farzin and Bond, 2006).

In summary, our empirical findings affirm the positive impact of natural resource rents and underline the constructive link between economic complexity and economic growth in BRICS countries. This study underscores that economic complexity augments the positive effects of natural resources on vibrant economic growth. The results reaffirm that natural resources are a blessing in disguise when coupled with economic complexity and robust governance encompassing the rule of law, regulatory quality, anti-corruption measures, and political stability.

7. Conclusion and Policy Implications

This study contributes significantly to the existing literature by examining the interplay between natural resource rents, economic complexity, and economic growth within the context of the BRICS countries. The empirical analysis using the system GMM model substantiates key propositions: the beneficial role of natural resources is underscored by the lens of economic complexity, governance quality, and economic openness. The empirical findings reaffirm a substantial and positive nexus between natural resource rents, economic complexity, and economic growth. Moreover, the results of our analysis illuminate a positive relationship between governance quality, economic openness, and economic growth. This underlines the importance of economic complexity and governance quality in optimizing the advantages of available natural resources.

To put it in perspective, robust economic outcomes from natural resources in BRICS countries hinge on a combination of economic complexity and governance quality. Remarkably, the positive impact of economic complexity persists even after considering resource endowments, signifying that heightened economic complexity augments natural resource use efficiency, thereby fostering economic growth. This positive influence further

underscores the significance of elevating economic complexity for promoting economic prosperity within the BRICS economies.

The study could not disagree regarding its multifaceted contribution. From a theoretical perspective, it enhances the existing literature by introducing an innovative theoretical framework that combines natural resource-driven economic growth with a specific focus on economic complexity and the quality of governance. In terms of empirical insights, this research presents substantial evidence that sheds light on the potential role of natural resources in shaping economic growth within the BRICS region. Armed with these findings, the BRICS countries can proactively address obstacles that hinder the efficient utilization of resources and constrain economic growth. Economic complexity should be embraced as a viable solution, prompting the formulation of strategies aimed at fortifying it to unleash the latent potential of natural resources. To achieve this, it is imperative to implement robust policies that cultivate economic complexity through skilled development, enhance Research and Development culture, diversify the economic structure that contributes to GDP, easy patenting facilities for innovative products and services to encourage inventors and innovators, export promotions and elevate the quality of institutions. These endeavours can draw inspiration from the experiences of successful Asian economies such as Japan, Taiwan, and South Korea.

Declaration

Availability of data and materials: The datasets used for this study have been obtained from open sources like the World Bank. The sources of data are cited in Table I of the manuscript. The consolidated data is available upon request.

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Note

- (1) The ECI measures the diversity and sophistication of a country's productive capabilities through its exports. The ECI, in a nutshell measures a country's different productive capabilities. Productive capabilities are the inputs, technologies, and ideas that all determine the frontiers of what an economy can produce i.e., mixed of products that countries exports. The ECI is included in the Global Innovative Index ranking which is within the Knowledge and Technology output pillar.

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The relevance of theories of foreign direct investment to mergers and acquisitions in Africa

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Abstract. *There is no single theory that explains all the activities of multinational enterprises (MNEs). In this article, I briefly discuss selected theories relevant to developing countries and from a historical perspective. This theoretical literature review explains why international production takes place, explains the Mergers and Acquisitions (M&A) mode of entry for FDI, and demonstrates the relevance of the selected theories to M&A in Africa. The article concludes that developments in theories of FDI since the beginning of the 21st century no longer view FDI in aggregate form. To understand trends of FDI, researchers must draw from theories that consider entry mode-choice.*

Keywords: foreign direct investment, international business, mergers and acquisitions, modes of entry, Africa.

JEL Classification: F21, F23, C35.

1. Introduction

Foreign Direct Investment (FDI) and international production are mainly carried out by multinational enterprises (MNEs). Ownership alone is not what matters for FDI, but also control of value-adding activities that distinguish FDI from portfolio investment. The International Monetary Fund (IMF) and the United Nations Conference on Trade and Development (UNCTAD) suggest a minimum of 10% of ownership in equity capital or voting power to ensure control of an enterprise. In this article, and following Dunning (2009), I use international production and FDI interchangeably and assume that FDI is carried out by MNEs.

International capital movement in the 19th century and up to the end of the Second World War was mainly portfolio investment. However, the post-war period witnessed a substantial growth in FDI and activities of MNEs, especially in the United States of America (USA) and Europe as documented by Buckley and Casson (1976, pp.2-31). The neo-classical economic theory at the time could not explain the phenomenon of MNEs and a whole new approach was required. In the mid- to late- 1950s Stephen Hymer set out to explain FDI and MNEs in his PhD thesis, completed in 1960. Since then, there have been various theories of FDI.

Theories of international production draw from several fields in economics; among them international trade, industrial organisation and microeconomic theory of the firm. It is established in the literature that there is no single theory that explains all FDI and activities of MNEs. Therefore, in this article, I briefly discuss some selected theories that are more relevant to developing countries and follow the historical approach of Ietto-Gillies (2012).

The objectives of this article are to explain why FDI takes place; to explain the M&A mode of entry for FDI; and to point out the relevance of the selected theories in an African context. The article is organised as follows. Sections 2 and 3 examine theories of FDI and MNEs based on the industrial organisation approach. These include market power theory and internalisation theory, which have their roots in the Coasian theory of the firm. Section 4 discusses the eclectic paradigm, which integrates earlier theories, and concludes the purely industrial organization approach to FDI.

Section 5 deals with approaches based on international trade; that is, the new trade theory that views FDI in terms of horizontal and vertical forms. Section 6 briefly discusses more recent theories, which combine elements of industrial organization and international trade approaches. These include the assignment theory of FDI, which considers the two entry-mode choice for FDI, and the theory of M&A that specifically addresses the case of M&A entry mode. I conclude the article in Section 7.

2. Market power theory

Stephen Hymer was the first to present a theory of FDI and MNEs in his PhD dissertation (Hymer, 1960). Previously, FDI was not considered a separate field of study requiring its

own theory; instead, FDI was analysed using the theory of portfolio investment by Mundell (1960). Hymer (1960) set out to distinguish the two international capital flows: portfolio investment and FDI. The author argues that whereas portfolio investment is explained by interest rate theory, FDI is not. The reason is that interest rate theory does not explain *control* of MNEs, and therefore cannot explain FDI.

Hymer (1960) criticises the theory of portfolio investment for not being able to explain some stylised facts of FDI and activities of MNEs. In particular, the theory does not explain bi-directional flows of FDI. According to Cantwell (1991) portfolio investment theory explains less FDI between countries with similar factor proportions. Hymer (1960) argues that market imperfections are difficult to explain using the theory of portfolio investment and, therefore, the theory does not explain FDI. Hymer (1960) is credited for being the first economist to explain 'why FDI?' and 'why MNEs?' (Dunning and Pitelis, 2008) making him the father of modern theories of FDI and MNEs.

Hymer's (1960) theory is mainly concerned with why MNEs take up investment opportunities in foreign countries, other than their own countries, regardless of the costs of doing so, such as language and cultural barriers. The author suggests two main motivations for FDI. The first is, to remove competition with rival firms in foreign countries. The second is, the existence of specific advantages that the firm can profitably exploit abroad.

The motivation of removal of competition with rival firms in foreign markets was inspired by the theory of firm developed by Bain (1956), who associated incumbent oligopolists with collusive behaviour. When firms try to enter a new market and rival firms are already operating in that market, then a conflict results. A solution to this conflict would be to agree to share the market with rival firms (that is, collude or merge) or take direct control of the market (that is, acquire). Ietto-Gillies (2012) notes that the latter strategy of acquisition and control of foreign market results in further increase in market power for the acquiring firm.

The second motivation of FDI, the possession of firm-specific advantages, is directly related to the existence of market imperfections. The author observed that some firms have considerable advantages over others in particular activities. For such firms, it is more beneficial to take control (of these activities) to obtain the best returns for their skills and abilities. The author adds "unequal abilities of firms is a sufficient condition for foreign operations" (Hymer, 1960, pp.46). However, it is not a necessary condition, as Dunning and Pitelis (2008) note, because a firm can choose alternative ways to enter a foreign market such as licensing or exporting. The main reason a firm will choose direct production is market imperfections.

To conclude this section, Hymer (1960) made a 'seminal and lasting contribution' to the theory of FDI and MNEs (Dunning and Pitelis, 2008). The author identified two broad motives of FDI and MNEs. These motives are the removal of competition with rival firms and the possession of firm-specific advantages. The specific-advantages motive laid the foundation of the internalisation theory of FDI and inspired scholars such as Dunning (1980a) to come up with ownership advantages in the eclectic paradigm of FDI.

Hymer's (1960) argument that rivalry between competing firms in foreign markets can be reduced or even eliminated through M&A is still relevant in modern-day strategic asset seeking motive of firms, even in Africa. Often, we find firms competing in the same market, using advantages such as marketing and advertising to increase their market share. Such firms could benefit, for instance, by cutting down on costs in management and marketing, if they merged or acquired one another. However, unlike during the author's time, institutions such as competition tribunals have been established to control increasing market power by such firms.

Hymer's (1960) market power theory associates the existence of firms, particularly MNEs, to market imperfections. The same author explains that MNEs develop firm-specific advantages, which are best exploited within the firm, and are used to compete in foreign countries. What is also different from the author's time is the kind or type of competitive advantages that foreign firms use. For instance, emerging market MNEs, some of which are from Africa, use firm-specific advantages such as knowledge of local environment, cultural attributes, and other business practices to compete with more established firms from developed countries.

3. Internalisation theory

The basic insights into the internalisation theory of international production come from the theory of firm by Coase (1937), who observed that economic theory assumes markets, that is, the price mechanism to be the only means to allocate resources. However, the author argues that in business, activities are co-ordinated by managers of firms. Therefore, markets and firms are alternative mechanisms of resource allocation. Whereas Coase (1937) examines imperfections in domestic markets, Hymer (1960) explains imperfections in international markets. Hymer (1960) suggests that some advantages are generated within a firm, and that it is more beneficial for MNEs to internalise these advantages. However, the same author did not further explain the aspect of internalisation, which was transformed into a fully-fledged theory of FDI and MNEs by Buckley and Casson (1976).

Buckley and Casson (1976) use Coasian ideas of market imperfections to explain why MNEs internalise intermediate markets. The authors argue that the price mechanism cannot efficiently facilitate transactions involving, firstly, intermediate products and secondly, knowledge. Regarding intermediate products, the authors explain that output from firms are not just final goods and services but semi-processed materials and most importantly "types of knowledge and expertise, embodied patents, human capital" Buckley and Casson (1976, pp.33). The authors assert that the market for certain intermediate products is either difficult to organise or imperfect, and this difficulty creates an incentive to bypass the external market and use an internal one, that is, internalise the exchange. According to Rugman (1986) the main argument in the internalisation theory is that MNEs use hierarchical structures to avoid inefficient or inoperable market systems.

Buckley and Casson (1976) regard the market for knowledge to be the strongest case for internalisation. The authors explain that knowledge is a public good within the firm, whose transaction costs in the external market are much higher than those of internally selling knowledge, and, as a result, an internal market is preferred. Internal information within a firm is one type of knowledge that is difficult to sell in the external market.

Grubel (2014) explains that a bank cannot sell information about a client because the bank would not get a fair price, because of information asymmetries. The client would not like this either! The author argues that the main source of competitive advantage by subsidiaries of multinational banks is the ability to draw on information and personal contacts from the parent firm at a low marginal cost. Tschoegl (1987) argues that in multinational banking, certain factors such as economies of scale and knowledge of local conditions cannot be sold unless there is a well-functioning market. Unfortunately, certain markets such as that of knowledge do not exist because of information asymmetries. Rugman (1986) reinforces the argument of non-existence of external markets for knowledge by regarding internalisation of information as the main advantage of the multinational bank.

The other type of knowledge emphasised by Buckley and Casson (1976) is research and development (R&D) which the authors define in very broad terms to include technical- as well as market-oriented R&D. The authors argue that modern business activities not only involve routine production of goods and services but particularly important is expertise in marketing, R&D, training of labour, mobilisation, and management of finance among other factors. There is a strong incentive to internalise R&D to cover the costs of generating and transmitting this kind of knowledge, hence the internal market within a firm is considered the best option. However, Auerbach et al. (1993) criticise the underlying assumption of internalisation that a market always exists, and a manager of a firm has a choice between the external market and internal one. The point is that some products may not have markets outside the firm.

Internalisation explains international production when market imperfections occur not only in domestic markets but also across national boundaries. As Buckley and Casson (1976, pp.45) explain “there is a special reason for believing that internalisation of the knowledge market will generate a high degree of multinationality of firms. Because knowledge is a public good which is easily transmitted across national boundaries, its exploitation is logically an international operation.” However, Dunning and Lundan (2008) criticise internalisation for not fully developing the international perspective of the firm. The authors argue that the theory of internalisation takes the aspect of internationalisation for granted and focuses too much on the organisation of the firm. According to Ietto-Gillies (2012) the biggest criticism of internalisation theory comes from empirical evidence in the last three decades, which has brought up the phenomenon of externalisation; that is, outsourcing and downsizing, at both domestic and international levels.

To conclude this section, I note that internalisation theory is developed from Coasian transaction cost theory of the firm. The theory capitalises on the weakness of imperfections of external markets and suggests the alternative as internal markets within firms. The

theory's focus on intangible assets of knowledge and information, sharpens our understanding of how MNEs generate firm-specific advantages, a concept developed earlier by Hymer (1960).

The main challenge with internalisation theory has been how to test the theory empirically. Buckley (1988) acknowledges that the theory cannot be tested in its general form, and only more restricted forms can be tested. The testing could most probably take place at industry level. Even so, challenges remain on how to measure variables such as transaction costs. Nevertheless, the theory is still useful in explaining multinational banking and markets for primary products such as food, minerals and oil. This makes internalisation theory much more relevant at explaining FDI in Africa which is well-endowed with minerals and agricultural products, where internal markets perform much better than external ones.

Internalisation theory contributes to the understanding of MNEs and FDI, especially investment in knowledge-intensive sectors. This kind of investment is mainly found in developed countries. The theory has also been incorporated in imperfect competition models of the new trade theory by Helpman and Krugman (1985) and Markusen (1984) as explained later in Section 5.

4. The eclectic paradigm

The eclectic paradigm is the most comprehensive and successful approach to international production and FDI (Cantwell 1991). The theory draws from previous approaches based on imperfect markets (Buckley and Casson, 1976; Coase, 1937; Hymer, 1960) and adds a third dimension of location. The paradigm asserts that the extent and pattern of international production is a function of a combination of three key factors: ownership advantages (O), locational advantages (L), and internalisation advantages (I) commonly referred to as the OLI advantage (Dunning 1980a).

Dunning (2001, pp.175) defines ownership advantages as "any kind of income-generating asset that allows firms to engage in foreign production." These advantages come from a firm's privileged ownership or access to assets that are exclusive or specific to the enterprise (Dunning 1980b). Dunning builds on earlier work by Hymer (1960) who argues that "for firms to own and control foreign value adding facilities they must possess some kind of cost or marketing advantages, sufficient to outweigh the disadvantages faced in competing with indigenous firms in the country of production" (Dunning 1988, pp.28). Perhaps Calvet (1981, pp.44) explains ownership advantage more succinctly: "foreign firms must possess a countervailing advantage over local firms" for direct investment to be viable.

Ownership advantages are specific to the firm and include tangible or Ricardian-type factor endowments like natural resources, capital and manpower, as well as intangible assets such as information, technology, marketing, organisational and entrepreneurial skills, and access to intermediate and final products (Tolentino, 2001). These ownership advantages

may be used domestically or internationally and lead to reduction in a firm's production costs, hence allowing firms to compete in foreign markets (Nayak and Choudhury, 2014). Multinational firms from developed countries mostly use financial capital and proprietary technologies as their competitive advantage, particularly in host developing countries.

Internalisation advantages (I) "relate to the way firms organise the generation and use of resources and capabilities" (Dunning 2001, pp.175). These advantages arise from the failure of external markets because of high transaction costs. Hence firms must rely on hierarchies to effectively co-ordinate their value adding activities across national boundaries. Such activities would otherwise be dispersed between different firms and countries. In this way, an advantage arises from them being co-ordinated from the parent multinational firm. Internalisation advantages explain why firms choose to exploit their ownership advantages internally, other than to acquire and/or sell them through the open market (Dunning, 2001). So, the alternative to external markets is hierarchies within a firm.

From the above discussion of both O and I advantages, it can be observed that a multinational firm not only needs to possess superior resources such as technology as Hymer (1960) argued, but MNEs must also "have the desire and ability to internalise the advantages which result from their possession" (Calvet, 1981: pp.50). Once a firm has acquired these two advantages, it can then exploit them beyond national boundaries, that is, to internationalise. This brings us to the third component of the eclectic paradigm - the addition by Dunning (1980a).

Location advantages are external to the firm and relate to the geographical and political space within which firms operate. The advantages include the cultural- legal- political- and institutional environment, government legislation, and policies (Dunning 1991 in Dunning (1995). As can be noted, locational advantages combine both home- and host- country incentives of multinational firms to invest abroad. For instance, regarding home advantage, a developing country multinational firm might have a location or geographical advantage over a developed country firm in a host developing country through similarities in culture, institutions, and business strategy among other things. As for political advantage, host governments might encourage foreign investment in or by certain countries through legislation; or these governments may give tax incentives or, create the necessary infrastructure such as industrial development zones. Therefore, location is one of the key factors that explain the geographical distribution of multinational firms. Even though a decision to invest in a particular country is firm specific, depending on firm strategy, MNEs tend to invest in a particular country or region as a group; that is, collectively. Knickerbocker (1973) called this 'a bandwagon effect', a kind of herd behavior. This phenomenon could partly explain the tendency of MNEs to flock to the East Asian region in the 1990s and to Africa in the 2000s during the commodity boom.

What location advantage attracts FDI into regions such as East Asia or Africa? Before I tackle this question, there is a need to emphasise the regional dimension of location. According to Sethi et al. (2003), MNEs may not evaluate a location based on a country but on a region, because countries in a region may have similar cultures, political and economic

systems, and development level. Therefore, location takes a wider dimension, encompassing more than one country. A region may have a configuration of locational advantages that makes it attractive to FDI. For instance, in the 1990s, many countries in Asia liberalised their economic policies, particularly regulations on FDI. In addition, the East Asian region has well-trained labour force, good infrastructure, rapidly growing economies, and a supportive banking system, and all these factors make the region attractive to investment especially efficiency-seeking type. Furthermore, relatively low wages of abundant skilled labour is important. Rapid and sustained economic growth in the region further added to the drive to invest in East Asia. FDI in Europe and Latin America has followed this kind of regional dimension to exploit the advantages of economic integration and regional similarities (Sethi et al. 2003).

The eclectic paradigm stresses the importance of each of the OLI advantages. Dunning (1998) argues that the three advantages work together like a three-legged stool that would be balanced only if the three legs were in place. Therefore, one cannot isolate an advantage such as O and claim that it is the most critical because the advantage only works in the presence of the two others. The author made this argument in response to a comment by Ethier (1986, pp.803) who claimed that internalisation is the "Caesar of the OLI triumvirate". Dunning (2001) further asserts that the way the three advantages combine varies across industries, regions or countries. Therefore, it is necessary to identify the configuration of advantages that give a specific country or industry, and a region such as Africa competitive advantages in foreign owned production.

The paradigm is *eclectic* because it partly draws from different strands of economic theory, even though the author insists that the paradigm is not bound by any doctrine (Dunning, 1986), and partly because the paradigm explains elements of alternative approaches to international production, which are direct investment, exports and contractual resource transfers or licensing (Dunning 1980b). As such, the paradigm should not be treated as a general theory because of its generality. As explained by Dunning (1988, pp.1), the eclectic paradigm should not be misunderstood as another general theory "precisely because of its generality, the eclectic paradigm only has limited power to explain or predict particular kinds of international production; even less, the behaviour of individual enterprises."

Since 1990 Dunning (1995) and Rugman and Verbeke (2004) have attempted to adapt the OLI framework to accommodate developments such as international M&A, international joint ventures and collaborative alliances and the so-called 'newcomers' (Ietto-Gillies, 2012). However, the eclectic paradigm does not explain some aspects of international production, for instance emerging markets MNEs that exhibit different characteristics from the ones the eclectic paradigm was initially hypothesised from.

Aykut and Goldstein (2007) and Bonaglia et al. (2007) argue that the OLI paradigm as proposed by Dunning (1980a) is based on the experiences of large, successful firms mainly from North America, Europe and Japan, which are well established and which can "easily find resources and the capabilities to expand internationally if they wished to do so" (Bonaglia et al. 2007, pp.4). However, emerging market MNEs do not have OLI advantages

such as proprietary technology, financial capital, brands, or experienced management. Indeed, MNEs from emerging markets internationalise to take advantage of the opportunities created by globalisation, to acquire the resources that enable them to grow (Aykut and Goldstein, 2007). Developing country MNEs do not have much time to develop advantages like their developed country counterparts. The MNEs cannot wait until they are large enough to internationalise and must grow quickly because protection at home is eroded by market liberalisation (Aykut and Goldstein, 2007).

As such, emerging market MNEs have developed a unique way of internationalising, which is contrary to the traditional perspective. Even though some of the MNEs may be small in size, they make extensive use of linkages with other firms globally. Lau (1992) supports the idea that the size and the level of technology that developing country MNEs have is not comparable to those that developed countries of North America and Western Europe have. Therefore, the theory of FDI based on experiences of developed country MNEs may not necessarily apply to developing country MNEs.

To summarise this section, the main contribution by Dunning (1980b) is that the author brought together separate elements of previous complementary theories that attempted to explain international production. The eclectic paradigm takes Hymer's (1960) specific advantage, combines the advantage with internalisation theory, and adds a new element of location of FDI. In this way, the OLI theory puts together three broad determinants of FDI. According to Dunning (2001), the three elements of the theory must work together. The paradigm identifies a set of factors for each of the motives for FDI; for instance, ownership advantage determines which firms will pursue foreign production. Location advantage indicates where the production will take place, and a firm will avoid market imperfections by internalising its ownership advantages.

5. The new trade theory and FDI

Since 1990, FDI has grown faster than international trade and plays an important role of facilitating trade. Navaretti et al. (2004) observed that, almost a third of world trade in intermediate goods is intra-firm – between subsidiaries of firms – and intra-industry. This observation indicates how trade and FDI have become inter-dependent and, therefore, the need to examine this relationship.

The mathematical modelling of monopolistic competition by Dixit and Stiglitz (1977) resulted in many applications in economic theory, especially in international trade theory, and specifically led to the development of the new trade theory. Previous attempts to incorporate imperfect competition in international trade models had been constrained by the assumption of constant returns to scale. However, Dixit and Stiglitz's 1977 model enabled the analysis of increasing returns to scale and product differentiation which are important elements in understanding intra-industry trade (Brakman and Garretsen, 2008) especially in manufactured goods between developed countries.

The argument behind the new trade theory is that specialisation and trade are because of economies of scale and comparative advantage (Krugman, 1985). Economies of scale are of two kinds: those internal to the firm and those external to the firm. Internal economies relate to the firm whereas external economies relate to the industry. Internal and external economies can combine with each other and accelerate the process of specialisation and concentration of industries in specific areas, resulting in spatial agglomeration effects. For instance, in Yangtze River Delta in Taipei, the Chinese government established modern infrastructure such as highways, ports and airports in the Delta, which attracted many technology firms that produce personal computers in the region creating economies of scale. The concentration of similar industries reduced service link costs, as firms in the area could easily obtain parts and components required in production (Thorbecke and Salike, 2013). This spatial agglomeration also attracted business partners in related industries, which promoted pooling skills and technologies together and further reducing costs and creating economies of scale.

There are two main strategies for FDI, horizontal and vertical. Horizontal FDI occurs when a parent firm replicates production units in other countries, whereas vertical FDI occurs when a parent firm fragments production into various stages, with each stage of production occurring in a different country, to take advantage of lower production costs. For instance, a MNE would produce a high-skill intensive product in the USA and assign production of labour-intensive input such as assembly in a low-wage country. This fragmentation of production and location in various countries enables the MNE to take advantage of, or arbitrage, on differences in labour costs.

Since the emergence of the new trade theory in the 1980s, there has been a renewed interest in re-examining theories of international production. Helpman (1985), Markusen (1984) and other authors, have attempted to integrate theories of international trade and FDI. The authors were inspired by the ideas of Hymer (1960), Buckley and Casson (1976) and Dunning (1980a) to explain international production within the framework of imperfect markets. Furthermore, Helpman (1985) and Markusen (1984) were inspired by Dixit and Stiglitz (1977) to apply monopolistic competition to international trade under the new trade theory. I therefore consider theories of FDI and MNEs in the context of the new trade theory.

5.1. The new trade theory and vertical FDI

Helpman (1983) and Helpman (1985) develops a general equilibrium model that incorporates the role of MNEs and FDI in international trade. The author makes assumptions about internal economies of scale that are generated within the firm because of utilisation of shared inputs. The joint inputs, which Helpman (1985) calls 'headquarter services', can be used by other firms within the organisation or transferred to such firms located in different countries at a low cost. This exchange of services leads to intra-firm trade in intangibles and vertical integration of firms within a country or across countries. The headquarter services are specific to the organisation and include services such as management, marketing, and R&D.

Krugman (1985) explains the role of MNEs in the new trade theory. Like Buckley and Casson (1976), the author argues that technology is a joint input that cannot be traded in the external market due to transaction costs. As such, services of joint inputs, or headquarter services, must be internalised within the organisation through transfer to different firms, resulting in intra-firm trade. Owing to market imperfections, firms cannot export joint inputs or license them. The firm must produce inputs directly in different countries. Hence Krugman's (1985) model leads to vertical fragmentation of production across countries as well as intra-firm and intra-industry trade. Like Hymer (1960), the author views the main characteristic of MNEs as control of activities across borders. The author argues: "what the new models make clear, above all, is that a multinational enterprise is not a type of factor mobility. It represents an extension of control, not necessarily movement of capital." (Krugman 1985, pp. 34).

It can be argued that Helpman (1983), Krugman (1985) and Helpman and Krugman (1985) models of vertical integration of production, based on factor endowments, explain the geographical location of FDI in developing countries. The models assume factor endowments between different countries, and separate production of intermediate and final goods, which predict the production of labour-intensive products in developing countries and production of capital-intensive products in developed countries. The new trade theory also assumes that MNEs are headquartered in developed countries; for this reason, the main source of FDI is developed countries.

FDI in East Asia can partially be explained by Helpman and Krugman's (1985) vertical integration of firms. In terms of source of FDI, East Asia has attracted high levels of investment from Europe, Japan, and the USA. Regarding factor endowment, the region has a skilled labour force, with factor prices relatively lower than in home developed countries. Production in the region is in labour-intensive products such as textiles and clothing, or/and in labour-intensive assembly operations like electronics. Thorbecke and Salike (2013) show that trade within the East Asian region is mainly in electronic parts and components (intermediate inputs) and in final goods such as computers and office equipment from the region to the rest of the world. This vertical FDI takes place through fragmentation of production, such as that of a personal computer, in different countries in the region depending on factor endowment. This production and the assembly of products have created intricate regional value chains in East Asia.

It appears that countries in East Asia are grouped into production blocks depending on their capabilities, that is, labour intensive and technology intensive. For instance, more advanced economies such as Japan, Korea, Singapore, and Taiwan belong to a block that produces high-technology intermediate products which are then exported to assembly operations in relatively more labour-intensive economies such as China, Malaysia, Thailand and Indonesia (Blattner, 2005; Thorbecke and Salike, 2013). The final goods are then exported to the rest of the world. This grouping of countries is a clear example of vertical integration of MNEs in the East Asian region and the creation of value-adding chains in the region.

Vertical FDI has also been observed in other world regions such as the North American Free Trade Area (NAFTA) between USA, Canada and Mexico. Hanson et al. (2005) find that USA MNEs fragment production depending on factor prices, trade costs and host country characteristics. Regarding factor prices, the authors find that parent companies export intermediate inputs to affiliates located in countries with relatively less skilled labour such as Mexico. Though East Asia is quite distant, USA firms still export intermediate inputs in industries such as electronics for further processing because of relatively low wages and open markets in East Asia. Another finding from the study is that intra-firm trade in intermediate inputs also takes place with countries that have lower trade costs, Canada for instance. Hanson et al. (2005) argue that vertical FDI is more prevalent in certain industries – machinery, transport equipment and electronics (especially computers). Characteristics of these industries enable production to be divided and separated into various stages such as design, component production and assembly. Factor inputs required in the production process are also different, for instance, design and component production require high-skilled labour whereas assembly of product requires low skilled labour. Owing to these different factor-input requirements, firms locate production in different countries to take advantage of factor prices.

From this subsection of the new trade theory and vertical FDI, I note that Helpman and Krugman (1985) combine elements of ownership – that is, firm-specific advantages – with internalisation elements in the form of utilisation of intermediate and intangible products. To these, the authors add locational aspects to explain the role of MNE in the prediction of trade patterns. Helpman (1983) explains that the role of MNE is to exploit factor endowments in different countries, by locating firms in relatively low-cost countries.

5.2. The new trade theory and horizontal FDI

Markusen (1984) draws from the OLI paradigm to develop a knowledge- capital model of MNE activities. The author emphasises the importance of intangible firm-specific assets which become joint inputs in multi-plant operations. These firm-specific assets are found in “human capital of the employees, patents or other exclusive technical knowledge, copyrights or trademarks, or even more intangible assets such as management, knowhow or the reputation of the firm” (Markusen 1995, pp.174). The author therefore calls these ‘knowledge-based assets’, which he argues are quite different from physical capital assets, because they can easily be transferred across space and supplied to additional production units at a low cost. The ease of transfer of knowledge-based assets gives them the property of a public good, which can be used in multiple plants at the same time, and in turn increases firm efficiency, by creating economies of scale.

Markusen’s (1984) theory explains international production taking place between countries at a similar level of development; such countries would also have similar factor endowments. Knowledge-capital theory predicts horizontal FDI, by which similar plants are set up in different countries to produce the same products. This replication of production in different locations results in intra-industry trade and FDI. In this case, direct production is preferred to exports, because of reduction in transport and trade costs.

The knowledge-capital model has proved quite useful in explaining the direction of FDI. Empirical data shows that most FDI occurs between developed countries that have similar factor endowments. The horizontal FDI model has been empirically tested by Carr et al. (2001), Markusen and Maskus (2002) and Brainard (1993) and results are in support of the knowledge-capital theory. However, the theory does not explain the organisational aspect of FDI; that is, why firms prefer to internalise and not to license or outsource.

The new trade theory approaches to international production have been criticised for not being able to explain the I element in the OLI paradigm, which constitutes the essentials of a theory in FDI. Dunning (1995) argues that the new trade theory ignores the organisational aspect of the firm. The author argues that organising agents such as hierarchies within firms, networks, consumer groups and governments play an important role in organising economic activity. Thus, the market cannot be assumed to be the most effective way of allocating resources. The roles of such agents may sometimes complement or conflict with the market. When such agents are supportive of the market mechanism, they may create an enabling environment for the market to operate effectively. Therefore, the inadequacies of the market mechanism, have resulted in other resource allocation agents.

6. Theory of FDI and M&A

The distinction between the two subsets of FDI, greenfield investment and M&A becomes crucial at this point, as demonstrated by recent developments in FDI theory – discussed below – which have focused on the two modes of direct foreign investment, and on vertical and horizontal M&A.

Nocke and Yeaple (2008) examine the theory of vertical FDI by considering entry-mode choice. In the ‘assignment theory of FDI’ the authors argue that FDI occurs because of country differences in factor endowments. According to the theory, greenfield FDI occurs when firms take advantage of factor price differences by relocating their production from high- to low- cost countries. In contrast, M&A take place not just because of factor price differences but also because of the desire to exploit complementary firm-specific capabilities in host economies, such as distribution networks. This theory has been used in the arguments for M&A in Africa by Wilson and Pholo (2019).

Neary (2007) draws from the industrial organisation literature and international trade theory to come up with a theory for cross-border M&A as ‘instruments of comparative advantage.’ Unlike Dixit and Stiglitz (1977), the author proposes a general oligopolistic equilibrium model that allows for strategic interaction between firms. Strategic interaction is a crucial element of M&A activities. Brakman, Garretsen, and Van Marrewijk (2007) test the theory of M&A using sectoral data for five Organisation of Economic Co-operation and Development (OECD) countries from 1980 to 2004. The authors find that acquiring firms that come from low-cost sectors have revealed comparative advantage as measured by the Balassa index. Further, the authors find a positive autocorrelation of mergers within sectors, which suggests that M&A come in waves.

Neary (2009) further argues that the experience of 1990s, when trade liberalisation increased at the same time as FDI, contradicts the proximity- concentration trade-off, which suggests that a fall in trade costs should discourage FDI. The author claims that most FDI is horizontal, and this type of FDI should have decreased in the 1990s. Instead, horizontal FDI was encouraged within economic blocs such as the European Union (EU), by intra-bloc trade liberalisation. The reason is that foreign firms, specifically USA firms, established export platforms within the trading blocs (the EU Single Market), to serve the entire regional market.

Neary (2009) also revisits an earlier model of cross-border M&A in oligopolistic markets, which had been introduced in Neary (2003) and extends the model to explain that trade liberalisation encourages cross-border M&A. The author argues that the strategic motive of firms, a characteristic of M&A, and economic integration, lead to competition within a trade bloc and promote cross-border M&A. Neary (2009) theory has been applied in the analysis of regional integration and M&A in Africa by Wilson and Pholo (2019). The authors find that the size of market size within a regional bloc is important driver of cross-border M&A in Africa.

7. Summary and conclusion

This article reviews a selection of theories of FDI and MNEs from a historical perspective. The article presents a theoretical background to the empirical analysis on determinants of FDI by explaining the activities of MNEs. The first economist to address the question ‘why FDI?’ and ‘why MNEs?’ was Hymer (1960) in his PhD thesis. The author argued that international production does not only involve transfer of financial capital but also transfer of ‘specific advantages’ that MNEs possess, such as technology-, managerial- and marketing expertise. Therefore, MNEs need to own these firm-specific advantages to be able to overcome the many disadvantages of foreign production, such as unfamiliar culture and unfamiliar political and economic environments.

Buckley and Casson (1976) extend the ideas of Coase (1937) on market imperfections in domestic markets to international markets, and come up internalisation theory of FDI and MNEs. The authors explain that imperfections in cross-border markets for intermediate products and knowledge, is the primary reason why MNEs exist – to exploit internal markets within firms. However, for internal markets to be utilised, the benefits of internalisation must outweigh the higher resource, organisation and communication costs. Even though internalisation theory explains knowledge intensive FDI in developed countries, the main challenge of the theory has been how to test it empirically.

To integrate earlier theories of international production into a general theory of FDI, Dunning (1980a) suggests the OLI framework. The paradigm takes the ‘specific advantage’ suggested by Hymer (1960), combines the advantage with internalisation theory and adds a new element of location of FDI. In this way, the OLI paradigm puts together three broad determinants of FDI.

Theories of international production have also borrowed from international trade theory and these theories tend to focus more on the location of FDI. The location of FDI views international production in two forms; horizontal and vertical FDI, both of which are developed from internalisation theory. Two strands of literature on FDI emerge, with vertical FDI (Helpman, 1985) explaining foreign investment based on factor endowment. However, vertical FDI only explains part of FDI, such as that between developed and developing countries. There is strong evidence that most FDI is horizontal, between countries at similar levels of development and mainly developed countries. Markusen (1995) explains this phenomenon using the knowledge- capital theory, which is supported by much empirical evidence. However, studies such as Hanson et al. (2005) and other empirical evidence suggest that there is no clear-cut distinction between the vertical and horizontal FDI, and that some FDI has elements of both.

Consequently, developments in theories of FDI since the beginning of the 21st century have combined industrial organisation and international trade theories. This literature has maintained the two strands of FDI- horizontal and vertical, and has gone further to consider the two modes of foreign market entry, that is greenfield investment and cross-border M&A.

Therefore, recent theories of FDI no longer view FDI in general form, that is, aggregate FDI. To understand trends of FDI, researchers must draw from the literature that considers entry mode choice for FDI.

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The impact of employment in industry on income inequality in Great Britain

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Abstract. *Economic inequality is one of the most debated issues in economic science. It is known that politicians have to choose between efficiency and equality, and decisions, which are finally made by them, influence social stability in a state. The factors of income inequality in Great Britain are analyzed in the present article. Regression analysis shows that the main cause of growing market income inequality in the UK in the latest decades is decreasing employment in the British industrial sector. Moreover, shifts in employment in industry directly and indirectly affects other factors of income inequality. Employment in industrial sector is also, in its turn, influenced by technological development and globalization. A combination of factors, having impact on employment in the British secondary sector and, as a consequence, on market income distribution in the UK, is analyzed in the paper.*

Keywords: income inequality, income distribution, industrial sector, structural changes, Kuznets curve.

JEL Classification: D63.

Introduction

The aim of the present article is to study the relationship between share of employment in industrial sector in Great Britain and the Gini index before taxes and transfers on the base of regression analysis. The final conclusions underline the influence of the economic structure on income inequality: the developed industrial sector with existing technologies, level of education and institutions is one of the key factors of narrowing of economic, particularly market income, inequality, while the process of deindustrialization in terms of the decreasing share of employment in industrial sector in Great Britain widens income inequality – this is the central argument of the paper. A regression model is built in order to estimate the effect of this process. However, the share of employment in industry is affected by other forces (described in ‘Results’ section), which mostly indirectly influence market income distribution in the UK.

Theoretical overview

The variable, which is employed in the model in the present article, is “the share of employment in industrial sector”. The data covers the period of 1950-2021, when Great Britain has transformed from the industrial economy into the postindustrial one (it means that the structure of economy, or economic complexity, has changed greatly). By using this variable, it is possible to demonstrate the impact of such a transition on income inequality. Similar approach was used by Mehic (2018), who showed the negative relationship between the share of employment in industry and income inequality. He linked the decline in employment in the secondary, or industrial, sector with trade liberalization and technological changes. Trade liberalization, or economic globalization, is considered as a factor of rising income inequality in a number of articles: e.g. financial globalization is identified as a key factor of growing inequality in the EU by Asteriou et al. (2014); Bergh & Nilsson (2010) and Dreher & Gaston (2008) also demonstrated that globalization and deregulation increased the level of income inequality. Behera & Viswanathan (2022), using the sample of India, concluded that economic globalization can reduce income inequality, while social and political globalization, as well as sectoral shifts (rapid growth of the service sector and the decline of agricultural sector) widen it. They underlined that “although the growth in the services sector triggers economic growth, the employment and income benefits accrue to only a limited segment of the population” (Behera & Viswanathan, 2022: p. 369). The negative relationship between the share of agricultural sector in GDP and income inequality is as well showed by Raeskyesa (2020) on the sample of ASEAN-5 Countries. Harjes (2007) questioned the negative impact of globalization on income inequality and claimed that the increase in income inequality in euro-area countries can be explained by changes in labor market institutions. Sato & Fukushige (2009), using the case of South Korea, came to the results that economic globalization effect on income inequality depended on the angle of economic globalization, from which the effect was studied. Thus, the openness of good markets reduced inequality, while the openness of capital markets widened it. The study of Adams & Klobodu (2018) demonstrates that the share of agriculture in GDP (the structure of economy) does not have a clear impact on income inequality in 21 African countries, while trade liberalization has a positive impact on it. Ghosh et al. (2022) concluded that the structure of economy, i.e. the economic

complexity, had a negative impact on the Gini index, at the same time trade openness led “to fairer income distribution” (p. 2519). However, in order to fully explain the role of structural transformations on income inequality it is necessary to refer to the Kuznets’s hypothesis and Milanovich’s “neo-Kuznets waves”.

In the paper «Economic growth and income inequality» (1955) Simon Kuznets analyzed the causes and factors of long-term changes in personal distribution of income. S Kuznets took into account political and social factors of narrowing of inequality that were the consequences of governmental economic measures, like establishment of a progressive scale of taxation and providing governmental assistance to poor people (free contributions), but the main feature of his hypothesis is the explanation of the reduction in income inequality by determination of structural change in economies. S Kuznets underlined that, besides the interference with legislation and political decisions of the government on upper-income groups of people (e.g. inheritance taxes or indirect influence by inflation, which reduce the real wealth and the real cost of savings of the richest people), the less obvious at first glance forces caused the narrowing of inequality and, in particular, the reduction in the difference in savings between groups. The first force is demographic growth. The demographic growth is usually the feature of the rapid economic growth, because the productivity increase demands a large number of free workers. On the other hand, when the rapid economic growth provides the raising living standards, the latter in its turn creates favorable conditions for population growth. For example, there were waves of «baby boom» in developed countries during and after post-war reconstruction. However, later the population growth stops in developed countries due to changes in an approach to social and cultural issues and rethinking of the family values: i.e. the transition from traditional families to families which plan the quantity of the children. In the agrarian countries the families usually have many children regardless of the economic growth rate, because the children help their parents in the agricultural work.

Nevertheless, S Kuznets paid attention to another result of demographic growth – deconcentration of savings. It leads to narrowing of income inequality as the savings are concentrated in the hands of an increasing number of people (in particular, in the hands of the heirs). This factor is also accompanied by the increasing of an average income in countries with rapid economic growth and by the fact that, as S Kuznets wrote (1955), the inequality of savings is usually sharper than in holdings of assets.

Another group of factors of narrowing the savings inequality is connected with “the very nature of dynamic economy” (Kuznets, 1955: p. 10). S Kuznets meant that new industries arising due to technological progress attract more capital and the old industries have a decreasing specific weight. Nonetheless, it is important to consider the political influence of the entrepreneurs of old industries, who can hinder the rapidly developing industries in some way if these industries hamper their further enrichment. A lot of attention to political factor is paid by J Stiglitz (Stiglitz, 2012), who indicates the connivance of the authorities to the rent-seeking of the richest part of the society. J Stiglitz underlines the big role of the richest 1% of American population in the sphere of the tax legislation, governmental intervention in the economy, budget allocation, etc. (Stiglitz, 2015). All these problems threaten democracy.

Moreover, the idea of S Kuznets about the narrowing of savings and income inequality caused by the development of the new industries instead of the old ones is disputable when, for instance, we talk about the investments in the alternative sources of energy because the oil and coal magnates retain their positions. Therefore, this group of factors is a characteristic of not only a dynamic growing economy, as S Kuznets wrote, but also of a really competitive economy with a high level of economic freedoms and a low level of corruption and other misuse of politicians.

The third group of factors, identified by S Kuznets, is connected with the situation on the labor market (“a shift of workers from lower-income to higher-income industries” (Kuznets, 1955, p. 10)) and the reduction in number of possibilities of people with high incomes to increase their earnings and profit. It is very hard or even practically impossible to maintain the revenue of the company at the constant high level, at least, due to changes in demand volume or the rise in price of raw materials and other market forces. Monopolies can be the exceptions. It is also difficult for an employee to demand a salary increase if the employee already gets a high salary.

In addition to the factors listed above (direct and indirect governmental intervention in the economy; tax legislation; demographic growth; a shift of capital and workers from lower-income or old industries to higher-income or new industries, as a consequence, the deconcentration of savings), S Kuznets wrote about the role of urbanization and migration in the processes of industrialization: the industrialization always needs a large number of free workers, who live in the towns or cities and often come from villages (the agricultural sector) or foreign countries (Kuznets (1930) underlined the significance of immigration in cyclical fluctuations and mentioned that “immigration is conditioned by the same forces that make for economic growth” (Kuznets, 1930: p. 7)). According to S Kuznets, the growing economy with the increasing weight of the nonagricultural sector raises the per capita income and narrows the income inequality.

To summarize, S Kuznets’ idea can be expressed in this way: the income inequality is initially increasing and then decreasing during the period of economic development, and, as a result, the inequality should be at low level in a developed economy. S Kuznets’ curve explained the income inequality for several decades, but approximately in the 1980-s it faced some problems caused by a widening of income inequality in developed, rich and even egalitarian countries. An attempt to solve the problems of the S Kuznets’ curve has been made by B Milanovich.

B Milanovich (2016) underlines the significance of endogenous factors, social democratic and communist political parties, governmental measures, taxation policy, the bargain power of workers trade unions. However, the foundation of this theory is a modified Kuznets theory. B Milanovich uses not Kuznets curve, but Kuznets waves in order to explain modern inequality. This «neo-Kuznets» curve (instead of Kuznets inverted U-shaped curve) includes the period of decreasing of income inequality till approximately 1980-s and also the second period in evolution of income inequality, that was accompanied by widening of economic inequality due to reasons, which B. Milanovich calls «TOP»: technology, openness, policy (but wars, conflicts, humanitarian problems also remain).

In pre-industrial society there was a limit for the increasing of inequality, because the average (mean) income was stagnant, stable (agriculture and slowness of technological progress are the reasons for it) and it can be only reached by decreasing of the population of poor people, so the widening of inequality is the consequence of idiosyncratic events: e.g. wars, epidemics, famine (the importance of demographic changes for the economy was analyzed by T Malthus (1798)). However, modern wars practically do not harm the 'global plutocrats' as some of these plutocrats get profit by selling the weapons and pursue their selfish goals.

During the two world wars and wars before them the destruction of the capital and means of production (factories, logistic chains, etc.) took place and capitalists faced with the damage that led to losses. Nevertheless, there can also be benign factors that narrow income inequality, but their influence is rather limited and not ubiquitous in pre-industrial society (e.g. the Church and its charitable activity).

In the societies with increasing medium income (industrial and postindustrial societies) there is enough room for an increasing inequality level (Milanovich, 2016). However, there are not only negative (wars, civil conflicts, epidemics, famine), but also positive factors, which decrease inequality level in modern societies (political factors, progressive taxation, free healthcare and education, etc.). That is the next phase of Kuznets waves (or cycles).

The breaking point is the WWI (the same breaking point is in Piketty's theory [2017]), but the engine for the structural changes in economies was the technological progress and, more exactly, technological revolution. According to B Milanovich, technological changes which help low-skilled workers, mass education, increasing demand on social protection (direct transfers from government) due to aging of population, political deterrence factors (workers trade unions with strong negotiating positions, social democratic and communist parties and movements) are positive factors that narrow income inequality. In case if the economy begins to stagnate, the situation with inequality levels in different countries will be similar to the situation of preindustrial periods and Kuznets waves will continue in conditions of the permanent medium income. However, the factors influencing the Kuznets waves explain a widening/narrowing of economic inequality within countries, but B Milanovich (2016) is also considering international inequality. The main force that decreases economic inequality between countries is the economic convergence. The Milanovich's paper (2012) underlines the aspects of international inequality, e.g. we see how much richer is the average American in comparison with the average citizen of a poor country. Nevertheless, the issue of the present article is inequality within the country (the UK), so the process of economic convergence is not described here in detail.

To sum up, we see that, Kuznets proposed the idea that structural changes are the key factor of income inequality. His statement that the development of nonagricultural sector narrows income inequality is proved again in the present article from another angle: the decline of industrial sector widens market income inequality. Milanovich (2012, 2016), Mehic (2018) and other authors, whose papers are mentioned above, reveal the influence of globalization, openness and technological change on the structure of economy and, hence, on income distribution.

Data and methodology

In the present paper the United Kingdom has been chosen for the analysis. The reason for it is that there is more open data on developed economies, like the British one, rather than on less developed countries: hence, we can track the dynamics of fluctuations in market income distribution for a long period (since 1950 till 2021). Moreover, Great Britain has become a service economy and finally lost the status of industrial power during this period, mainly due to the policy, being realized since ‘Thatcherite Revolution’ (e.g., see Jakopovich (2011: pp. 435-442)), therefore, it is possible to study the relationship between rapidly decreasing share of employment in the industrial sector and income distribution. Sources of the data for this study are the Office for National Statistics (ONS, data on the employment in the secondary sector till 2016; after 2016 the OECD data was used)⁽¹⁾, OECD (Gini coefficient for years 1994-2021, market income, before taxes and transfers)⁽²⁾, Atkinson’s paper (2002: p. 35; Gini coefficient, market income, before taxes and transfers)⁽³⁾. All the data includes only the statistics for Great Britain without overseas territories and former colonies. Although such sources of data as OECD and ONS are rather reliable, we have to remember about statistical error, therefore, even if the data is very close to the reality, it still is not absolutely true. By using the regression model, the relationship between income distribution in Great Britain and the share of employment in the secondary (industrial) sector of the British can be witnessed. OLS method is used here for estimating the regression equation.

Table 1. *Data on income inequality in Great Britain*

Year	Share of employment in the secondary sector (from 0 to 1)	Gini index (market income before taxes and transfers; from 0 to 1)
UK 1950	0,3826	0,41
UK 1951	0,3856	0,4075
UK 1952	0,3819	0,4075
UK 1953	0,3842	0,4075
UK 1954	0,3875	0,4075
UK 1955	0,3915	0,405
UK 1956	0,3920	0,4
UK 1957	0,3919	0,4
UK 1958	0,3895	0,4
UK 1959	0,3896	0,4
UK 1960	0,3976	0,395
UK 1961	0,4005	0,395
UK 1962	0,3970	0,395
UK 1963	0,3941	0,405
UK 1964	0,3977	0,41
UK 1965	0,4001	0,415
UK 1966	0,4015	0,4
UK 1967	0,3924	0,428
UK 1968	0,3887	0,43
UK 1969	0,3879	0,44
UK 1970	0,3821	0,41
UK 1971	0,3731	0,415
UK 1972	0,3619	0,42
UK 1973	0,3603	0,415
UK 1974	0,3579	0,435
UK 1975	0,3462	0,425
UK 1976	0,3399	0,43
UK 1977	0,3384	0,44
UK 1978	0,3337	0,435

Year	Share of employment in the secondary sector (from 0 to 1)	Gini index (market income before taxes and transfers; from 0 to 1)
UK 1979	0,3293	0,43
UK 1980	0,3190	0,43
UK 1981	0,3047	0,44
UK 1982	0,2953	0,44
UK 1983	0,2864	0,46
UK 1984	0,2801	0,47
UK 1985	0,2759	0,48
UK 1986	0,2705	0,49
UK 1987	0,2668	0,488
UK 1988	0,2632	0,5
UK 1989	0,2601	0,51
UK 1990	0,2538	0,51
UK 1991	0,2421	0,5
UK 1992	0,2332	0,52
UK 1993	0,2269	0,51
UK 1994	0,2268	0,507
UK 1995	0,2260	0,5065
UK 1996	0,2242	0,5065
UK 1997	0,2216	0,5065
UK 1998	0,2217	0,5065
UK 1999	0,2134	0,506
UK 2000	0,2068	0,512
UK 2001	0,2007	0,503
UK 2002	0,1931	0,499
UK 2003	0,1866	0,502
UK 2004	0,1814	0,5
UK 2005	0,1771	0,503
UK 2006	0,1740	0,503
UK 2007	0,1725	0,504
UK 2008	0,1680	0,508
UK 2009	0,1630	0,519
UK 2010	0,1569	0,523
UK 2011	0,1561	0,524
UK 2012	0,1549	0,524
UK 2013	0,1527	0,527
UK 2014	0,1515	0,518
UK 2015	0,1508	0,52
UK 2016	0,1511	0,506
UK 2017	0,1414	0,506
UK 2018	0,1400	0,513
UK 2019	0,1400	0,508
UK 2020	0,1403	0,507
UK 2021	0,1385	0,51

Correlation analysis demonstrates us that there is a strong relationship between Gini index and share of employment in industry (the value is -0,95, it is close to -1, hence, there is a strong negative correlation).

The econometric model is as follows:

$$Y_t = \alpha + \beta_1 X_t + \varepsilon_t,$$

Where:

Y_t denotes Gini index (market income, before taxes and transfers, from 0 to 1), X_t is the share of employment in the industrial sector (from 0 to 1), t is a period of observations.

Figure 1. Regression Analysis Results

Regression statistics					
Multiple R	0,951109148				
R Square	0,904608611				
Adjusted R Square	0,903245877				
Standard Error	0,014682503				
Observations	72				
ANOVA					
	df	SS	MS	F	Significance F
Regression	1	0,143103341	0,143103341	663,81886	1,9134E-37
Residual	70	0,015090312	0,000215576		
Total	71	0,158193653			
	Coefficients		Standard Error		P-value
Intercept	0,595896567		0,005387977		2,562E-80
Share of empl.	-0,471730766		0,018309202		1,9134E-37

In this case the regression equation is as follows:

$$\hat{Y}_t = 0,5958 - 0,4717X_t$$

$R^2 = 0,9046$ means that 90,46% of variation of Gini index before taxes and transfers (Y_t) can be explained by the share of employment in industrial sector (X_t). P-values of the coefficients is less than a significance level $\alpha=0,05$ and modulo t -stats of all coefficients are greater than $t_{crit} = 1,994437112$, consequently, all regression coefficients are significant at the 5% significance level. F equals 663,81 and is greater than $F_{crit} = 3,97$. Significance F is lower than 0,01. We can conclude that the model is statistically significant.

The disadvantage of the model is that the results explain income distribution only at the moment. For forecasting income distribution in future economies with new technologies, AI, demand for new specialists with tertiary education, new institutions and other attributes of a new technological structure, a completely another model is required.

Results

The regression analysis shows us that deindustrialization, in terms of decreasing employment in the secondary (industrial) sector, results in increasing market income inequality. It is also important to reveal, which forces are implicitly included in the model, even though they are not used as variables: employment in industry influences on other, 'derived', factors of income inequality and it is also influenced by some of such factors.

Firstly, most of trade unions are formed in the framework of industrial sector. According to the OECD data, there is a decline of the British trade unions, which is accompanied by the decrease of the share of employees in industry. Trade unions require earnings/wages above the market ones for their members, consequently, income inequality in the country narrows. The service sector, or tertiary sector, does not have such strong workers' unions as the industrial sector has (at least, in the Britain's case).

Secondly, the difference in salaries in the service sector is larger than the one in the industrial sector. This is caused by the absence/lack of strong trade unions and also by the earnings' range that is wider in the service sector (especially in developed economies, like the British economy) as the sector includes more different jobs and specializations with different requirements to education level and other conditions. While there is an earnings' range (from salaries of top-engineers to wages of low-skilled workers) in the industrial sector, it is not so wide as it is in the tertiary sector. Tertiary sector is more heterogeneous and 'motley' itself (growing wage dispersion): it includes high-paid CEOs, managers, specialists from financial, insurance, real estate, IT and many other businesses and liberal professions, like tutors, doctors, lawyers to maintenance staff. Henceforth, a decrease in the share of employment in industry and an increase in the share of employment in service sector lead to fluctuations in income inequality and income inequality widening, if other opposite factors (e.g. education) do not overweight the factor of industrial decline. Especially important role in these fluctuations plays financial sector as a part of the service sector. Deregulated financial markets with high salaries and bonuses for bank executives and financial managers and with growing share of financial sector in a country's GDP results in high levels of income inequality (e.g. see Piketty [2017], Stiglitz [2012]). The philosophy of neoliberalism (in particular, the British version of neoliberalism – Thatcherism) puts forward the idea of control on financial and intangible assets, but not on tangible assets: this point is closely connected with the factor of globalization, which is described below. Hence, the financial sector is growing, the share of the industrial sector is decreasing and, as a consequence, market income inequality is widening.

Thirdly, the level of employment in industry influences, in particular, on the political landscape in democratic countries (e.g. since the 'Thatcherite Revolution' (1979-1990) the politicians of the Labour Party of the UK have been Prime-Ministers only for approximately 13 years, while the Conservatives representatives have been Prime-Ministers for about 20 years). The more people are employed in the industrial sector, the higher is the level of popularity of labour, social democratic and other left-wing parties, while the popularity of these political parties and their actions make an impact on the redistributive policy (however, in the present paper the redistributive policy is not considered as only market income inequality is the object of the analysis) and, as a consequence, on income inequality and such indicators, like Gini index after taxes and transfers.

Fourthly, the industrial sector usually needs workers with an upper-secondary level of education (in the second half of the XX century) and the majority of people in industrial economies has the same level of education. In the service economy the number of people with tertiary education increases. Similar level of education among population is usually a factor of deterrence of income inequality. Together with a large share of the industrial sector, a similar level of educational attainment among the population can be considered as a base of the middle class in the UK in the second half of the XX century, and it remains so in other countries with larger industrial sectors than the one in the UK.

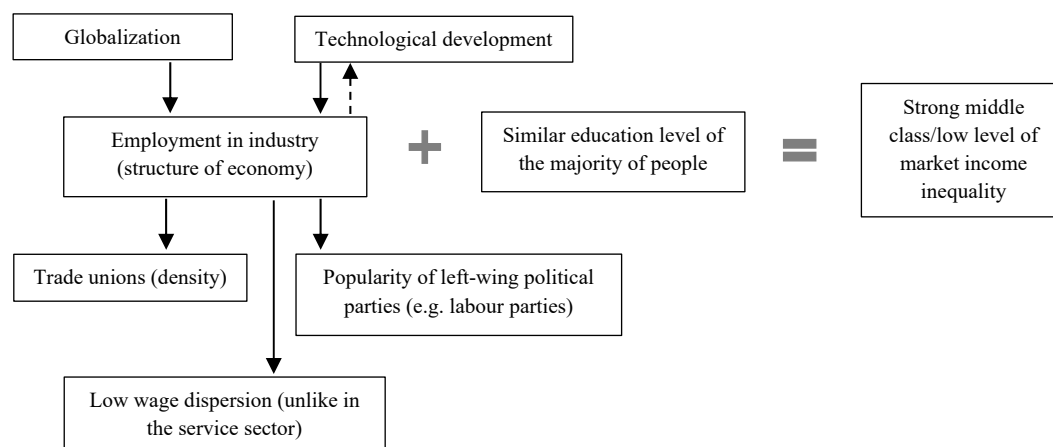
Fifthly, globalization is indirectly included in the presented model as with the acceleration of globalization in the end of the previous century more and more industrial enterprises

have been moving to the countries (mostly Asian) with emerging markets, cheap resources and workforce. Such a process has resulted in the fact, which is proved by B Milanovich (2016), that the winners of globalization are the ‘global plutocracy’ – the largest owners of the financial assets – and the Asian middle class (due to convergence). Hence, by measuring the share of industrial sector we may also estimate the degree of globalization (openness) influence on market income distribution.

Finally, technological development, undoubtedly, also has an impact on the share of employment in the industrial sector and, thus, on the market income inequality (e.g. see Mehic [2018]). B Milanovich (2016) stressed that technological development may influence income inequality in two ways; it can either increase productivity of low-skilled workers and their wages respectively or cause reduction of personnel: low-skilled workers can be substituted by new technologies (while the productivity and salaries of high-skilled workers may rise with the use of these new technologies). The present paper does not aim at defining which force – technological development or globalization – has had a stronger impact on the employment in industry, as both factors have affected it. However, according to the data on market income inequality in the UK, we can draw a conclusion that in the UK technological development has helped (in terms of increasing productivity and, consequently, salaries) high-skilled workers rather than low-skilled ones.

To summarize, the share of employment in industry in comparison with other sectors of economy influences market income inequality in the UK (inequality level after taxes and transfers are not considered in the present paper), thus, the structure of economy plays a key role in income distribution (at least, for now) as it is both the reason for the impact of other forces, influencing income distribution (like trade unions, labor and left-wing political parties) and the consequence of the impact of such forces, like globalization and technological development (anyway, industry is a factor of technological progress too), and it is itself the force (as well as the growing education level), usually narrowing income inequality. As it is shown in the paper, the industrial sector has been the pillar of the strong middle class in the UK.

Figure 2. Scheme of factors of market income inequality in Great Britain



Conclusions

The variable “share of employment in the secondary (industrial) sector” has been employed in the model. This variable reflects transformations in the structure of economy, as a decreasing share of employment in the industrial sector in advanced economies, like the British economy, usually is accompanied by an increasing share of employment in the service sector. The regression analysis shows that there is the negative relationship between the share of employment in industry and income inequality: when the value of the share of employment in industry decreases, Gini index (market income, before taxes and transfers) increases. The roots of deindustrialization and transformations in the structure of economy are economic globalization (trade liberalization) and technological development, and these processes lead to distortions in initial distribution of incomes. The base of the middle class in the UK has been a large industrial sector with a big share of employment in it and a similar level of education among the population. To summarize, the structure of economy, its transformations and the effects of accompanying processes (like the decline of the trade unions) are the main factors, influencing income distribution in Great Britain.

Declarations

Competing interests: The author reports there are no competing interests to declare.

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Data availability statement: Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Notes

- (1) Due to the difference in counting methods between ONS and OECD, the average value of the difference in OECD and ONS indicators was subtracted from the OECD indicators for years 2017-2021.
- (2) There was no exact data for 1995-1998, henceforth, the average indicators (1996 and 1999) were used.
- (3) Due to the data extraction from the graph, the data for years 1950-1993 is not absolutely accurate, a small margin of error should be taken into account.

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Structural transformation, poverty, and inequality in emerging countries

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Abstract. *This study makes a valuable contribution to the existing literature by examining the impact of structural transformation on poverty reduction in 13 emerging economies during the period 2008-2018. The research utilizes a generalized method of moments (GMM) dynamic panel regression technique to identify the key drivers of poverty and inequality reduction. The findings reveal that structural change significantly contributes to poverty and income inequality reduction in the emerging economies under consideration. Specifically, the service sector and industry sector play pivotal roles in eradicating poverty and income inequality in these countries. However, the results suggest also that the agricultural sector may not be the most efficient means of reducing poverty and inequality in emerging economies. To increase its impact on poverty reduction, it is crucial to modernize and transform the agricultural sector into an agribusiness.*

Keywords: emerging countries, GMM, inequality, poverty, structural transformation.

JEL Classification: E24, F16, I32, J31.

1. Introduction

Over the past two decades, emerging economies have witnessed impressive economic expansion, outpacing that of developed countries (IMF, 2023). This economic growth has significantly reduced poverty in many developing regions. Since the seminal work of Bourguignon (2004), a multitude of theoretical and empirical studies have emerged examining the relationship between poverty, inequality, and economic growth. A consensus has emerged that achieving sustained inclusive growth is crucial to alleviate both poverty and inequality (Mlachila et al., 2017).

Poverty can be explored as one of the basic features of unsustainable socio-economic development and as a persistent phenomenon that can disturb people's lives (Bossert et al., 2022). As highlighted in the latest United Nations Report (2021) in the 2030 Agenda for Sustainable Development, the first goal aims to eradicate poverty in all its forms everywhere. Inequality may take many different forms and refers to the unequal distribution of resources, opportunities, and rewards within a community or between various groups of people. Undoubtedly, one of the biggest dangers to societal stability is wealth disparity (Kharlamova et al. 2018).

Indeed, achieving poverty reduction, reducing inequalities, and promoting inclusive growth necessitate coupling gross domestic product growth with dynamic and substantial structural transformation across various economic sectors (African Development Bank, 2019). Addressing this challenge is essential for better socioeconomic and human development (Khan, 2019). However, social economists are currently focusing on the concept of poverty as a key facet of sustainable development. For example, according to McMillan and Rodrik (2011), countries that have experienced structural changes in their economic activity have successfully lifted themselves out of poverty and achieved higher levels of prosperity. For Barbier and Hochard (2014), in developing countries, the simple impact of growth on poverty reduction is clarified by the fact that a larger share of the population lives on agricultural land, which is less advantageous to production.

Over the last decade, emerging countries have made great strides toward reducing poverty. In certain instances, the economic transformation process has sparked wage and productivity growth, assisting in the eradication of poverty. Also, in emerging countries, agriculture is still undeveloped and characterized by poor production. As a result, it appears that this country's agriculture sector is not going to be able to eradicate poverty. To escape the middle-income trap, these nations need to go through a transition. The government is worried about the shift from an agriculture-based nation to one that places a priority on added value from the manufacturing sector. The structural change will boost added value in addition to boosting productivity since it will employ more employees in the manufacturing sector and provide commodities from upstream to downstream, promoting more inclusive economic growth (Kim et al., 2018). Structural change reflected the redistribution of economic activity from low-productivity sectors to high-productivity sectors. As such, it helps ensure strong, sustainable, and inclusive growth (UNCTAD,

2016). It is usually marked by at least two stylized facts: either the strengthening of the share of the manufacturing sector and high-value-added services in GDP and a rapid reduction in the share of agriculture, or the decrease in the share of agricultural employment and the movement of workers to other more productive sectors of the economy.

Structural transformation is one of the main components of economic development, as the resource effect should lead to higher overall productivity and therefore higher incomes. It is broadly defined as the reallocation of resources from low-productivity activities (traditionally identified with agriculture) to high-productivity activities (industries and services). Support for industrial policy has become a necessary condition for structural transformation in most industrial economies today. This means that industrial policy support has become a prerequisite for structural change. Industrial policy refers to a specific type of policy aimed at reshaping the production structure of a sector to enhance the potential for economic growth (Pack and Saggi, 2006). Structural change consists of shifting economic activity among the three main sectors of the economy: agriculture, manufacturing, and services, to ensure future growth.

Therefore, this paper aims to seal the empirical gaps in the current literature and contribute to the debate on sustainable development goals in emerging countries. To our best knowledge, no research has referred to the case of emerging countries by examining the influence of structural transformation on poverty and inequality. The main motivation for this research, compared to other associated studies, is to investigate the role of structural transformation on income distribution, inequality, and poverty reduction in emerging countries that are experiencing radical changes in their economic structures, by providing support based on a solid theoretical and empirical background.

The current study aims to fill the theoretical and empirical lacunas in the existing literature and contribute to the debate in various ways. We verify the extent to which structural transformation affects the probability of escaping from poverty and inequality in emerging countries and identify that if agricultural incomes increase, it will help reduce the inequality arising from rapidly increasing income from other sources for a panel of 13 emerging countries⁽¹⁾ over the period 2008-2018. To test this hypothesis, we use the generalized method of moments (GMM). Our study focuses only on emerging countries. This is particularly important for two main reasons. Emerging countries, which heavily rely on industrial and manufacturing as these countries have been transforming their economic profiles from agriculture into the manufacturing and service industries (Naudé et al. 2013). Furthermore, agriculture remains underdeveloped and is characterized by low productivity in emerging countries.

The rest of the paper is organized as follows. Section two is about the descriptive analysis of data on structural transformation and poverty. Section three presents the empirical review and section four presents the method of analysis and the data used. Section five discusses the empirical results, while section six concludes the paper.

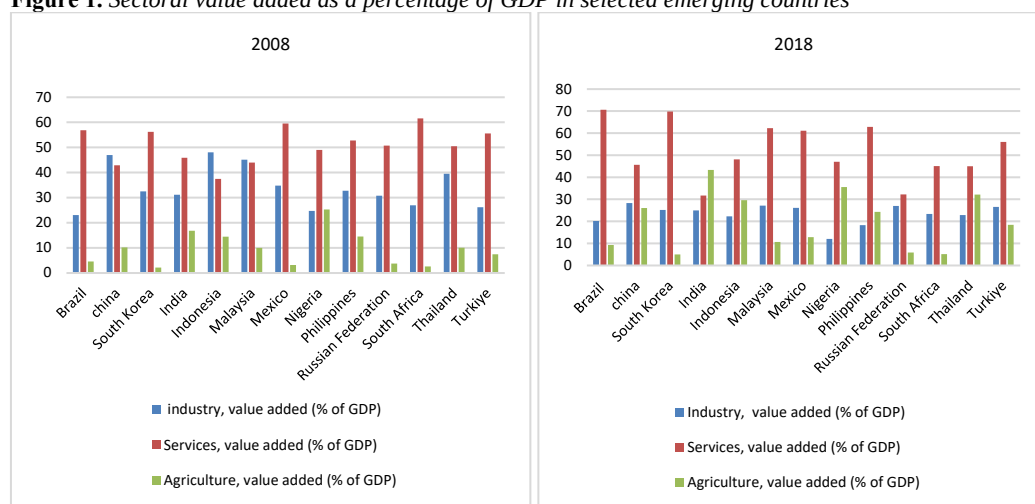
2. Evolution of structural transformation and poverty in emerging countries

2.1. Structural Transformation in Emerging Countries

In recent years, many emerging economies have experienced substantial industrialization, which has greatly aided their economic development. Manufacturing, mining, building, and energy production are examples of industries. Another vital part of the GDP in emerging economies is the services sector. A vast range of activities, such as finance, tourism, transportation, education, healthcare, and more, are included in the services sector.

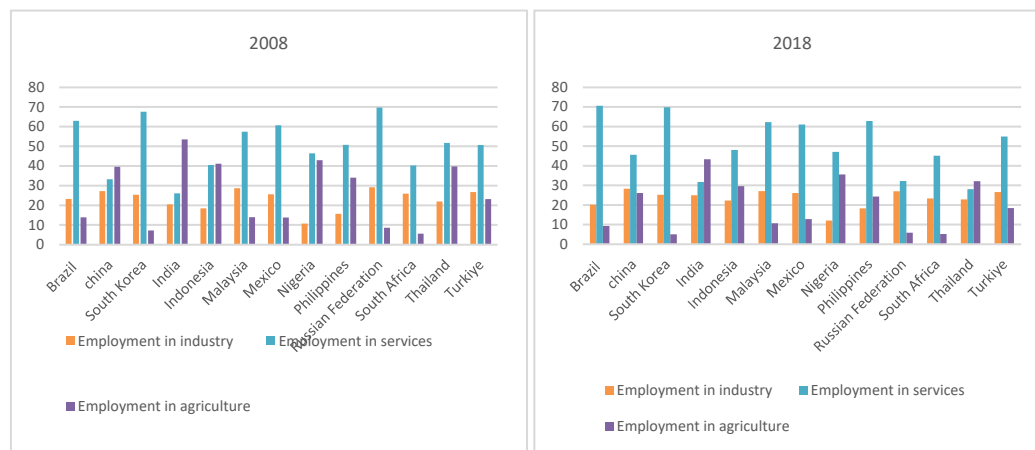
Figure 1 shows that industrial activities and services in emerging countries have the largest percentage of GDP in 2018, while the agricultural sector had only a very low added value in GDP. Therefore, sectoral added value comes mainly from the industrial sector and the service sector. Structural change implies a movement of labor from traditional to modern activities. This subsequently leads to a reorientation of productivity to diversify and modernize it by embracing labor from the agricultural sector, which is the primary employer sector in certain developing nations.

Figure 1. Sectoral value added as a percentage of GDP in selected emerging countries



Source: World Bank (WDI).

Figure 2 shows that structural transformation in emerging countries seems to be moving in the right direction. The shift in employment patterns transfers the focus from the less productive sectors, such as agriculture, to the more productive ones, such as industry and services between 2008 and 2018.

Figure 2. Distribution of employment (% total employment by sector)

Source: World Bank (WDI).

2.2. Poverty and inequality situation in emerging economies

Poverty refers to the condition where a person or community lacks the basic material, social, and economic resources needed to lead a decent and satisfying life. This can include a lack of access to food, housing, healthcare, education, decent employment, and other basic needs. Poverty reduction is a key objective for many governments and international organizations to create a more equitable society and improve the living conditions of vulnerable populations. According to the United Nations (2021), approximately 10% of the world's population lives in horrendous poverty and struggles to meet its basic needs, such as health, education, sanitation, and access to water, among others.

In this study, we will use three indices of poverty which are the most popular. The first index is the poverty rate (PR), which is the percentage of the population living below the poverty line (\$1.90 per day). The poverty gap index (PGI) of \$1.90 per day is a measure of the average lack of income or consumption compared to the poverty line of \$1.90 per day. It measures the average shortfall in income or consumption of people living below the poverty line from the line itself. It examines not only who is poor but also how far below the poverty line they are. The Gini index (GINI) reflects the extent to which the distribution of income between individuals is equal. The Gini Index is the value that shows the level of income or wealth inequality in the population being studied. A lower Gini Index indicates a more equal distribution, while a higher index implies greater inequality.

Figure 3 shows that the poverty rate has been significantly reduced in emerging countries in recent years except in South Africa, but it remains high, especially in Nigeria and India. The poverty gap has decreased, particularly in China, but it has increased in South Africa. In Mexico and South Africa, people who live below the poverty line are very far from the \$ 1.90-a-day line. Income inequality in certain emerging countries slightly increased but the levels are still higher, where a significant portion of the population lives on very low incomes while a smaller segment enjoys higher levels of wealth.

Figure 3. *Share of poor population in emerging countries*

Source: World Bank (WDI).

3. Review of Empirical Literature

3.1. Structural transformation and poverty

The empirical literature that contributes to the subject continues in a premature stage. These studies vary depending on the measure of poverty used, the countries included in the data set, and the determinants of poverty. However, the impact of structural poverty transformation processes in all emerging economies has received little attention and needs to be demonstrated. Among previous investigations related to the impact of structural transformation on poverty reduction, UNIDO (2012) has emphasized that the process of structural change has been accompanied by a decrease in the poverty rate in Brazil, Russia, India, China, and the country of South Africa (BRICS) over the period 1984–2004. This process has had the greatest effect in China, where the poverty rate has fallen from 15% to 3% over this period. This reduction is explained by the migration of poor inhabitants from rural areas to urban areas and their jobs in the manufacturing sector. In other countries,

poverty reduction is sorted by economic growth, industrialization, and policy distribution. Similar results are obtained by Kahya (2012) who shows, for a sample of ASEAN countries (Malaysia, Indonesia, Thailand, and the Philippines) using the OLS method, that the impact of structural changes on poverty has been meaningful and positive in all countries. More recently, Lee (2018) uses the GMM system method and a panel comprising 30 countries over the period 1990–2014. He indicates that poverty reduction can be alleviated through structural reforms.

Lin J. (2019) demonstrates how structural changes impact individuals' income in both rural and urban areas before introducing a new structural economics approach to eradicating poverty. The findings indicate that boosting personal income is the initial step in reducing and ultimately eliminating poverty. New technology and job prospects will frequently coexist with structural changes in both rural and urban regions, helping individuals increase their wages. In a similar vein, Lugo et al. (2022) reveal that structural transformation have been the main driver of poverty reduction in China by creating better-paying employment and raising worker productivity.

Several works have highlighted the role of the industrial sector in poverty reduction (Cadot et al., 2016; Erumban and Vries, 2021 and Lin C. et al., 2022). The study by Cadot et al. (2016) of 35 sub-Saharan African countries concludes that the industrial sector has a better track record of eradicating poverty than the agriculture and service sectors. Similarly, Erumban and Vries (2021), using data from 42 developing nations collected over 28 years, show that structural change and expansion in the manufacturing sector are positively and significantly associated with poverty reduction. In a related study, Lin et al (2022) found a positive relationship between regional economic growth and China's local industrial reduction of poverty.

Interestingly, few studies focus on the link between the service sector and the reduction of poverty like Rifa and Listiono (2021) and Kamaludin A. (2023). Rifa and Listiono (2021) demonstrate that the service sector has a significant and positive effect on poverty reduction for 38 East Java cities during the period 2012–2015, whereas they assumed that the role of the industrial sector was not significant. Therefore, this study suggests that the service sector is more effective in reducing poverty. According to Kamaludin A. (2023), when communities with an agricultural dominating basis have enough or have changed to other sectors in addition to the service sector, there is a clear association between the fall in the number of rural poor people and the shift to the third sector.

3.2. Structural transformation and inequality

The relationship between structural change and inequality in the development process was well articulated in early works by Lewis A. (1954) and Kuznets S. (1955). These authors formulated a working hypothesis that, at the initial level of development, economic growth accelerates in the modern sector while wage rates in the traditional sector remain relatively lower due to unlimited labor supply, thereby increasing the degree of income inequality at the national level. The premise here is that inequality in the traditional sector is substantially smaller (owing to unequal production levels), but inequality in the modern

sector is considerable. So, the existing literature presents conflicting positions regarding the impact of structural change on reducing inequality.

Nangarumba (2015) outlined the common issue that developing countries face, which is their propensity to leave the agricultural sector in favor of advancement in the industrial sector. Many employees in the agricultural sector are uneducated. A large percentage of the agriculture industry's workforce lives in poverty. In contrast, the growth of the industrial and service sectors can help to lessen inequality in developed nations. This is because people in industrialized countries tend to have higher levels of education and utilize technology very quickly, which can motivate them to work in the industrial sector.

The study by Morsy et al. (2023) highlighted that the flow of workers from low to high-productivity sectors might increase by one standard deviation, which would reduce overall inequality by 0.5 percent and opportunity inequality by 1.1 percent. They suggest that swift structural change might result in a long-term decline in inequality in Africa. Wang et al. (2023) and Chen (2016) are examples of this line of research. These studies investigate the impact of industrialization and urbanization on reducing inequality.

However, Roy and Roy (2017) provide further evidence of the negative effect of structural transformation on reducing inequality in 217 countries from 1991 to 2014. The authors found that the process of structural transformation enhances income inequality, while trade liberalization and FDI inflows assist in alleviating it. Income distribution is more equitable in infrastructure development. Capello and Cerisola (2023) show that reallocation towards higher value-added sectors in Central and Eastern European countries (CEECs) could lead to higher regional inequalities. Sectoral transition is a tough process since it is dependent on the long-term sectoral composition of countries and regions as well as the fact that job-specific skills are not simply transferrable from one industry to another.

Given the foregoing discussion, it is worth noting that most empirical studies have been limited to evaluating the impact of the industrial and service sectors on reducing poverty and inequality in emerging countries. Consequently, our research is inspired to clarify this effect.

4. Methodology and Data

This section outlines the research methods used to examine the relationship between structural change and poverty.

4.1. Model

The model for the analysis of "structural transformation and poverty" was extended to the model used by Rifa and Listiono (2021).

$$Poverty_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 ST_{it} + V_t + U_i + \varepsilon_{it}$$

Where poverty is the poverty index, i and t represent a country and time, respectively. In addition, X_{it} is a vector of explanatory variables; ST_{it} represents the variables related to structural transformation; U_i is a country-specific effect; V_t is a time-specific effect and ε_{it} is an error term.

4.2. Variables and Data Sources

We use panel data from 13 emerging countries from 2008 to 2018. The data for targeted variables has been collected from World Development Indicators (WDI) and other databases.

The explanatory variables chosen are those that are often used in empirical research on structural change and poverty. Table 1 provides a description and definition of the explanatory variables. We use the poverty gap at \$1.90 per day (PPP 2011) (PGI), the poverty rate (% of the population) (PR), and the Gini index (I. Gini) as the dependent variables.

Table 1. Presentation of explanatory variables

	Variable	Definition
Indicator of structural transformation	VAJ-IND	Industry, value added (% of GDP)
	VAJ-SER	Service, value added (% of GDP)
	VAJ-AGR	Agriculture, value added (% of GDP)
	EMP-IND	Employment in industry (% of total employment)
	EMP-SER	Employment in services (% of total employment)
	EMP-AGR	Employment in agriculture (% of total employment)
Control variables	FDI	Foreign Direct Investment (% GDP)
	OPE	Trade opening (X+M) (% GDP)
	RD	Research and development expenditure (% of GDP)
	EDU	Public expenditure on education (% of GDP)
	INT	Internet users (% of the population)

The estimation model with the three poverty indicators is expressed as follows:

In the first model, we use the poverty rate as a poverty proxy.

$$PGI_{it} = \beta_0 + \beta_1 PGI_{it-1} + \beta_2 X_{it} + \beta_3 ST_{it} + V_t + U_i + \varepsilon_{it} \quad (1)$$

In the second model, the PGI is a poverty proxy.

$$PR_{it} = \beta_0 + \beta_1 PR_{it-1} + \beta_2 X_{it} + \beta_3 ST_{it} + V_t + U_i + \varepsilon_{it} \quad (2)$$

In the third model, we use the GINI index as a measure of the equality of income distribution between individuals.

$$Gini_{it} = \beta_0 + \beta_1 Gini_{it-1} + \beta_2 X_{it} + \beta_3 ST_{it} + V_t + U_i + \varepsilon_{it} \quad (3)$$

5. Result and discussion

The outcomes of the estimation between structural transformation and poverty in emerging nations are presented in Tables (2), (3), and (4).

5.1. Structural Transformation and Poverty

The dependent variables are, respectively, the poverty rate (PR) and the poverty gap index (PGI). In the first regression, structural transformation is measured by sectoral value added (Table 2), while in the second regression, it is measured by sectoral employment (Table 3). The coefficient associated with lagged poverty (L.) has a positive and statistically

significant impact on poverty. The population was already experiencing high levels of poverty in the previous year, it is probable that this poverty will persist partially due to structural and systemic barriers that don't resolve rapidly. This result is consistent with the study of Nessa et Imai (2023) who show that once one falls into the working-poor trap, it is challenging to escape without external shocks.

A potentially fundamental element of poverty elimination is the industrial sector, whose results show that the coefficients of (VAJ.IND) and (EMP.IND) are negative and significantly reduce poverty. These findings are in line with those of Amadou et Aronda (2020), Cadot et al. (2016), and Unido (2012). The emerging countries have experienced, over the last 30 years, one of the most remarkable economic transformations in history. It's moving from a centrally planned economy to a market-oriented economy, which has led to rapid industrialization, urbanization, and export-led growth (ILO, 2020). As a result, the industrial sector significantly contributed to the growth of workers, both directly via the production and manufacturing processes and indirectly through the supply chain and related services.

Our empirical outcome of the service sector (VAJ-SER) and (EMP-SER) indicates a negative and significant effect on poverty. This estimation means that the higher the structural changes in the service sector, the lower the ordinary expenditure gap of each poor person to the poverty line. The service sector outcome is equally in concordance with Rifa and Listiono (2021). The service sector has been a major source of employment in emerging countries, providing jobs for a significant portion of the population. Services trade is essential to economic growth, job creation, and value chain participation.

The contribution of the agriculture sector has an insignificant relationship with poverty. Our findings tie in with the findings of Ferreira et al. (2010) but contradict studies like Obiakor et al. (2021) and Enongene (2023). This means that increasing the contribution of the agricultural sector to GDP will increase poverty levels. The agriculture sector suffers from difficulties in emerging countries. A significant portion of agriculture is subsistence farming, where farmers primarily produce for their consumption. This can limit their ability to generate surplus income to escape poverty. Also, outdated farming practices, a lack of access to modern technology, and inadequate infrastructure can lead to low agricultural productivity. Insufficient yields can prevent farmers from generating sufficient income.

The control variables introduced into the structural transformation equation also have the coefficients indicated in the theoretical predictions. The coefficient of (FDI) is negative and statistically significant. These results are similar to those of the study by Ahmed et al. (2019), they show that FDI has a highly significant impact on reducing poverty in ASEAN and SAARC countries. Emerging countries in the region that draws the most FDI in research and development (R&D), which is influenced by factors like Industry 4.0 initiatives in countries, which include the digital economy and industries related to infrastructure, like electricity or information and communications technology, OCDE (2022). To preserve their technical power, emerging nations have a long history of

scientific research and continue to spend on R&D. Thus, a high level of research and development serves to reduce poverty. The variable measuring trade openness appears with a negative and significant sign. Indeed, openness significantly reduces poverty. This result is consistent with the study of Nissa et Imai (2023). Many emerging countries implement supportive policies to boost ICT development, such as mobile Internet. So, for the quality of infrastructure, measured by the number of internet users (INT), the coefficient of this indicator is also found to be statistically significant, negatively indicating that access to the internet reduces poverty. These results corroborate the findings of Yang et al. (2021).

The education systems of emerging countries have achieved in quality. Some universities made it to the top degree of universities in the world, but these countries are preferably hardly represented in the top 1000 universities in the world, given the demographic strength, and the size of their education effort (in terms of enrolments) (Wolhuter, 2023). Our results confirm that and indicate that public spending on education (EDU) reduces poverty in emerging countries. This outcome is consistent with the research of Ngepah et al. (2022), which demonstrates that a person with a primary school education will have a 1% lower sensitivity to poverty.

Table 2. *The relationship between structural transformation (sectoral value added) and poverty*

Variables	Dependent variable: PR			Dependent variable: PGI		
	(1)	(2)	(3)	(1)	(2)	(3)
L.	0.837*** (0.022)	0.779*** (0.046)	0.729*** (0.030)	0.492*** (0.164)	0.511** (0.259)	0.562* (0.319)
FDI	-0.368** (0.183)	-0.312* (0.184)	-0.105 (0.192)	0.1495* (-0.089)	-0.070 (0.412)	-0.414** (0.184)
OPE	0.005 (0.007)	-0.014** (0.007)	-0.016** (0.007)	-0.007 (0.009)	-0.076** (0.037)	-0.027* (0.015)
R&D	0.176 (0.278)	-0.069 (0.395)	0.568 (0.499)	-0.933*** (0.313)	-2.150* (1.160)	-4.040* (2.270)
EDU	0.241 (0.168)	-0.434** (0.216)	-0.917*** (0.236)	-1.692*** (0.581)	0.14311 (0.443)	-1.242 (0.833)
INT	-0.026*** (0.008)	-0.017 (0.016)	-0.020** (0.009)	-0.033** (0.016)	0.028 (0.022)	-0.0178 (0.015)
VAJ. IND	-0.874*** (0.030)			-0.280** (0.126)		
VAJ. SER		-0.732* (0.042)			-0.503** (0.242)	
VAJ. AGR			0.302*** (0.059)			0.085** (0.427)
Constant	3.790** (1.933)	5.453* (2.989)	-3.265 (2.553)	1.058*** (9.519)	5.548** (2.511)	3.313*** (0.998)
Observations	145	145	145	144	137	144
Ar1p	0.258	0.270	0.264	0.0668	0.0652	0.0255
Ar2p	0.945	0.843	0.833	0.982	0.921	0.963
Sarganp	0.961	0.988	0.962	0.944	0.744	0.739
Hansenp	0.923	0.971	0.903	0.941	0.738	0.752
Number of instruments	13	11	14	12	11	12
Heterogeneity test	0.0	0.25	0.23	0.81	0.12	0.28

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3. *The relationship between structural transformation (sectoral employment) and poverty*

Variables	Dependent variable: PR			Dependent variable: PGI		
	(1)	(2)	(3)	(1)	(2)	(3)
L.	0.342* (0.185)	0.737*** (0.029)	0.714*** (0.027)	0.397** (0.156)	0.410** (0.165)	0.479*** (0.146)
FDI	-0.287 (0.195)	-0.141 (0.167)	-0.520*** (0.081)	-0.271 (0.209)	-0.312 (0.228)	-0.223 (0.217)
OPE	-0.033*** (0.012)	-0.015** (0.007)	-0.028*** (0.007)	-0.027*** (0.009)	-0.023*** (0.008)	-0.015** (0.007)
R&D	5.209** (2.081)	0.401 (0.380)	0.314 (0.265)	-1.353*** (0.428)	-0.669** (0.333)	-0.595* (0.324)
EDU	-0.743 (0.513)	0.238 (0.148)	-0.693*** (0.224)	-0.877*** (0.257)	-0.843*** (0.268)	-0.549** (0.256)
INT	-0.160*** (0.050)	-0.012** (0.006)	-0.0198** (0.008)	-0.030** (0.012)	-0.048*** (0.017)	-0.047*** (0.017)
EMP.IND	-1.558*** (0.529)			-0.340*** (0.106)		
EMP.SER		-0.114*** (0.018)			-0.0621*** (0.023)	
EMP.AGR			0.134*** (0.038)			0.077** (0.031)
Constant	5.622*** (1.167)	-0.111 (0.209)	-0.504 (1.431)	-4.526*** (1.744)	0.612 (1.250)	5.481** (2.325)
Observations	145	138	145	144	137	144
Ar1p	0.506	0.250	0.259	0.066	0.065	0.025
Ar2p	0.435	0.791	0.921	0.982	0.921	0.963
Sarganp	0.814	0.550	0.493	0.944	0.744	0.739
Hansenp	0.805	.513	0.459	0.944	0.744	0.739
Number of instruments	12	12	14	12	11	12
Heterogeneity test	0.28	0.07	0.12	0.81	0.12	0.28

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.2. Structural transformation and inequality

Table 4 below presents the results of the econometric estimations of the interrelationship between structural transformation and the inequality model.

The result demonstrates path dependence, as the lagged dependent variable is determined to be positive and significant. As a result, if inequality exists now, it will likely persist in the future if it is not controlled. These findings are corroborated by the work of Roy and Roy (2017).

The estimation results show that structural changes to the industrial sector due to the negative coefficients of the variables (VAJ.IND) and (EMP.IND) tend to make income distribution more equal. In countries where the proportion of employment in industry has constantly increased, inequality tends to be lower. The results are consistent with the previous conclusion of Baymul and Sen (2020). Our empirical outcome of the service sector (VAJ-SER) indicates a negative and significant effect on income distribution. On the other hand, the service sector reduces income inequality. This is in line with the findings of Morsy et al. (2021). Uniquely, the coefficient of SER-EMP is, as expected, negative but not statistically significant. According to the findings, nations that have consistently increased their share of employment and value-added in industry, followed by services, have a lower rate of inequality.

The VAJ-AGR and EMP-AGR coefficients are significant and positive, indicating that where agriculture has stalled and its employment share has increased, there appears to be high inequality. Our findings tie in with the findings of Kahya (2012) but contradict the studies of Romli (2016) who shows that agriculture was a sharing industry that was successful in reducing income disparities. However, it was shown that the sharing sectors of industry and service increased income disparities.

Concerning the control variables introduced into the structural transformation, we found that the coefficients for foreign direct investment (FDI) are positive and statistically significant. A positive correlation between FDI and the Gini index suggests that demographic groups may disproportionately benefit from foreign investment. This may result in a concentration of income and wealth among a small group, thereby escalating income inequality. Huang et al. (2020) found the same results and suggested that FDI may increase income inequality as a country initially develops.

The coefficient of Trade Openness (TO) is significant and negative but low; this could indicate that openness to international trade has had a relatively limited impact on the reduction of economic inequality in emerging countries. These results are comparable to those of Dorn et al. (2020).

The results illustrate that R&D reduces inequality in emerging countries. In this context, Chan et al. (2022) find that a higher R&D subsidy rate decreases the ratio of asset income to wage income, so it would have a decreasing or even a U-shaped effect on income inequality.

Public spending on education (EDU) increases inequality in emerging countries.

Access to quality education is not equitably distributed in society, which can reinforce pre-existing inequalities. Individuals from higher socio-economic backgrounds often have more resources to access better education, which can perpetuate disparities. According to Yan and Qui (2015), education increases inequality because poor families invest less in their children's early education than wealthy families; as a result, their children attend lower-quality schools, making them less likely to pursue higher education.

For the quality of infrastructure, measured by the number of internet users (INT), the coefficient of this indicator is also found to be statistically significant, negatively indicating that access to the internet reduces inequality.

Table 4. *The relationship between structural transformation and income distribution*

	Dependent variable: GINI INDEX					
	(1)	(2)	(3)	(4)	(5)	(6)
L.	0.492*** (0.164)	0.511** (0.259)	0.562* (0.319)	0.955*** (0.100)	0.985*** (0.041)	0.797*** (0.143)
FDI	0.149* (0.089)	-0.070 (0.412)	0.414** (0.184)	0.032 (0.101)	0.029 (0.031)	-0.275 (0.179)
OPE	-0.007 (0.009)	-0.076** (0.037)	-0.027* (0.015)	-0.001 (0.010)	0.005 (0.004)	-0.016* (0.010)
R&D	-0.933*** (0.313)	2.150* (1.160)	-4.040* (2.270)	0.442 (0.739)	-0.482** (0.214)	-2.028 (1.624)
EDU	1.692*** (0.581)	0.143 (0.443)	-1.242 (0.833)	0.212 (0.272)	0.4621*** (0.148)	-0.439 (0.439)
INT	-0.033** (0.016)	0.028 (0.022)	-0.017 (0.015)	-0.011** (0.005)	-0.014*** (0.004)	-0.024 (0.021)
VAJ. IND	-0.280** (0.126)					
VAJ. SER		-0.503** (0.242)				
VAJ. AGR			0.857** (0.427)			
EMP.IND				-0.245* (0.141)		
EMP.SER					-0.005 (0.12)	
EMP.AGR						0.152* (0.085)
Constant	1.264 (0.378)	1.395*** (1.265)	0.967 (0.118)	7.00311* (3.749)	-1.85184 (2.674)	2.627 (0.075)
Observations	144	144	144	144	137	144
Number of ids	12	12	12	12	11	12
Ar1p	0.046	0.341	0.144	0.040	0.055	0.066
Ar2p	0.572	0.696	0.932	0.710	0.404	0.659
Sarganp	0.859	0.448	0.860	0.200	0.969	0.966
Hansenp	0.862	0.496	0.753	0.325	0.932	0.954
Number of instruments	12	11	11	12	11	13
Heterogeneity test	0.45	0.78	0.41	0.49	0.45	0.41

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Conclusion

The driving objective of this study was to emphasize the causal impact of the structural transformation on poverty and inequality reduction in emerging countries over the period 2008–2018. We used the GMM system to analyze these interrelationships.

According to the results, poverty and inequality tend to rise when the share of value-added and employment in agriculture increases. Despite industry and service sectors tending to decrease it. If labor mobility is shifted from traditional to modern sectors, emerging countries can reduce poverty and inequality better. Other indicators, such as research and development expenditure, the internet, and trade openness, have been shown to reduce poverty and inequality in the study. Despite the reduction of poverty, the problem of inequality has worsened due to FDI and public education spending in emerging countries.

The study has a significant impact on the literature by introducing numerous important dimensions for policy analysis. Emerging economies are demanding sound policies to

reduce income distribution and poverty through structural transformation, infrastructure development, and trade liberalization. FDI and education can be chosen as policy instruments to reduce poverty and inequality. As a result, emerging nations have implemented policy reforms to attract FDI. They have improved business conditions by lowering bureaucratic hurdles, simplifying rules, and strengthening investor protection. They must also initiate collaborations in higher education through student and faculty exchange programs, joint research projects, and academic partnerships. This helps in sharing knowledge, expertise, and research capabilities.

Note

- (1) List of countries: Brazil, China, South Korea, India, Malaysia, Mexico, Nigeria, Philippines, Russia, South Africa, Thailand and Turkey.

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How work works for the new generations?

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Abstract. *This paper investigates the essential components required to establish a work environment that is safe, motivating, and goal-oriented, and that promotes employee productivity, well-being, and engagement. It pinpoints the primary factors that contribute to the creation of such an environment, such as the availability of mental health resources, the flexibility of work arrangements, and the straightforward communication of job security and prospects. The study underscores the significance of a workplace culture that is equitable and respectful, actively combats bias, harassment, and discrimination, and promotes creativity and innovation through inclusivity. The significance of management is underscored, emphasising the necessity of communicative, supportive leadership that offers consistent positive feedback, career development opportunities, and empowers employees with autonomy in their positions. The research also investigates the influence of constructive coworker relationships, diverse and challenging tasks, and manageable burdens on the prevention of burnout and the maintenance of motivation. Lastly, the paper explores the ways in which long-term employee satisfaction and organisational success are influenced by continuous training and career advancement opportunities. According to the results, a supportive, well-rounded work environment not only improves individual well-being but also results in enhanced organisational outcomes, such as increased productivity, reduced turnover, and a stronger corporate reputation.*

Keywords: work, productivity, “bare minimum” concept, manipulation.

JEL Classification: J24, M54.

1. Introduction

A safe, motivating and goal-oriented work environment inspires employees to give their best work. It includes elements that are social, psychological, and physical and that assist with productivity and well-being.

It is essential to have access to mental health resources including stress management classes, employee assistance programs (EAPs), and counselling services. Employees can better balance their personal and professional life with flexible work schedules, remote work alternatives, and sufficient vacation time. Anxiety and uncertainty are decreased when stability in employment and prospects are communicated clearly. There should be a fair culture that actively addresses bias, harassment, and discrimination, and all employees should be treated with respect.

Creativity and innovation are encouraged by an environment where all workers feel appreciated and included. An environment based on strong teams and a feeling of community can be developed by promoting cooperation and honest communication. An personable, encouraging, direction-giving but professional manager goes a long way towards establishing a positive workplace.

Consistently providing positive feedback, creative criticism and acknowledging accomplishments makes workers feel appreciated and inspired. Long-term employee engagement is supported by offering career development options like training, coaching, and advancement. Providing workers with independence and decision-making power in their positions promotes efficiency and fulfilment at work (Becker, 2003). Employee engagement and awareness are increased when company objectives, expectations, and changes are communicated openly, giving a sense of stability and balance. Maintaining a sustained level of productivity and preventing burnouts is achieved by ensuring that staff have a manageable workload.

Maintaining motivation and engagement can be achieved by assigning a range of challenging and interesting tasks for employees that will make them feel creative and helpful, giving them a sense of achievement, which will bring satisfaction at both ends.

Establishing a helpful and pleasurable work environment is facilitated by cultivating pleasant interactions and relationships among coworkers by creating different tasks that will allow them to bond by mixing the best of their abilities and qualities over solving those tasks. An enjoyable work environment may be maintained, and problems can be kept from getting worse by having clear procedures in place for handling and resolving disagreements.

Continuous training and chances for career advancement enable employees to advance their careers and acquire new skills. In addition to improving employees' well-being and job satisfaction, a healthy work environment improves organizational results like productivity and minimizes turnover, all of which contribute to a positive corporate reputation.

2. The key to lack of productivity – the story behind the “bare minimum”

The phrase "bare minimum" in a work setting describes completing the bare minimum of work necessary to meet expectations or carry out job tasks without going above and beyond what is officially needed.

Completing chores as quickly and with as little effort as feasible, avoiding going above and beyond or accepting additional responsibilities, doing the bare minimum required by supervisors or to fulfil the demands of the job, completing the essential tasks of the position without looking for ways to innovate or improve upon it is eventually creating an environment that is affecting both ends.

Going further on the idea of “bare minimum”, it could consist of a low level of interest in contributing to meetings or only joining in on team projects when called upon. Also refusing to take the lead or help with new tasks or projects, or responding to assignments or problems as they come up as opposed to planning and taking care of them beforehand is considered as doing the bare minimum. Failing to look for chances for career or personal growth, choice which will affect their career and life quality on long term, also creating work that is passable but not outstanding, and emphasizing completion above quality, not making the extra effort necessary to meet or surpass deadlines or guarantee excellent results.

Even while working as little as possible could be enough to keep a job, it can have negative consequences. A negative outcome would consist of reduced opportunities for advancement or career growth as a result of idleness, or being viewed by superiors and coworkers as disinterested or lacking motivation, which will lead to a unbalanced work relationship and environment, affecting everybody involved. Decreased motivation and personal fulfilment is an aftermath of applying the bare minimum strategy since work has little to no dedication beyond what is required.

To sum up, the "bare minimum" strategy is defined by an emphasis on getting by with little further work, involvement, or dedication to excellence.

3. The byways between determination and needs

How much effort someone is willing to put into their work is mostly determined by their motivation. Theories like Deci and Ryan's Self-Determination Theory (SDT – Deci, Ryan, 1985), Herzberg's Two-Factor Theory (Herzberg, et al., 1957, Herzberg, et al., 1959), and Maslow's Hierarchy of Needs (Maslow, 1943) provide explanations for why certain workers could decide to perform the minimal amount of work.

According to Maslow's Hierarchy of Needs (Maslow, 1943), if an employee's basic needs—such a stable employment or a safe workplace are not satisfied, they are unlikely to be inspired to pursue more ambitious objectives like self-actualization. Under such circumstances, focusing on survival rather than growth may be reflected by doing the bare minimum.

According to Herzberg's Two-Factor Theory (Herzberg, et al., 1957), there are two types of factors, like motivators (such as: success and recognition) and hygiene factors (like wage and work conditions). When workers feel that there aren't enough incentives or that there aren't enough hygienic aspects, they can get disengaged and put in less effort (Georgescu, 2020).

According to the self-determination theory, relatedness, competence, and autonomy are crucial for promoting self-motivation. Workers who believe their workplace inhibits their independence, undervalues their skills, or doesn't foster deep social relationships may find themselves doing just enough to get by.

The tendency of performing the bare minimum is also influenced by the changing ideas of society towards work-life balance. In the past, success was generally associated with hard labour and dedication, and work was frequently viewed as the focal point of life. But there has been a movement in culture, especially among younger generations, favouring family life, leisure, and personal well-being over career success.

The idea of "work centrality", which describes the significance of work in a person's life, can be used to explain this change. When it comes to people with low work centrality, employment is more of a means to an end—a way to make ends meet—than a source of fulfilment or identity. Considering that their main priorities are outside of the office, these people could not perceive the benefit of going above and beyond the bare minimum. This trend has been further exacerbated by social media movements that support self-care and work-life balance, which encourage employees to set personal limits and avoid going above and beyond at work.

Psychological principles like conformity and social proof imply that people often shape their behaviour after that of those around them. Employees may imitate their colleagues if they see them continuously performing the bare minimum with no consequences. This conduct has the potential to become deeply ingrained in the culture of the company, resulting in a cycle of minimal effort.

It's natural for workers to feel disengaged and demotivated when they believe their pay is unfair. In this situation, doing the bare minimum can be considered an act of protest. Workers may justify their low effort by arguing that it is consistent with their pay grade and that they are merely providing what they are paid to do.

Doing the bare minimum, in the short run, reduce stress and give someone a feeling of control over a perceived unjust circumstance. But there could be long-term effects as well that outweigh the short-term gains.

This kind of approach can damage the career in the long run. The lack of effort and interest may be seen by employers, which may reduce chances of getting a raise, getting promoted, or even losing the job. This may put people in a downward spiral of limited, minimal income and slow professional progress.

Even if this type of action may seem reasonable to some employees, others may see them as passiveness or a lack of professionalism. Their reputation may suffer because of applying

this type of strategy, making it more difficult for them to grow and advance in their current position or locate better prospects elsewhere.

Especially while looking for new employment, their professional reputation is quite important. A reputation for putting in the bare minimum might harm their network and result in bad references, which can limit their options in the future.

Regularly performing the bare minimum can result in a reduction in one's sense of fulfilment and self-worth (Miner, 2005). Additionally, it could encourage a pessimistic outlook that lets them feel stuck and unsatisfied with their job, which can affect other aspects of their life.

Taking a doing the bare minimum approach can have a detrimental effect on employees' mental health and eventually cause emotions of exhaustion, regret, and stagnation.

4. The macroeconomics that results from doing the "bare minimum"

Adopting the "bare minimum" approach at work can have a few negative implications on an individual, in the long term it can result in several detrimental effects on mental health, even while at first it could appear like a solution to lessen stress or prevent burnout.

When someone does the bare minimum, they might not feel challenged or involved in their work, which might leave them feeling empty or unfulfilled, this can eventually lead to a feeling of meaninglessness and a decline in work satisfaction. Their work may feel uninteresting due to a lack of variation or challenge, which can lead to boredom and a lack of drive, both of which can worsen mental health.

Workers who put in minimal effort may be concerned about their job security, believing that their lack of effort will be exposed and may result in disciplinary actions or unemployment, leading to anxiety and tension because of this persistent concern. When one does the bare minimum, they frequently put off work until the last minute, which can lead to a vicious cycle of stress and procrastination as deadlines get near.

Making little to no effort might make people feel guilty or inadequate because they think they are falling short of their potential and that can feel like they are disappointing themselves and other people. Self-esteem may be badly impacted by this.

A common consequence of doing the absolute minimum is skipping out on extra chores, responsibilities, or team activities, which can cause social isolation at work and create an unbalanced work environment for everybody involved. This can be seen as poor-quality selfish type of behaviour among coworkers, since a lot of extra work activities will fall on them to complete, rather to be shared with everybody else so there will be no overload of work.

A disengaged approach has the potential to further separate people from the fulfilling aspects of their work, which can leave them feeling purposeless and disconnected from the objectives or core values of the organization.

Those who are performing the bare minimum may feel left behind as others advance or take on new responsibilities, which can exacerbate feelings of inadequacy and contribute to concern about their professional trajectory, making them feel even more unhappy with their life and work quality.

The bare minimum approach can paradoxically induce burnout even though it may appear to be a means of preventing it. An alternative type of burnout that is marked by cynicism, a sense of inefficacy, and emotional tiredness can result from a lack of involvement, purpose, and fulfilment.

It can be cognitively taxing to constantly try to accomplish as little as possible, avoiding chores or duties, which over time can cause a sensation of exhaustion, fatigue and depression.

A person's work frequently plays a big role in defining their identity and people who always perform the bare minimum may experience identity and self-worth issues, wondering about their worth and purpose outside of the job. The bare minimum technique can lead to internal conflict and feelings of discontent and a separation from their sense of self if the work they accomplish is not in line with their personal beliefs or ambitions.

Those who stick to the bare minimum may eventually come to regret not making the most of their abilities or following their goals, resulting in long-term discontent and psychological anguish. Some may feel guilty if their lack of effort has a negative effect on their team or place of employment. Guilt can exacerbate stress and anxiety symptoms.

The phenomenon of doing the bare minimum can be attributed to a complex interaction between psychological elements such as organizational culture, motivation, burnout, and shifting cultural ideals. It takes a sophisticated grasp of these underlying psychological factors as well as a dedication to creating healthier, more enjoyable workplaces to address the issue.

A sustainable plan would be for people to look for strategies to pursue growth both personally and professionally, equilibrium as well as more meaningful work-life connections (Bodislav, 2011).

While doing the bare minimum at work might seem like a personal decision, the cumulative impacts can have long lasting major consequences for public services, innovation, workplace culture, social equality, economic growth, and general societal well-being.

Overall productivity can drop when a significant percentage of the workforce performs at minimum capacity. This lower productivity can impede economic expansion and impede innovation, both of which are essential for the evolution of society. Businesses may see a decline in market share, decreased profitability, and even job losses if workers' lack of effort causes them to become less competitive, which could have an impact on the overall economy.

A culture where doing the bare minimum becomes acceptable can spread, resulting in a widespread decline in work ethic and motivation across the workforce. This may reduce the sense of accomplishment that comes from meaningful work as well as overall

satisfaction with work. Workers who do the bare minimum may contribute less to team projects, which might harm teamwork and possibly cause resentment or conflict among coworkers who now have to bear even more responsibility, causing them to feel overload with work, creating conflict in the workspace and therefore, an unbalanced, negative work environment.

Innovation frequently demands going above and beyond the call of duty, whether it is through initiative, innovative problem-solving, or fresh idea proposal. A workforce that just concentrates on the bare minimum is less likely to push for innovation, which may block advancement across a range of sectors and industries. In sectors like healthcare, education, and public services, doing the bare minimum can delay necessary improvements and reforms, which will lower the quality of vital, critical services.

If the majority of workers are satisfied with doing the bare minimum, wages may stall, being that it's possible for employers to see no reason that it's necessary to provide raises or better working conditions considering the low quality of interest given by the employees for their job, which will lower their overall living standards and eventually add to income inequality.

Employees who work less may lose out on opportunities for growth, which could cause the divide between highly and lowly motivated workers to grow, this may eventually lead to a more stratified workforce in which only a small percentage of workers benefit from opportunities for advancement.

Doing the bare minimum can result in a drop in the quality of services offered to the public in public sectors such as healthcare, education, and government, which can have a detrimental effect on the well-being of society.

The public's trust in institutions can be damaged by a culture that places less emphasis on providing basic services and offer less and less quality in their services, which can make people more disengaged or doubtful.

Complex issues like environmental sustainability call for proactive measures and going above and beyond the bare minimum. Missed opportunities to stop climate change, secure natural resources, and advance long-term environmental health can result from a lack of effort and interest in these areas.

In a number of businesses, cutting corners may compromise ethical standards and result in inferior quality goods, services, or operations that could harm consumers or the environment.

5. Harmful minimalism vs. Constructive minimalism – social media' manipulative trend

It would be more beneficial to discuss salary openly with the employer if low pay is the problem. Looking at and being interested in possibilities for professional growth or more responsibility, which could result in a rise in salary, is also a good quality measure.

Taking advantage of the chance to learn new skills or obtain certifications that could open doors to a better-paying position or promotion rather than giving up is a good measure to apply. This proactive strategy might bring a feeling of accomplishment and a feel of more control career wise.

Looking for other options where work will be adequately compensated if the money is inadequate may be more empowering and, in the end, result in greater work satisfaction.

Finding a balance that allows to preserve mental health and professional integrity is just as crucial as maintaining fairness in efforts in relation to pay. Giving it all while operating within the constraints of a difficult circumstance can be more rewarding and may lead to better possibilities.

Low pay can certainly be a real source of dissatisfaction, but using it as an excuse to do the bare minimum might have unfavourable long-term effects, not just on personal life but on society as well. A more positive strategy could involve looking for better chances, learning new skills, or negotiating for fair compensation, all of which can result in increased job satisfaction and advancement.

The idea of minimalism is frequently praised for emphasizing effectiveness, simplicity, and getting rid of excess. But minimalism can take two different forms in the workplace: harmful minimalism and productive minimalism. Disengagement and a lack of effort are traits of harmful minimalism, which can jeopardize important functions and have negative repercussions on society (Bodislav, Georgescu, 2023; Bodislav, et al., 2023). Constructive minimalism, on the other hand, places an emphasis on productivity and work-life balance while making sure that important activities are completed to the highest standards and that societal demands are satisfied.

Employees who practice "doing the bare minimum" as a way to disconnect from their work rather than using it as a productivity strategy are guilty of harmful minimalism. This type of minimalism can often be caused by burnout, discontent, or a lack of drive. Even though it could give the person momentary relief, it can have negative effects on society and organizations.

Harmful minimalism can have disastrous effects in fields like public safety, healthcare, and education where attention to detail, precision, and dedication are essential. For example, the quality of treatment declines and patient risks may increase if the healthcare personnel carry out the bare minimum of responsibilities without pushing the extra mile to guarantee patient comfort and safety.

Harmful minimalism can damage company culture, which can set off a downward spiral of employee dissatisfaction and low morale. When workers see their colleagues working as little as possible, it might set the tone for minimal effort, which lowers overall productivity and creativity. This culture of disengagement has the potential to spread, increasing turnover rates, making it harder to find talent, and generally decreasing the effectiveness of the company.

Harmful minimalism can erode public trust and social institutions to a greater extent. When important societal functions are jeopardized by disengagement, communities are affected.

For instance, if social workers, emergency responders, or public employees take a minimalist approach, the standard of public services suffers, and people lose faith in these organizations (Georgescu, et al., 2021). Because individuals who depend on these services are frequently the most vulnerable, over time this can weaken social structures and promote inequality.

Constructive minimalism is an approach that prioritizes productivity, efficiency, and work-life balance without sacrificing the standard of the job or the demands of society. It involves establishing priorities for work, limiting off unnecessary tasks, and concentrating on what really counts. This kind of minimalism focusses on doing more with less, maximizing effect while preserving wellbeing, rather than doing less for the sake of doing less.

Constructive minimalism pushes employees to cut out unnecessary procedures and distractions in favour of essential quality work. Employees can accomplish more in less time by prioritizing high-impact tasks and optimizing procedures. This strategy is especially helpful in fields like technology, research, and entrepreneurship where creativity and flexibility are essential. Reducing unnecessary effort allows staff members to focus more on strategic and creative thinking, which promotes advancement and innovation.

Constructive minimalism's emphasis on work-life balance constitutes one of its most important advantages. By emphasizing productivity and eliminating unnecessary work, employees can accomplish their career objectives and yet make time for their families, personal interests, and relaxation. Maintaining this balance is essential for long-term health and can help avoid burnout, which can result in more sustainable career trajectories and greater job satisfaction all around. Businesses that embrace constructive minimalism frequently witness decreased employee attrition, increased engagement, and a happier work environment.

The high standard of the work is never compromised by constructive minimalism. Rather, it guarantees the efficient execution of necessary tasks and the satisfaction of society's needs. For instance, a constructively minimalist strategy in the healthcare industry would entail automating repetitive chores with technology so that medical staff can focus more on patient care. To ensure that students obtain a high-quality education while avoiding burnout, educators may choose to concentrate on the most effective teaching strategies (Georgescu, 2023).

In the workplace, minimalism can take the form of either productive efficiency or detrimental disengagement. Constructive minimalism provides a route to increased productivity, work-life balance, and long-term success, but harmful minimalism puts vital functions, workplace culture, and society well-being at risk. Organizations may profit from the benefits of minimalism while avoiding its drawbacks by creating an atmosphere that promotes efficiency without sacrificing quality. This well-rounded strategy guarantees that people can complete their personal and professional goals, innovation flourishes, and social needs are satisfied.

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Assessing the nexus between market openness and economic growth: an emerging market perspective

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Abstract. *The countries with greater economic freedom are believed to have higher economic progress. Over the last two decades, researchers have focused on the impact of institutional quality on economic development of a country but not much insights are drawn about the individual components of economic freedom. The present study addresses this gap by assessing the impact of market openness on economic growth of the emerging economies, the BRICS bloc for the period 1995-2019 using Feasible Generalized Least Squares method. Our panel data analysis revealed a new evidence suggesting a negative impact of the sub-components of market openness on economic growth.*

Keywords: economic freedom, market openness, gross domestic product, panel data, BRICS.

JEL Classification: J43, C33.

Introduction

Assessing the impact of institutional quality of a country on its economic development has emerged as a significant area of research over the past two decades. Economists across the globe have a consensus that economic freedom is a significant factor that determines a country's institutional quality. The cross-country differences in the economic growth can be well understood by the difference in the levels of economic freedom achieved by the countries. The measurement of economic freedom has been a problem for a long period of time because of the absence of a formal definition of economic freedom and lack of data. However, the two institutions namely Fraser Institute and Heritage Foundation have solved this problem in the last two decades by providing the data for the economic freedom variable in a comprehensive manner. A good number of research studies along with several others have focused on the overall index of economic freedom and growth which failed to provide deeper insights on the relationship between the two variables as economic freedom constitutes the different sub-components viz., market openness, regulatory efficiency, rule of law and government size. The present study focuses on one important component of economic freedom, that is, market openness which constitutes trade freedom, investment freedom and financial freedom.

The research objective of the study aims at addressing the important question of whether a liberalized trade and investment regime coupled with a well-developed financial system exerts a significant effect on growth in the emerging market economies. BRICS economies, considered to be the representative developing countries, make an interesting case for this study as these countries have made tremendous efforts towards liberalization in trade and investment related aspects. The study found a significant negative impact of market openness on the economic growth of BRICS countries. The findings from the study serve as a caution to policymakers not to strive towards higher level of economic freedom without ascertaining the impact of the sub-components of economic freedom on growth.

Review of literature

Over the past two decades, economic freedom gained prominence in the economic growth literature due to its perceived role in a country's economic development. Researchers have tried to address the question whether economic freedom contributes to the economic growth of a country or not. A country progresses economically when it has different sorts of freedom like freedom in choice of resources, protection of property rights, engaging freely in trade among others (North & Thomas, 1973). In this section, the literature focused on the economic freedom-growth nexus has been reviewed thoroughly. The relevant key words have been used to source research papers suitable to the purpose of our study using several databases like Science Direct, Taylor and Francis, Emerald, Sage Publishers and Google Scholar.

As stated earlier, the studies assessing the relationship between economic freedom and growth have largely used the overall index for measuring economic freedom. A good

number of researchers have found a strong economic freedom-growth nexus using various samples of developing and developed countries (Spindler & Miyake, 1992: pp. 230-254; de Vanssay & Spindler, 1994: pp. 359-372; Dawson, 1998: pp. 603-619). Economic freedom was found to be a key driver of growth (de Haan, Lundstrom & Sturm, 2006: pp. 157-191; Berggren & Kurrild-Klitgaard, 2004; Berggren, 2003, pp. 3-41). The extensive review of literature conducted by (de Haan *et al.*, 2006: pp. 157-191) on the relationship between economic freedom and growth revealed a significant positive impact of freedom on growth. Some studies have tried to assess whether economic freedom exerts a direct impact on growth or indirectly through some channels. (Paakkonen, 2010: pp. 469-479) argued that economic freedom does not affect growth directly but indirectly through investment. However, (Gwartney, Holcombe and Lawson, 2004: pp. 205-233) found that economic freedom affects growth both directly as well indirectly. They held that countries having relatively higher freedom attain more investments and thus greater productivity gains from such investments. (Dawson, 1998: pp. 603-619) and (Gwartney, Holcombe and Lawson, 2004: pp. 205-233) confirmed the same in their empirical studies. The focus of research in this domain has also extended to address the question of whether the level of economic freedom or change in economic freedom exerts an impact on growth. Given such focus, (Dawson, 2003: pp. 479-495) observed a unidirectional causality running from level of economic freedom to growth, however, the bidirectional causality was found between change in economic freedom and growth. In addition to this, several other studies argued that the relationship between change in economic freedom and growth is stronger compared to the one between level of economic freedom and growth (Sturm & de Haan, 2001: pp. 839-844; de Haan *et al.*, 2006: pp. 157-191; Ashby & Sobel, 2008: pp. 329-346).

Since the greater portion of growth literature in this direction is focused mainly on the impact of an overall index of freedom on growth, much deeper insights have not been gained on the subject. The study conducted by (Carlsson and Lundstrom, 2002: pp. 335-344) revealed that economic freedom-growth nexus is largely contingent upon the sub-components of economic freedom. While assessing the freedom-growth nexus, (Justesen, 2008: pp. 642-660) argued that some components of freedom like size of government and regulatory policy framework exert a strong positive influence on economic growth whereas the other components do not have a significant impact on growth. More emphasis was thus laid on analyzing the relationship between the sub-components of economic freedom and growth. It has been found by several researchers that some components of economic freedom have a greater impact on growth compared to others (Heckelman & Stroup, 2000: pp. 527-544; Heckelman, 2000: pp. 71-91; Berggren & Jordahl, 2006: pp. 141-169; Ayal & Karras, 1998: pp. 327-328). Therefore, it becomes imperative to assess the influence on individual components of economic freedom on the economic growth to gain a deeper understanding in this regard. Against this backdrop, we aim at assessing the impact of market openness (a component of economic freedom) on growth in this study. We find it interesting to study the relationship between market openness and growth in the fastest emerging market economies, that is, the BRICS countries which have made good progress towards openness of their markets in terms of trade and investment related aspects.

Materials and methods

The present study uses secondary data over the period 1995-2019. The data for Gross Domestic Product growth (proxy for economic growth) has been taken from the World Investment Reports given by World Bank and UNCTAD. The data for market openness variable has been taken from the Heritage Foundation. Heritage foundation releases data annually for all the sub-components of economic freedom variable. In this study, we aim at examining the impact of the 3 components of market openness viz., trade freedom, investment freedom, financial freedom on growth of BRICS countries. The dependent variable (DV) is GDP growth and independent variables for the study are trade freedom, investment freedom and financial freedom. Since the data is panel in nature, we use panel data methods for analyzing our data. The equation that specifies our model is as follows:

$$GDPG_{i,t} = \beta_{1i} + \beta_2 TF_{i,t} + \beta_3 IF_{i,t} + \beta_4 FF_{i,t} + u_{i,t}$$

where:

GDPG = gross domestic product growth;

TF = trade freedom;

IF = investment freedom;

FF = financial freedom and $u_{i,t}$ is the error term.

First and foremost, we begin our econometric analysis by conducting the unit root test so as to ascertain if our variables are stationary or not. The unit root test (LLC) suitable for panel data analysis proposed by Levin, Lin & Chu (2002) has been used in this study. It tests the hypothesis of whether panels contain a unit root or not. After the unit root test is conducted, the data is subjected to panel data regression analysis. The main models used for panel data analysis are Pooled Ordinary Least Squares (POLS) regression, Least Squares Dummy Variable model (LSDV), Fixed Effects (FE) and Random Effects (RE) models. The simplest of all the models used for panel data analysis is Pooled Ordinary Least Squares (POLS) regression assuming no cross-sectional differences (Asteriou and Hall, 2007). LSDV model assumes slope to be constant and intercept to vary. Fixed effects (FE) model allows data transformation within the groups (Brooks, 2008). In this model, the dependent and explanatory variables are shown as deviations from mean (Gujarati and Porter, 2009). Random effects model assumes an intercept arising from a common intercept, β_1 and a random variable, ε_i which remains constant over time but varies across cross-sections (Brooks, 2008). We use model selection criteria to evaluate the different panel data models. F-test is used to evaluate pooled ordinary least squares regression against LSDV model and Breusch-Pagan Lagrange Multiplier (LM) is used to evaluate random effects model against pooled ordinary least squares regression model (Breusch and Pagan, 1980: pp. 239-253). Hausman test is applied to evaluate fixed effects model against random effects model (Hausman, 1978: pp. 1251-1271).

Finally, the assumptions of classic linear regression model like serial correlation, cross-sectional dependence and heteroscedasticity are checked using appropriate diagnostic tests before the final model is used to achieve the research objective.

Results

1.1. Summary Statistics

Descriptive/summary statistics is conducted to check the behavior of data. The two descriptive measures that we used in our panel data study are mean and standard deviation. The mean of dependent variable, that is, GDP growth is 4.65 and the standard deviation of the same is 3.83 (Table 1). The mean of independent variables namely trade freedom, financial freedom and investment freedom is 59.39, 42.64 and 43.68 and the standard deviation is 17.4 for trade freedom (TF), 13.1 for investment freedom (IF) and 12.3 for financial freedom (FF).

Table 1. *Descriptive Statistics*

Variables	N	Mean	Std. Deviation
DV			
GDPG	125	4.65	3.83
IV			
Trade Freedom	125	59.39	17.41
Investment Freedom	125	43.68	13.12
Financial Freedom	125	42.64	12.32

1.2. Correlation Analysis

The results of correlation analysis reveal that there exists a significant negative correlation between the components of market freedom, viz trade freedom, financial freedom and investment freedom and GDP growth, which contrasts with some earlier studies (Barro, 1991: pp. 407-443; de Vanssay & Spindler, 1994: pp. 359-372) as shown in Table 2.

Table 2. *Correlation between DV and IV*

Variables	GDPG	Trade Freedom (TF)	Investment Freedom (IF)	Financial Freedom (FF)
GDPG	1.000			
TF	-0.278 (0.0017)	1.000		
IF	-0.349 (0.0001)	-0.2063 (0.0210)	1.000	
FF	-0.4833 (0.000)	0.2052 (0.000)	0.6351 (0.0217)	1.000

1.3. Stationarity (LLC unit root) test

Using Levin-Lin-Chu unit root test to check the presence of unit root in our panel data series, we found that that both dependent and explanatory variables are stationary at level and do not have a unit root (Table 3).

Table 3. *LLC Unit Root test*

Variables	LLC Unit Root Test		
	Stationary At	T-Stat	P-Value
GDPG	Level	-2.226	0.0130
Trade Freedom	Level	-3.55	0.0002
Financial Freedom	Level	-1.77	0.038
Investment Freedom	Level	-2.871	0.0020

1.4. Panel Data Analysis

1.4.1. Panel Data Regression Models

The four panel data models discussed in methodology section compared against each other using model selection criteria. We run all these models but after selection of final panel data model only can we interpret the results.

Table 4. Results of Panel Data Analysis

	Pooled OLS	Fixed Effects LSDV	Fixed Effects (within)	Random Effects
VARIABLES	GDPgrowth	GDPgrowth	GDPgrowth	GDPgrowth
TF	-0.0582 (0.0376)	-0.0190 (0.0211)	-0.0190 (0.0211)	-0.0220 (0.0206)
IF	-0.0643 (0.0502)	-0.00625 (0.0333)	-0.00625 (0.0333)	-0.0108 (0.0326)
FF	-0.0901*** (0.0171)	-0.0586* (0.0313)	-0.0586* (0.0313)	-0.0613** (0.0308)
2.id		5.440*** (1.066)		
3.id		2.858** (1.097)		
4.id		-0.427 (0.906)		
5.id		0.711 (0.826)		
Constant	14.76** (3.977)	6.837** (2.843)	8.554*** (2.479)	9.048*** (2.871)
Observations	125	125	125	125
R-squared	0.290	0.515	0.039	
Number of id			5	5

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Evaluation of panel data models

F-test (Table 5) has been used to see if fixed effects model is appropriate or Pooled OLS model, the results suggest fixed effects model to be more suitable in comparison to OLS regression model and the results of Breusch Pagan LM test (Table 5) found random effects model to be more appropriate than the pooled OLS regression model. Finally, we conduct the Hausman test to see if fixed effects model is better than random effects model or not and results (Table 6) found that Random effects (RE) model is better.

Table 5. F-test and LM Test

Models	Tests	Model: GDPG (DV) TF, FF, IF (IV)	Decision
Fixed versus OLS	F-test P-value	13.6* 0.000	Rejection of null hypothesis (H ₀)
Random versus OLS	LM test P-value	93.52* 0.000	Rejection of null hypothesis (H ₀)

* Significant at 1%

Table 6. *Hausman Test*

	Coefficient
Chi-sq. value	0.54
P-value	0.909

1.5. Diagnostic tests

Before interpretation of results from RE model, it is important to check the model for assumptions of classic linear regression.

Wooldridge autocorrelation test is conducted to check if the model is free from the problem of serial correlation. The results from Table 7 reveal that the hypothesis of no serial correlation is rejected which means that the model suffers from the problem of serial correlation.

Table 7. *Wooldridge Autocorrelation test*

Ho: there exists no autocorrelation	
F(1, 4)	37.92*
Probability > F	0.0035

*Significant at 1%

It is important that the residuals should not be correlated with each other. In this regard, Pesaran's cross sectional dependence test the results of which reveal that the model suffers from the problem of cross sectional dependence (Table 8).

Table 8. *Pesaran's CD (Cross Sectional Dependence) Test*

Ho: Residuals are not correlated cross sectionally	
Pesaran's Statistics	4.55*
P-value	0.000

*Significant at 1%

Wald's group-wise heteroscedasticity test indicates that our model suffers from the issue of heteroscedasticity as shown in Table 9.

Table 9. *Wald's Group-Wise Heteroscedasticity*

Ho: $\sigma_i^2 = \sigma^2$ for all i	
Chi-square (5)	3577.56*
Prob. > chi-square	0.0000

*Significant at 1%

1.6. Feasible Generalized Least Squares Model

Since RE model was found to be the most appropriate for our panel data analysis, however, the model suffered from the problems of serial correlation, cross sectional dependence and heteroscedasticity. To avoid misleading results obtained from running such model, it is recommended to conduct cross sectional time series Feasible Generalized Least Squares (FGLS) model the results of which are shown in Table 10.

Table 10. *Feasible Generalized Least Squares (FGLS) Regression*

DV: GDPG	Coeff.
TF	-0.0582*** (0.0189)
IF	-0.0643** (0.0318)
FF	-0.0901*** (0.0339)
Constant	14.76*** (1.573)
Observations	125
Number of id	5

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Discussion

It has been found that the independent variables viz. trade freedom, investment freedom and financial freedom have a significant negative impact on the GDP growth of BRICS countries. GDP growth decreases by 0.058 units due to 1 unit increase in trade freedom. Economic growth declines by 0.064 units for 1 unit increase in investment freedom and for same 1 unit increase in financial freedom, growth decreases by 0.09 units. Some researchers have found a positive impact of economic freedom on growth (Barro, 1991, pp. 407-443; de Vanssay & Spindler, 1994, pp. 359-372). However, it is important to decompose the overall index of economic freedom for revealing its growth performance as some sub-components of freedom exert a positive growth impact while others have a negative impact on growth (Carlsson & Lundstrom, 2002, pp. 335-344), thereby emphasizing the significance of analyzing the impact of individual components of economic freedom on growth to derive valuable insights for policy making.

Conclusion

For understanding the relationship between economic freedom and growth in a comprehensive manner, it is important to examine the impact of components of economic freedom on growth. Given such focus, we assessed the relationship between market openness (an individual component of economic freedom) and growth in the BRICS bloc, the emerging market economies, for the period 1995 to 2019 using FGLS model. A new evidence was found in our paper that market openness comprised of trade, investment and financial freedoms exerts a significant negative impact on the economic growth of BRICS countries. This contradiction to previous studies conducted in this regard which reveal a positive relationship between overall economic freedom index and growth makes it clear to policymakers that they should not only strive towards higher level of economic freedom without examining the impact of its sub-components on economic growth. The upcoming research in this direction should be focused on studying the impact of other individual components of economic freedom on the growth of emerging economies.

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The relationship between access to electricity, CO₂ emissions, and economic growth in BRICS

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Abstract. *This study examines the relationship between Access to Electricity, CO₂ Emission, and Economic Growth in BRICS. This study uses secondary data sourced from the World Bank with the period 2000 to 2021. The analysis technique in this study uses panel data regression and graanger causality. The conclusion of this study confirms that increased access to electricity has a significant impact on economic growth in BRICS countries. Strong investment in energy infrastructure, including efforts to expand access to electricity, has proven to encourage sectors of the economy that rely on reliable energy.*

Keywords: access to electricity, CO₂ emission, economic growth, BRICS.

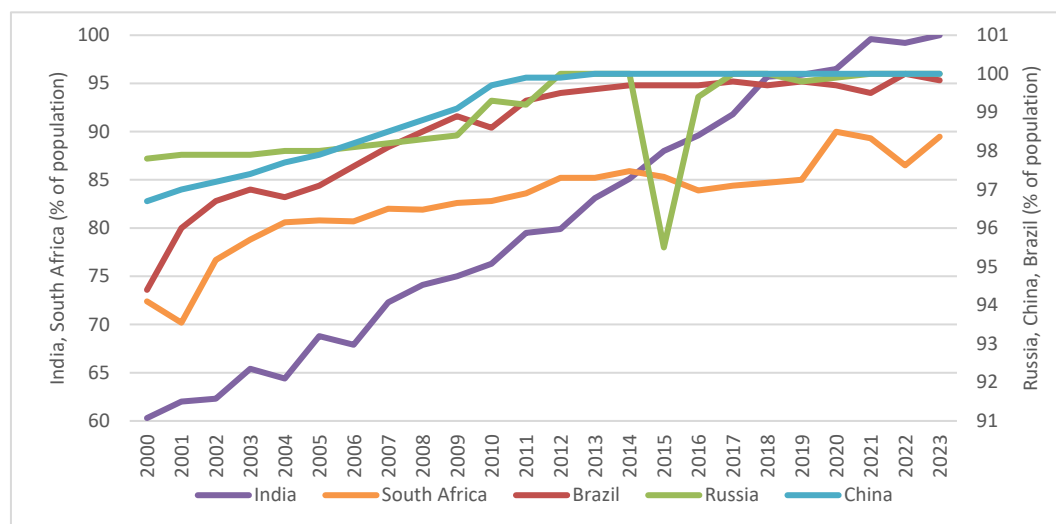
JEL Classification: O44, Q53.

1. Introduction

The BRICS, which consists of Brazil, Russia, India, China, and South Africa, is a group of countries with significant economic influence in the world (Lumumba-Kasongo, 2015). Since its inception, BRICS has been the center of attention in many economic, environmental, and energy-related research. These countries have an important role in the global economy, not only because of their large populations but also because of their rapid economic growth and abundant natural resources (Danish et al., 2019). One of the important aspects of economic development is access to electricity, which is the foundation for the development of industry, education, health, and daily life (Burke et al., 2018). On the other hand, increased economic activity is often accompanied by an increase in CO₂ emissions, which has an impact on global climate change.

Access to electricity is an important indicator of a country's infrastructure development and quality of life (Ahlborg et al., 2015). In BRICS countries, increased access to electricity has become a priority to support economic development and improve the quality of life (Gu et al., 2018), reflected in Figure 1. Adequate access to electricity allows for increased industrial productivity, increased efficiency in the agricultural sector, and expanded access to education and health services (Riva et al., 2018). However, the supply of electricity is often linked to the burning of fossil fuels that produce CO₂ emissions (Shahsavari & Akbari, 2018). CO₂ emissions are a major concern because of their contribution to global warming and climate change.

Figure 1. Access to Electricity in BRICS



Source: World Bank, data processed, (2024)

Sustainable economic growth in BRICS countries is the main focus in achieving various Sustainable Development Goals (SDGs) (Ali et al., 2018). The SDGs emphasize the importance of inclusive and sustainable economic growth, which supports the creation of decent jobs (SDG 8), reduces economic inequality (SDG 10), and improves access to basic services such as education and health (SDG 3). However, rapid economic growth is often

accompanied by environmental challenges, especially greenhouse gas emissions such as CO₂ (Liu et al., 2019). An uncontrolled increase in CO₂ emissions can lead to negative impacts on the environment, such as rising global temperatures, changing weather patterns, and an increase in the incidence of natural disasters (Rajak, 2021). Therefore, understanding the relationship between access to electricity, CO₂ emissions, and economic growth is crucial to formulating sustainable policies.

Research on the relationship between access to electricity, CO₂ emissions, and economic growth in the BRICS has very important relevance in today's global context. First of all, access to electricity plays a crucial role in economic and social development, affecting people's productivity, health, and education. However, this increased access often impacts CO₂ emissions, which are a major contributor to global climate change and environmental balance. This study not only explores the causal dynamics between these variables through the panel data regression method, but also uses the Granger causality approach to understand the direction and strength of the relationship between them empirically. The contribution of this research lies in developing a theoretical and empirical understanding of how energy and economic policies can be designed to achieve sustainable economic growth while reducing negative environmental impacts. The results of this study are expected to provide guidance for policymakers in formulating sustainable development strategies in BRICS countries and around the world.

2. Data and Methods

This study examines the influence and causality relationship between access to electricity, CO₂ emissions, and economic growth, the operational definition of the variable is described in Table 1. This study uses BRICS, namely Brazil, Russia, India, China, and South Africa as the research population. This study uses a type of secondary data taken from the World Bank with the period 2000 to 2023. The analysis technique in this study uses the panel regression described in equation 1.

$$EG_{it} = \beta_0 + \beta_1 ATE_{it} + \beta_2 CO2_{it} + \varepsilon_{it} \quad (1)$$

GDP is the real GDP per capita for economic growth; CO₂ emissions measured by CO₂ emissions (metric tons per capita); ATE is access to electricity; i is cross section; t is the time series; and e is the error term.

This study uses a panel data regression method, considering three different approaches: the Common Effects Model (CEM), the Fixed Effects Model (FEM), and the Random Effects Model (REM). Next, to choose the best method between the three using the chow, hausman, and lagrange multiplier tests.

Table 1. Variable Operational Definition

Variable	Description	Source
Economic Growth	GDP per capita, PPP (current international \$)	World Bank
Access to electricity	Access to electricity (% of population)	World Bank
CO ₂	CO ₂ emissions (metric tons per capita)	World Bank

Source: Author Compilation, (2024)

The analysis technique in this study also used Pairwise Dumitrescu Hurlin Panel Causality Tests type granger causality panels. The model of the granger causality equation is described as follows:

$$\Delta EG_{it} = \beta_1 + \beta_2 \Delta EG_{it-1} + \delta ATE_{it} - 1 + \sum_{i=1}^m \alpha_i \Delta CO_2_{it-1} + \varepsilon_{it} \quad (2)$$

$$\Delta ATE_{it} = \beta_1 + \beta_2 \Delta ATE_{it-1} + \delta EG_{it} - 1 + \sum_{i=1}^m \alpha_i \Delta CO_2_{it-1} + \varepsilon_{it} \quad (3)$$

$$\Delta CO_2_{it} = \beta_1 + \beta_2 \Delta CO_2_{it-1} + \delta EG_{it} - 1 + \sum_{i=1}^m \alpha_i \Delta ATE_{it-1} + \varepsilon_{it} \quad (4)$$

Equation (2) tests whether changes in access to electricity (ATE) and changes in CO₂ (CO₂) emissions affect economic growth (EG). Equation (3) tests whether changes in economic growth (EG) and changes in CO₂ (CO₂) emissions affect access to electricity (ATE). Equation (4) tests whether changes in economic growth (EG) and changes in access to electricity (ATE) affect CO₂ (CO₂) emissions. Overall, the Granger causality model aims to identify whether changes in one variable can be used to predict changes in other variables by taking into account time lag. It is important to understand the causal dynamics between access to electricity, CO₂ emissions, and economic growth in BRICS countries.

3. Results and Discussion

3.1. Model Selection

Table 2 shows the results of the best model selection test using the Chow Test and the Hausman Test. In the Chow Test, a probability value of 0.000 indicates that the Fixed Effect (FEM) model is better compared to the Pooled OLS model, with a significant result at a significance level of 1%. Similarly, in the Hausman Test, a probability value of 0.000 indicates that the Fixed Effect (FEM) model is more suitable compared to the Random Effect (REM) model, with a result that is also significant at a significance level of 1%. Therefore, these two tests consistently indicate that the Fixed Effect model is the best choice for this data analysis.

Table 2. Best Model Selection Test

Test	Prob	Selected Methods
Chow Test	0.000	Fixed Effect Model
Hausman Test	0.000	Fixed Effect Model

Source: Author Calculation, (2024)

Table 3 shows the regression results of panel data with dependent variables of economic growth plotted by GDP per capita, as well as independent variables of CO₂ emissions and access to electricity (ATE). Constant (C) has a coefficient of 5.003619 and is significant at a significance level of 1%, indicating that the base value of GDP per capita is 5.003619 when the other independent variables are zero. CO₂ emissions (CO₂) have a coefficient of 0.309066 and are significant at a significance level of 1%, indicating that every increase in CO₂ emissions will increase GDP per capita by 0.309066 units, ceteris paribus. Access to electricity (ATE) has a coefficient of 0.027198 and is also significant at a significance level of 1%, suggesting that every increase in access to electricity will increase GDP per capita by 0.027198 units, ceteris paribus. Overall, the results of this regression show that both

CO₂ emissions and access to electricity have a positive and significant effect on economic growth as measured by GDP per capita.

Table 3. Panel Data Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.003619	0.319956	15.63845	0.0000
CO ₂	0.309066	0.024264	12.73766	0.0000
ATE	0.027198	0.003595	7.565455	0.0000
C	5.003619	0.319956	15.63845	0.0000
Cross Section Effect				
Brazil	1.194258			
Russia	-1.291271			
India	0.779205			
China	-0.467071			
South Africa	-0.215121			
R-squared	0.878589	Mean dependent var		9.268153
Adjusted R-squared	0.872143	S.D. dependent var		0.665019
S.E. of regression	0.237792	Akaike info criterion		0.021720
Sum squared resid	6.389574	Schwarz criterion		0.184323
Log likelihood	5.696827	Hannan-Quinn criter.		0.087754
F-statistic	136.2874	Durbin-Watson stat		0.128434
Prob(F-statistic)	0.000000			

Source: Author Calculation, (2024)

The regression results show an R-squared value of 0.878589, which means that 87.86% of the variation in GDP per capita can be explained by this model. An adjusted R-squared of 0.872143 indicates a good adjustment for the number of independent variables in the model. The standard error of regression (S.E. of regression) of 0.237792 indicates the accuracy of the model's prediction. An F-statistic of 136.2874 with a probability of 0.000000 indicates that the model as a whole is significant at a significance level of 1%.

The regression results with the Fixed Effect (FEM) model provide insight into the unique variation between the BRICS countries (Brazil, Russia, India, China, and South Africa) in their contribution to GDP per capita, after taking into account independent variables such as CO₂ emissions and access to electricity. The cross-section effect in this model shows specific values for each country, reflecting different structural characteristics and economic conditions. Brazil has a positive cross-country effect of 1.194258, which suggests that specific factors in Brazil make a significant positive contribution to GDP per capita, beyond the influence of independent variables. In contrast, Russia showed a negative cross-country effect of -1.291271, indicating that specific factors in Russia have a negative impact on GDP per capita. India, with a cross-country effect of 0.779205, showed a positive contribution of its unique factors, while China, with a cross-country effect of -0.467071, and South Africa, with -0.215121, showed the negative impact of their specific factors on GDP per capita.

3.2. Granger Causality Results

In the causality analysis using the homogeneity test, the findings showed a significant pattern of relationships between the variables in the model. In particular, the results show a strong two-way causal relationship between CO₂ emissions and GDP (Table 4). A significant probability indicates that changes in CO₂ emissions may affect changes in GDP,

and conversely, changes in GDP also affect CO₂ emissions. These findings are consistent with the literature highlighting the reciprocal relationship between economic growth and emission levels in a global context.

Table 4. *Granger Causality Results*

Null Hypothesis:	W-Stat.	zbar-stat.	Prob.
CO ₂ does not homogeneously cause GDP	4.81962	2.20235	0.0276
GDP does not homogeneously cause CO ₂	6.11509	3.31992	0.0009
ATE does not homogeneously cause GDP	5.12368	2.46466	0.0137
GDP does not homogeneously cause ATE	3.79925	1.32211	0.1861
ATE does not homogeneously cause CO ₂	2.23685	-0.02572	0.9795
CO ₂ does not homogeneously cause ATE	2.71113	0.38343	0.7014

Source: Author Calculation, (2024)

Furthermore, there is strong evidence for a one-way causal relationship of access to electricity (ATE) to GDP, with a probability of 0.0137 suggesting that increased access to electricity contributes positively to economic growth as measured by GDP. However, there is no evidence to suggest that economic growth significantly affects the level of access to electricity in this model (probability 0.1861).

However, in the relationship between access to electricity (ATE) and CO₂ emissions, as well as between CO₂ and ATE emissions, the findings suggest that there is no significant causal relationship. The high probability suggests that changes in access to electricity or CO₂ emission levels do not significantly affect each other within the framework of the tested model.

3.3. Discussion

The results of the analysis show that increased access to electricity (ATE) has a significant positive impact on economic growth, an important finding in the context of BRICS countries. The study supports previous findings suggesting that a strong energy infrastructure, including better access to electricity, can be a key driver for sustainable economic development (Bhattacharya et al., 2015); (Burke et al., 2018). Researchers have identified that among BRICS countries, there is variation in the level of access to electricity and its impact on their respective national economies. India and South Africa face greater challenges in improving access to electricity in rural or remote areas, affecting their potential to achieve more inclusive economic growth (Singh et al., 2015); (Almeshqab & Ustun, 2019). On the other hand, China has shown a strong commitment to energy infrastructure, including programs to expand access to electricity at large, which has contributed significantly to their economic growth in recent decades (Geng et al., 2016).

The importance of access to electricity is not only limited to increasing the productivity and competitiveness of industrial and service sectors, but also in creating conditions that support investment in technological and infrastructure innovation (Osano & Koine, 2015). At an increasingly connected global level, the ability to address inequalities in access to electricity between urban and rural areas, as well as between BRICS member countries, will be key to ensuring sustainable and inclusive economic growth in the future. Therefore, public policies that prioritize investment in energy infrastructure, including renewable

energy sources and energy efficiency, will play an important role in shaping the economic future of the BRICS countries and maintaining their global competitiveness.

In this analysis, the results show that increased CO₂ emissions have a significant impact on economic growth, an interesting finding to consider in the context of global economic development. In some countries, especially in the early stages of their economic development, increases in CO₂ emissions often occur in tandem with the growth of the industrial and infrastructure sectors, which in turn can provide an initial impetus for broader economic growth (Sarkodie et al., 2020). For example, in the industrialization phase, countries could experience a spike in CO₂ emissions as a result of energy-intensive manufacturing activities, which could ultimately contribute to GDP growth and job creation (Avenyo & Tregenna, 2022).

BRICS countries are major producers of global CO₂ emissions due to energy-intensive industrial activities and rapid infrastructure growth (Baloch et al., 2020). China, as the largest member of the BRICS in terms of population and economy, has experienced a significant spike in CO₂ emissions over the past few decades in line with its rapid economic growth (Fu et al., 2021). Increased CO₂ emissions in cases such as China and India are often closely linked to the growth of industries that utilize fossil resources to meet their energy and infrastructure needs. While this can provide an initial boost to economic growth through job creation, infrastructure development, and industrialization, its long-term impact can be a serious challenge. Climate change induced by CO₂ emissions can threaten environmental and social sustainability, affecting sectors such as agriculture, health, and critical infrastructure (Kumar et al., 2021).

The results of causality analysis show that in the context of BRICS countries, there is a complex pattern of relationships between CO₂ emissions, access to electricity (ATE), and economic growth (GDP). The findings show a strong two-way causal relationship between CO₂ emissions and GDP, confirming that an increase in CO₂ emissions can affect economic growth, and conversely, economic growth can also affect CO₂ emission levels over a period of time. Previous research such as that conducted by (Wang et al., 2016); (Mardani et al., 2019) has shown that rapid economic growth is often associated with increased CO₂ emissions, indicating a two-way relationship between these two variables at the global level.

In addition, there is a significant one-way causal relationship of ATE to GDP. These findings show that increased access to electricity contributes positively to economic growth in BRICS countries. Although the level of access to electricity still varies among these countries, efforts to improve its accessibility have proven to have a positive impact on the development of economic sectors that rely on reliable energy infrastructure. Research by (Javid et al., 2021) shows that increasing access to electrical energy in developing countries can improve people's productivity and quality of life, which directly supports inclusive economic growth.

However, the results of the analysis also showed that there was no significant causal relationship between CO₂ emissions and access to electricity in the BRICS countries. Although the link between CO₂ emissions and access to electricity has not been shown to

be causal significant in the context of BRICS, this study highlights the importance of reliable energy infrastructure in supporting sustainable economic growth. This is in line with environmental economics theory which emphasizes the importance of sustainability in the use of resources and energy policies to reduce the negative environmental impact of economic growth (Stern, 2019).

4. Conclusion

The study reveals that in the context of BRICS countries, increased access to electricity has a significant positive impact on economic growth. These findings suggest that investment in adequate energy infrastructure, including efforts to improve electricity accessibility, can spur sectors of the economy that rely on reliable energy. While there are still challenges in addressing unequal access to electricity in rural or remote areas, China has shown that its commitment to energy infrastructure can have a significant positive impact on its economic growth. The implication of this study is the need for public policies that focus more on the development of sustainable energy infrastructure, taking into account the variety of unique needs and challenges faced by each BRICS country.

To support inclusive and sustainable economic growth in the future, BRICS countries need to increase investment in renewable energy and energy efficiency. These measures will not only help reduce the negative impact on the environment, but also strengthen their economic competitiveness at the global level. Additionally, it is important to continue to conduct research and development in innovative energy technologies, which can help address energy infrastructure challenges and improve electricity accessibility at large. Thus, BRICS can play a more active role in achieving sustainable development goals globally, while maintaining a balance between dynamic economic growth and sustainable environmental protection.

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Social aspects of the informal economy: evidence from EU countries

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Abstract. *Constantly developing, the informal economy continues to find new areas and directions of expansion, leading states to a position of constant search for solutions to temper it. The agricultural sector, the social one, and the rural areas are analyzed in this paper in relation to the informal economy, for the EU member states (including United Kingdom), between 2004-2020. Results show that both agricultural labor and rural population influence the informal economy. On the contrary, there is an indirect relationship between social benefits and the informal economy. In addition, some concluding suggestions for possible future research areas are proposed.*

Keywords: informal economy, social benefits, agriculture, rural sector, panel regression.

JEL Classification: A13, C33, E26.

1. Introduction

The informal economy (or *shadow economy*, or *underground economy*) is widely believed to be one of the most significant factors that constrain revenue mobilization of a country. Tax revenues are vital when it comes to the sources of funding of states in their economic development. The informal economy may have direct negative effects on the level of tax revenues, and therefore, it is of great interest for the long-term financial sustainability of a state. The informal and formal segments are best understood as complementary, rather than separated.

The paper is structured as follows: the first section summarizes the literature review on the informal economy and its social determinants, the second section contains the data and the methodology, the third section includes the obtained results and their interpretation, the fourth section presents the case of Romania, while the last one discusses the conclusions and limitations of the study.

2. Literature review

Hereafter, we will provide a review of existing studies on the informal economy and its social determinants. The existing literature on the informal economy, tax evasion and tax avoidance show that there are two main components for the tax revenue losses in developing countries: a domestic and an international one. As for the domestic component, the informal economy includes tax evasion caused by domestic activities, while the international component covers the base erosion and profit shifting by companies and offshore financial holdings by private persons (Cobham, 2005; Schneider, 2005; Baker, 2005; Schneider et al., 2010). Regarding the domestic component, it is to be analyzed in relation to the agricultural sector, respectively, to the social and rural ones.

The domestic component also includes the social policy of the states and, implicitly, the social benefits that states provide in their public programs. Our literature review investigation on how social policies of a state influence tax compliance shows that this perspective on the society does represent a significant factor when it comes to paying taxes. In this regard, Androniceanu et al. (2019) found that there is interdependence between tax evasion, on the one hand, and social, cultural development, on the other hand. Furthermore, according to Schneider (2017), the areas in which the most recent cases of nondeclaration of work are found are: the construction sector, followed by the agriculture/gardening sector and repairing/selling vehicles.

However, when it comes to rural areas, a controversial subject, this influencing factor must be viewed considering a slower process of human and economic development (La Porta and Schleifer, 2014). People in rural areas are not familiar with the concepts of filing statements online, insofar as they are not connoisseurs of the legislation. For these reasons, the shadow economy is more widespread in rural areas due to low education levels, the community bond, well-established traditions, and the power of informal institutions.

Informality is a long-established tradition among members of rural communities. In rural areas, informal activities are the ones that uphold livelihoods of depleted populations

through natural resources and land-based economic activities such as agriculture, forest harvesting, and mining. However, as states evolved and developed as states evolved and developed, the practices taken up by people in rural areas began to interface with the measures and rules that urban markets provide. This led to a stage in which obsolete informality rooted in customary practices came to co-exist with formal rules (Weng, 2015).

In close connection with those mentioned above in the previous paragraph, we must also mention the concept of fiscal morality that rural populations have not experienced in customary practices. As for Kubakh (2021), states aim through their agriculture-related legislative regulations to decrease the informal transactions. Furthermore, Williams and Horodnic (2017) consider that to improve the level of the underground economy, improvement of the moral tax among the rural population must also be taken into account. Thus, corroborating the authors' conclusions, both in terms of moral tax and legislative areas, agriculture influences the level of the underground economy.

OECD (2009) provides worldwide data on the informal sector and states that the decision of people to work in the developing world in the informal economy is due both to the fact that they are left out of formal jobs and to the fact that they voluntarily choose not to be part of the official structures. The illegitimate economy is a source of financial support during unemployment periods for those genuinely wishing to participate in the formal economy.

Regarding social terms, the general morale of the tax in a specific country is determined by the citizens' expectations of being beneficiaries of public services (Ali et al., 2014). Therefore, taxes can be seen from the perspective of a relationship between the government and citizens offering the latter quality public services in order to comply with the payment of taxes (Paler, 2013).

3. Data and Econometric Methodology

To start with, following the theoretical observations in Section 2, we initiated the study starting from the following working hypotheses stated both on the expectations of the authors and on the conclusions of the literature review undertaken, hypotheses whose confirmation/refutation we will describe in detail.

H₁: The informal sector is negatively related to the size of *social protection benefits*.

H₂: The informal sector is positively related to the *rural population*.

H₃: The informal sector is positively related to *agriculture labor*, in terms of salaried citizens.

Through this approach, the authors bring an innovation to the literature because although social issues related to agriculture and the rural population have been previously addressed in specialized articles, they have not been reflected through the indicators used by the authors. Moreover, based on the searches undertaken by the authors, no articles were found that would analyze these variables in the same equation and for the member states of the European Union of the. Thus, the conclusions to be drawn, as well as the suggestions to be

made, are meant to be of great interest to policymakers who are in a constant search for methods of economic progress and decreasing the size of the informal economy.

In our study, we used a wide range of data that aim at the period 2004-2020, for the 28 EU Member States, including the United Kingdom. For this study, we also considered the United Kingdom, being a country that, although leaving the European Union in 2020, was under the aegis of the same European Union legal framework during the entire aimed period. Our expectation is that this number of observations will allow us to confirm or refute, as the case may be, the hypotheses stated above.

Based on our research and having in mind all the information previously presented, we estimated the following equation:

$$\text{InfEco} = \text{Rural_Pop}(-1) + \text{Agri_Lab}(-1) + \log(\text{Soc_Benefits}) + \text{Unemp/Gen_Debt} + c \quad (1)$$

The data on informal economy was provided by Medina and Schneider (2018) for the period 2004-2017 and the data for years 2018-2020 were estimated using the Box-Jenkins method (ARMA (1.1) model). This database provided by the authors has been used in countless studies (i.e., Dronca, 2016; Remeikien et al., 2021), both as a standalone variable representing the underground economy, but also as a proxy for tax evasion. Furthermore, this variable will be interpreted considering both approaches.

In the subsequent Table 1, we will present the dependent variable - informal economy - and the independent variables used, as well as the sources for our database.

Table 1. What are the variables considered?

Indicator	Meaning	Unit of measure	Source
Informal Economy (InfEco)	It means the parallel economy, including activities of production and provisions of services and goods that are not reported to the competent authorities, including underground activities, informal household, and tax evasion.	% of GDP	Medina and Schneider (2019)
Agricultural labor (Agri_Lab)	This index provides information on income in the agricultural sector. More broadly, it represents the aggregate number of hours worked as an employee or a self-employed person during the calendar year, when the output of this work is included in the output of the agricultural industry.	Index, 2010-100; Salaried Annual Work Units (AWUs)	European Commission (Eurostat).
Rural Population (Rural_Pop)	This indicator is estimated by the World Bank on the basis of the United Nations Population Division's World Urbanization Prospects.	% of the total population;	World Bank
Social protection benefits (Soc_Benefits)	It reflects the total expenditures of a country spent on social protection benefits.	Euro per inhabitant	European Commission (Eurostat).
Unemployment Rate (Unemp)	The index represents the unemployed population related to the entire labor force.	% of total labor force	World Bank
General Debt (Gen_Debt)	The index represents the rate of general government debt as a percentage of the gross domestic product, at the end of the year.	% of GDP	European Commission (Eurostat)*

* for United Kingdom, the results are provided by the International Monetary Fund (IMF);

Source: European Commission – Eurostat (2021), The World Bank (2021), IMF (2021), Medina and Schneider (2019).

As control variables, we used the unemployment rate and general debt. Dobre et al. (2010) suggested that a rise in the unemployment rate leads to a growth in the informal economy, as more individuals seek work in this sector. This finding is supported by Schneider (2011) and Medina and Schneider (2018). Our study confirms the results reported by these authors.

The variables were analyzed from a fixed and random effects perspective, using *Redundant Fixed Effects Tests* and *Correlated Random Effects - Hausman Test*. The results provided by the indicated tests are indefinite among the two varieties of effects; thereby, we estimated hereafter only the non-effects model specification as it is the most suitable to be used, according to the aforementioned tests. As for the verification using the robustness, for this study we used general debt as a control variable, and we estimated the regression also using the *Robust Least Squares* method.

Before discussing the results, we will point out the test results that have been applied. Thus, all data series were tested for root unit and for the presence of significant correlation using the Unit Root Test, the results indicating that the data series are stationary. As regards the correlation between the variables, the correlation matrix indicates that there is a small to medium correlation between the independent variables. The correlation indexes have values between (-0.75) to (+0.32) and indicate that they are supplementary metrics and that the informational content is not superfluous.

4. Results of the study

Based on the detailed steps and modeling procedures outlined earlier, the results of the analysis are summarized in *Table 2* below. This table provides a clear overview of the outcomes from the different analytical techniques and methodologies used in the study, reflecting the thorough data evaluation and model estimation processes undertaken.

Table 2. Estimation of the equation - results

	C	Rural_Pop	Soc_benefits	Agri_Lab (salaried)	Unemp	Gen_Debt
Coefficient	78.96625	7.387546	-6.773329	0.031639	0.198658	2.248874
t-Statistic	23.34316	5.348017	-25.65374	2.791024	4.529606	4.923926
Prob.	0.0000	0.0000	0.0000	0.0055	0.0000	0.0000
R-squared		0.668318				
Adjusted R-squared		0.665317				
F-statistic		222.6506				
Prob(F-statistic)		0.0000				

Source: own estimation.

As a first observation, our results confirm the assumptions made at the beginning. Specifically, the informal economy is indeed influenced by the rural population, social protection benefits, and the agriculture labor. Also, the expected results regarding the two control variables used, respectively, unemployment rate and general debt, are also confirmed in relation to the conclusions established in the literature and mentioned above.

In this paper, the rural sector is quantified in this paper by its population. According to the results obtained, the amplitude of the rural sector is positive linked to the informal economy, with a coefficient of 7.387546 (prob = 0.0000). This may be justified on the

grounds that, around their individual households, citizens in rural areas organize and carry out activities that, although according to the law, should be reported, by way of tradition or custom, have been practiced since ancient times. In this regard, we mention "working and paying per day" activities or the practice of selling agricultural products between neighbors without reporting.

According to the International Labour Office (2019), informality in the rural economy is in strong connection to other policy pursuits that are high on the international development strategy: without actions to temper income inequality, working poverty, and lack of social protection, it will be difficult to overcome rural poverty. Many employees or self-employed workers in the informal economy face a proper job deficit. This is extreme in the rural economy, specifically in agricultural activities, which are characterized by exceedingly increased levels of informality. These conclusions are also reflected in the results of our study, and those retained by the author are also confirmed by our study.

By social protection benefits, we refer to the intervention levers of the state to reward or to sustain its citizens, as the case may be. Such benefits could be state aid in cases of force majeure (e.g., the COVID-19 pandemic), the inclusion of the unemployed in programs to find jobs, the implementation of free training courses. How these social benefits are reflected in the perspective of people (both professional and nonprofessional) is quantified through the indicator *Social Protection Benefits*.

Between the informal sector and social protection benefits, the results indicate a negative relationship, with a coefficient of (- 6.773329) (prob = 0.0000). More precisely, when the level of social protection benefits offered by the state increases, this increase will be reflected in a positive way in the underground economy. By encouraging them to pay more attention to the state, it encourages them not to commit tax evasion, to pay their taxes and, more broadly, not to engage in informal activities. By making people feel that the state is paying more attention to them, it encourages them not to commit tax evasion, to pay their taxes, and, more broadly, not to engage in informal activities.

The informal economy and the agricultural labor relationship is then positive, as shown in Table 2. Our results indicate a coefficient of 0.031639 (prob = 0.0055), characterized by a t statistic of 2.791024. Regarding this indicator, in the estimated equation it was included with a lag of (-1), which will be reflected in our subsequent interpretations.

An upward trend in the agricultural labor force will lead to an increase in the informal economy. This means, in a broader sense, that with the growth of the agricultural sector, the size of the underground economy will also increase. Our results are in line with the prior literature from Weng (2015) and Eurostat (2018), which suggests that the agricultural sector is exposed to being illegitimate because it predominantly represents the activity carried out in rural areas. In other words, as we explained in the previous paragraphs, among the rural population people rely on community spirit and make trades with each other without declaring to the competent authorities the income/benefits obtained. Moreover, as crops are not easy to quantify, producers of agricultural goods may declare lower levels of their agricultural crops, may use their products for their own nourishment, or sometimes even turn the crop into other finished products, which they may later market.

In summary, the magnitude of agricultural labor, the scale of the rural population, and the scope of social protection benefits each play a significant role in shaping the informal economy. These factors collectively underscore the intricate interplay between agriculture, rural demographics, and social welfare policies as crucial mechanisms influencing the prevalence and expansion of informal economic activities. Consequently, agricultural conditions, rural socio-economic determinants, and social protection strategies emerge as fundamental vectors through which informal and illicit activities are facilitated and perpetuated.

5. Overview of the informal economy of Austria, Romania, and Bulgaria

In this section, we will delineate the data utilized in this study, focusing on Romania, Bulgaria, and Austria. This comparative analysis aims to trace the evolution of the informal economy across a spectrum of development levels—namely, less developed nations like Romania and Bulgaria, alongside a more developed country such as Austria.

By examining these varied contexts, we seek to illuminate the dynamics of informal economic activity in disparate developmental environments. Concluding the section, we will offer a series of strategic recommendations for policymakers, aimed at fostering long-term economic stability and achieving a balanced regulation of the informal economy.

Romania and Bulgaria are the two countries that during the analyzed period scored the highest dimensions of the underground economy, while Austria is the state that managed to best balance its economy and score rates below 8% throughout the period under analysis. In the following, we will rehearse what the economic context is of these three states and what are the economic events that have had an impact on their informality.

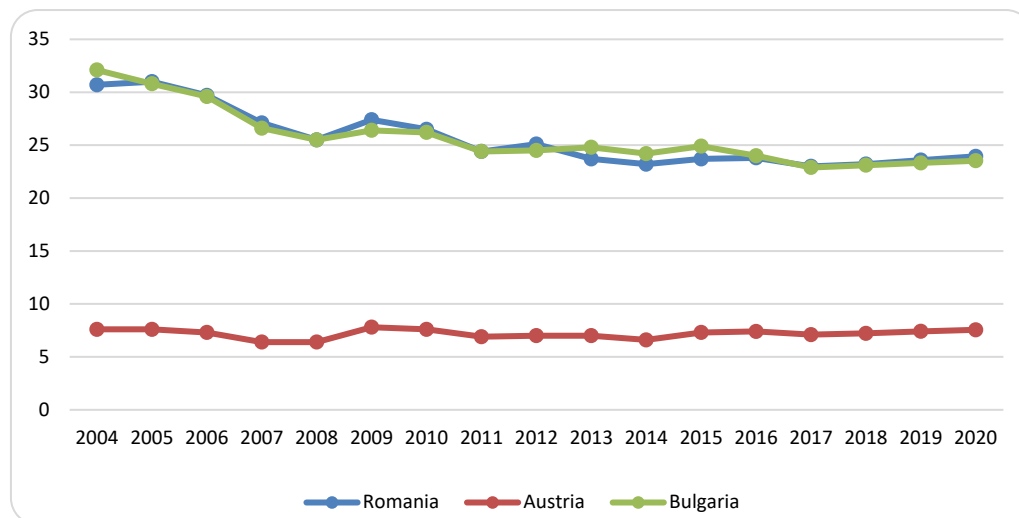
Austria is a great example of a state that carried out comprehensive reforms starting with year 2004 that led to considerable lowering of the tax burden. The Austrian reform package included three main elements: (a) balanced budget in terms of economy; (b) reducing the tax burden to less than 40% of GDP by year 2010; and (c) stimulating investment in infrastructure, education, and research (European Commission, 2005).

The goals of Austrian economic policy also appear in a changing composition of public expenditure. A fruitful policy package was considered as it tackled informality using an embedded approach by making formality affordable (and catchy) to both entrepreneurs and workers. It also included the extension of social protection among citizens to reduce the repercussions of informality. The benefits of this Austrian tax reform are also reflected in a positive manner in the levels of the Austrian informal economy for the period under review, an aspect which is in accordance with our results on the linkage between the informal economy and the social benefits.

As concerns Romania, it is important to observe that the trend of the informal economy is an overall descending one, which means that in the case of Romania the strategy for decreasing the population's appetite for informal activities was an effective one. We also note that Austria's trend towards the informal economy is uneven and that, overall, it is not declining significantly.

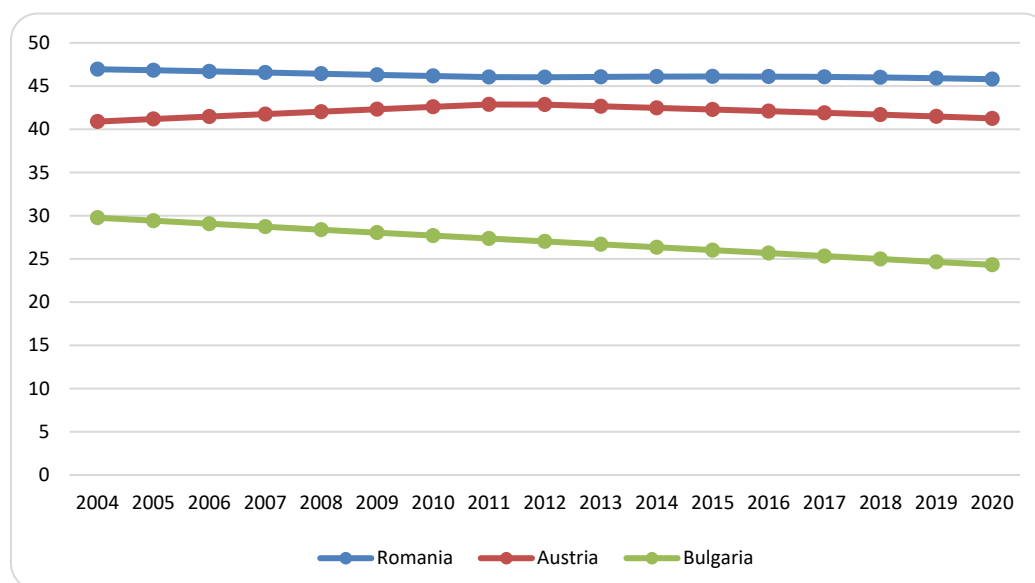
There have been studies (Goel et al., 2017; Zaman and Goschin, 2015) that hypothesize that the informal economy, if it is to a small extent and controlled by the state, can also have some beneficial effects on economic growth and may spur economic growth when synergies with the formal economy enhance productivity and development. This is also because often the money that is generated in informal activities returns to the economy, generating economic growth.

Graph 1. *Informal Economy Trend for Romania, Bulgaria, and Austria, 2004-2020*



Source: own processing.

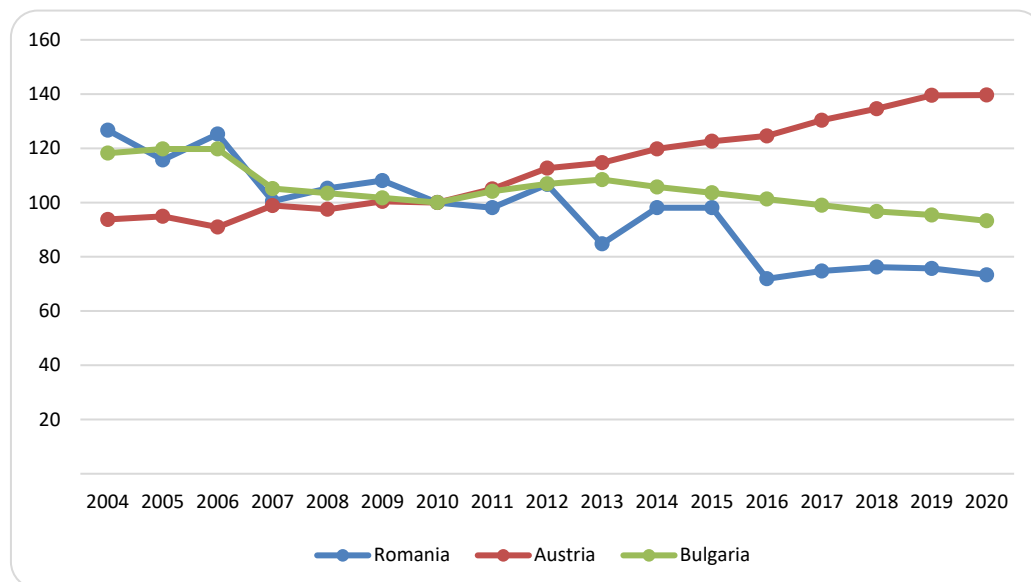
The rural population refers to people who live in rural areas as defined by the World Bank and national statistical offices. As Figure 2 reflects for the three states, Romania is the state with the largest rural population, followed by Austria and, with considerable difference, Bulgaria. The level of the rural population in the three states did not register major fluctuations during the period analyzed. In Romania and Bulgaria, the trend is slightly downward, due to several factors, including (1) the migration of people from rural to urban areas and (2) the transformation of many rural areas into urban or suburban areas. This phenomenon is a natural one, as the tendency of youngsters is to relocate to areas where they can study (high school, college)/find a job, and then very few of them return to the rural areas from which they left.

Graph 2. Rural Population trend for Romania, Bulgaria and Austria, 2004-2020

Source: own processing.

As far as the agricultural sector is concerned, the most developed state of the three is Austria. What is interesting to note is that, in 2004, from the perspective of the agricultural sector, it was the state with the lowest level of agricultural labor compared to Romania and Bulgaria, while in 2020 it ranks first among these three states. Therefore, if the trend for Romania and Bulgaria is decreasing in the period 2004-2020 (decreasing in the case of Romania from 126.67 AWUs to 73.33 AWUs and in the case of Bulgaria from 118.22 AWUs to 93.26 AWUs), Austria reported a considerable increase during this period, from AWU 93.76 to AWU 139.65.

Regarding the breadth of the agricultural sector for Romania and Bulgaria, there are many authors and many institutions that continue to monitor the evolution, Romania and Bulgaria being states with a huge potential in terms of land and land diversification, which favors the cultivation and growth of plants. To this end, however, it is required better planning of the agricultural sector, as it fails to produce enough to meet the needs of the population, thus increasing the chances of individuals to turn to informal sources from where to procure it (European Parliament, 2010; Anghelache et al., 2020; Rangelova & Vladimirova, 2017).

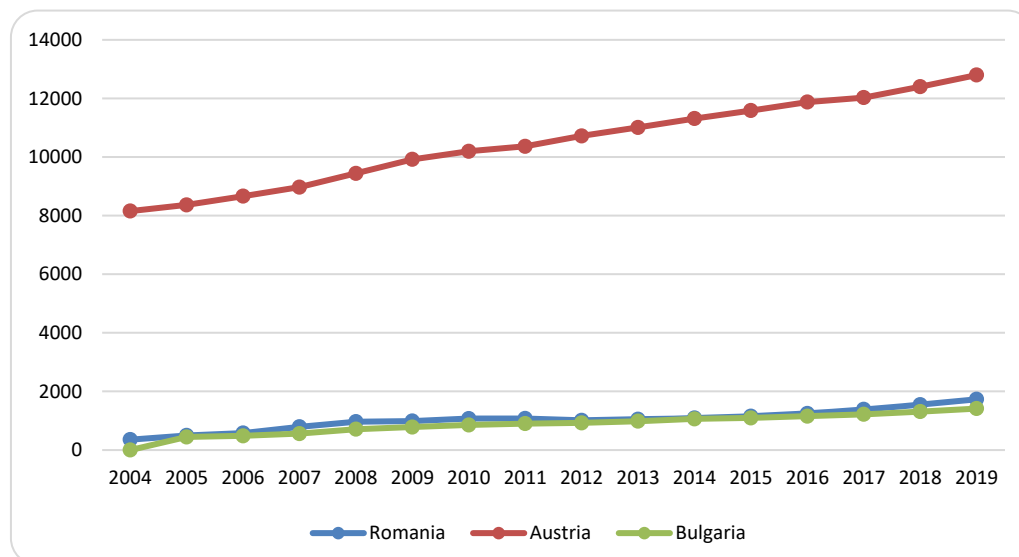
Graph 3. Agricultural labor trend for Romania, Bulgaria and Austria, 2004-2020

Source: own processing.

In terms of social policy, Austria provides a wide-ranging social security and welfare scheme, coordinated on both social benefits and services. As shown in Figure 4, the benefits Austria offers from the perspective of social protection to citizens are approximately seven times higher than the level offered by Bulgaria or Romania. Austria implemented in 2011 the *needs-oriented system of guaranteed minimum resources* which aims to provide the necessary minimum resources for people who cannot afford to support themselves and their families with what they own or earn.

In addition to this system, several social programs are being developed in Austria, which include benefits such as social assistance, unemployment insurance, employment-conditional benefits, housing and family benefits (including support for sole parent households) and childcare support (OECD, 2004; European Commission, 2005; LSE Health, 2017).

On the flipside, we find Bulgaria and Romania, whose social policies do not include a high level of benefits for citizens. For Romania and Bulgaria, Figure 4 below reflects an upward trend in social protection benefits for the analyzed period, 2004-2019. For Romania, if in 2004, the total expenditures of a country spent on social protection benefits were 356.5 euros per inhabitant, in 2019 they reached a level of 1,728.6 euros per inhabitant. In Bulgaria, in 2019, the total expenditures of a country spent on social protection benefits were 1,462.620 euros. This discrepancy between Austria, on the one hand, and Romania and Bulgaria, on the other, has its origins in the fact that the latter are ex-communist states whose transition to development began in 1990, with the fall of communism.

Graph 4. Social protection benefits trend for Romania, Bulgaria and Austria, 2004-2020

Source: own processing.

Following the data presented in this section, we can see that for the three states analyzed, the trends of the indicators concerned in relation to the underground economy would confirm, at an overall level, the results obtained in the previous section. Therefore, during the period 2004-2020, the level of social protection benefits increased, the rural population decreased, and the level of the underground economy recorded a decrease for all three states.

Regarding the agricultural sector, it did encounter different fluctuations, but we consider that it would deserve a more detailed expansion of the relationship between the agricultural sector and the underground economy, which also considers other variables related to the agricultural sector that could characterize informal economy. The quality of legislative regulations in the agricultural sector. However, the article has some limitations, as several other variables related to the agricultural sector that could characterize the informal economy should also be explored. Therefore, the results regarding the agricultural sector in terms of agriculture labor should be interpreted with caution.

Part of the conclusion of this section is that, in general terms, any society that has a strengthened social and agricultural framework is stable and trustworthy from an economic position. In this sense, improving the strategies provided by the states in a transparent way and providing social assistance to citizens may restore or consolidate, as the case may be, the confidence of the citizens in the society they are part of.

Our recommendation, based on the direct relationship between the agricultural sector and the rural population as obtained through our study presented in Chapter 4 (*Results of the study*), is that a state should provide the necessary tools for the agricultural sector to grow, even in rural areas, but to pay more attention to informality in these contexts. In this regard, committees/ associations/directorates of public employees could be organized and well

trained to develop a direct relationship with people from rural areas, respectively, with farmers, and to take over their bureaucratic task. Thus, being close to them, they will be able to have a better understanding of the gaps that allow informality, and they can propose applied solutions to tackle them.

6. Conclusions

In conclusion, from the results of the regression analysis, we can state that the social protection, agricultural, and rural sectors are of great importance for the size of the underground economy. While the agricultural sector and the rural population have a direct positive impact on the underground economy, social protection benefits have an indirect link with it. Therefore, the intervention of the state plays a significant role in supporting the agricultural and rural sector, both in terms of supporting the structure of the agricultural system and in terms of income support. This support will be further reflected in reducing the underground economy.

The results of our study were also confirmed by a brief analysis on the economies of Austria, Romania and Bulgaria, together with the evolution of the agricultural sector, social policy, and the rural population among them. Of the three states, Austria has the lowest level of the underground economy and, in terms of the determinants of the underground economy, as outlined in this study, it is positioned in points that favorably influence the level of the underground economy. On the other hand, Romania and Bulgaria, which have the highest levels of the underground economy, have also registered a positive evolution in the three directions with an impact on the underground economy, but to continue in a downward trend of the underground economy, they must consider reorganizations and improvements in social systems and agriculture, such as the strategies used by Austria.

Furthermore, our study can be developed using other indicators of the agricultural and rural sectors, so it can be observed whether they will confirm the results of the dependencies established on the basis of this paper. Opportunities for future research include qualitative indicators that could be added along with the quantitative ones analyzed by us, and in this sense, we would recommend an indicator that reflects the quality of legislative regulations in the agricultural sector. Finally, the last direction to develop our research is related to the database, when more recent data on the shadow economy will be released, the study should be resumed.

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Tracing the path: testing the environmental Kuznets Curve in Algeria using ARDL bounds testing

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Abstract. *This study aims to test hypothesis of Environmental Kuznets Curve (EKC) in Algeria using the Autoregressive Distributed Lag (ARDL) bounds testing methodology. The objectives include examining the long-term relationship between economic growth and CO₂ emissions, investigating the impact of structural breaks on this relationship's stability, and offering policy recommendations informed by the findings. The research utilizes annual data related CO₂ emissions and GDP per capita from 1962 to 2014 in Algeria. The data are analyzed through the ARDL bounds test to ascertain the existence of a long-term equilibrium relationship. The study incorporates structural breaks to account for potential changes in the economic-environmental relationship over time. The findings confirm the presence of an EKC pattern in Algeria, showing a reverse U-shaped nexus between economic growth and CO₂ emissions. The Inclusion of structural breaks in the analysis led to the stability of the model compared to the case of their absence that led to a variability in the model coefficients. Thus, it provides a more accurate and reliable understanding of this relationship. The threshold at which economic growth starts to decrease CO₂ emissions, is identified at a GDP per capita of approximately \$4125.58 (constant 2010 \$), which Algeria reached in 2005. Furthermore, if disequilibrium between CO₂ emissions and economic growth is occurred due to a possible short-term shock, the return toward the steady state requires three years approximately. While the results validate the EKC hypothesis for Algeria, the paper is limited to the period from 1962 to 2014 and may not capture more recent economic and environmental changes. Furthermore, the study aims to enrich the EKC literature in Algeria, which is characterized by scarcity, by using the recent ARDL bounds test methodology and addressing basic assumptions that were violated in previous studies. This study highlights the importance of considering structural breaks in environmental-economic analyses to avoid biased estimations and incorrect policy recommendations. Future research should explore additional determinants of CO₂ emissions, such as biofuel use, advanced technologies, environmental awareness, urbanization, foreign direct investment, and employment. Policymakers should promote clean energy and sustainable economic practices to ensure continued environmental improvements alongside economic growth.*

Keywords: Environmental Kuznets Curve, CO₂ emissions, cointegration; ARDL bounds test, structural changes.

JEL Classification: C22, C51, C87, O11.

1. Introduction

Global warming, marked by rising global temperatures and disrupted climate patterns, presents a complex challenge for scientists and policymakers. This phenomenon is mainly caused by human activities, such as combustion of fossil fuels, industrial processes, agricultural activities, and deforestation. A significant result of global warming is its negative impact on air quality due to the excessive concentration of carbon dioxide emissions (CO_2) in the atmosphere. As a result, the intricate relationship between economic activities and the environment gives rise to global warming.

The nexus between the environment and economic activity has garnered significant attention from researchers and decision-makers. The relationship between the environment and economic activity has garnered significant attention from researchers and decision-makers. However, what has surprised and was unexpected is the observation of having improved air quality and reduced air pollution at high levels of economic growth, after surpassing critical income levels. This phenomenon, known as the environmental Kuznets curve (EKC hereafter) and has garnered significant attention. Kuznets found that inequality initially increases at medium income, then decreases, following a bell curve that now bears his name. This hypothesis suggests that during the early stages of any development model, Economic Growth (E.G) may lead to increased pollution and environmental deterioration as countries favourite economic progress over environmental concerns. However, as countries achieve higher levels of affluence and industrialization, that allow to shift toward environmental conservation, conducting to reduced pollution and improved environmental quality.

The works of Shafik & Bandyopadhyay (1992) and Panayotou (1994), building upon the research by Grossman & Krueger (1991), that is what form the foundation of the EKC. These studies employ water pollution, CO_2 emissions, and deforestation as indicators of pollution, and GDP per capita as a measure of economic growth. Over the past two decades, the examination of the EKC has attracted significant scholarly attention, as evidenced by the growing body of literature on the subject.

Understanding the EKC hypothesis is a crucial requested ground for policymakers and environmental advocates to concept effective policies that harmonize economic growth with environmental sustainability.

The present research aims to examine hypothesis of (EKC) through the using of (ARDL) bounds testing approach, specifically within Algerian context. The objectives are to test the long-term relationship between Economic Growth (E.G) and CO_2 Emissions in Algeria with an explicit consideration of structural breaks on the stability of this relation, following by policy recommendations based on the findings.

The study addresses the following key questions:

Does the validation of the hypothesis of EKC depend on the inclusion of structural changes in the research model?

What is the impact of structural change on the stability of the relation between Economic Growth and Environment?

A significant methodological gap in previous research is the omission of structural breaks in the analysis. Ignoring structural breaks can lead to biased estimations and incorrect inferences about the relationship between economic growth and environmental degradation, as falsifies the reliability of recommendations deduced from such researches, besides they do not fully reflect the dynamic nature of the economic-environmental relationship in the Algeria context.

The research contributes to the present body of literatures using the ARDL bounds testing methodology with an explicit consideration of structural breaks; by merging structural breaks into the model and employing an updated and comprehensive dataset spanning from 1962 to 2014, the study's approach offers a reliable and more robust examination of the (EKC) hypothesis in Algeria.

Awaiting results show that the nexus between Economic Growth (E.G) and CO₂ Emissions in the Algerian area may be affected by structural changes. The presence of a positive coefficient for GDP and a negative coefficient for GDP squared in the long run could confirm the existence of the EKC, focusing on the significance of considering structural breaks in such EKC examination.

2. Literature review

The EKC hypothesis supposes a reversed U-shaped relationship between environmental degradation and income; it suggests that pollution levels initially increase with economic development, reaching a peak and then declining as income increases. (Shahbaz & Sinha, 2019). This hypothesis has received substantial scholarly attention during the last decades, and researchers have uncovered its carrying out in different contexts, numerous seminal works have laid the groundwork for understanding this phenomenon (Grossman & Krueger, 1991; Panayotou, 1994; Shafik & Bandyopadhyay, 1992), these works shown that at higher income levels, societies favor environmental quality, conducting to increased pollution and improved air quality (Purcel, 2020). On this basis, the theoretical framework of the hypothesis of (EKC) includes several mechanisms, at the early stages, Economic Growth leads to more pollution due to increased production and consumption, known as the scale effect. As economies develop, the industrial structure shifts from highly polluting industries to cleaner, service-oriented sectors, known as the composition effect. Furthermore, technological progress and higher incomes enable the adoption of cleaner technologies and stricter environmental regulations, known as the technical effect.

A large body of empirical work has examined the EKC hypothesis across various economies and pollutants, for example, (Dinda, 2004) has provided a comprehensive review of empirical research, confirming the existence of (EKC) for several environmental indicators, encompassing CO₂ emissions. However, the results are not uniform and the presence of EKC often depends on specific country characteristics and the type of pollutant considered. Furthermore, (Pao & Tsai, 2011) conducted a study using annual data on GDP and CO₂ emissions in the Brazilian context to examine the validity of (EKC), using the

cointegration method to test the ARDL bounds, their results confirmed the existence of the hypothesis of (EKC). In contrast, (Saboori et al., 2012) examined Malaysian data on CO₂, Economic Growth (E.G), and Energy Consumption (E.C), they concluded that EKC is a long-run phenomenon as their examination failed to identify short-run EKC using different cointegration methods. They further identified a bi-directional causality between economic growth and carbon dioxide emissions. Likewise, in Pakistani area, (Nasir & Ur Rehman, 2011) investigated the relationship between CO₂ emissions, economic growth, Foreign Trade and Energy, they have confirmed the presence of long-run EKC through the applying of Johansen cointegration,

The omission of structural breaks in analyses can lead to biased estimations and inaccurate policy recommendations. Studies by (Bai & Perron, 2003; Perron, 1989) highlighted the importance of accounting for such breaks to avoid spurious results. Hence, incorporating structural breaks into the models is decisive for a more robust examination of the (EKC) hypothesis (Sinha & Shahbaz, 2018), the ARDL bounds testing technique, particularly, captures both the short-run dynamics and the long-run equilibrium in the relationship between the variables, with including structural breaks, the modelling by ARDL approach becomes more robust and truthful.

Works by (Osabuohien et al., 2014) on different African states and by (Fan & Zheng, 2013; Hao et al., 2016) on Chinese provinces illustrate the common interest in testing the (EKC) assumption across various regions. These works underscore the significant of understanding the dynamics of Economic Growth and environmental sustainability, in particular in developing and transitional economies, furthermore, the work of (Van Alstine & Neumayer, 2008) underlined the need to update methodologies, such as the ARDL bounds testing method to improve the accuracy of (EKC) estimations.

The implementation of the assumption of EKC in Algeria involves examining the unique economic and environmental context of the country. Algeria's dependence on its fossil energy resources, coupled with its economic development trajectory, makes it an interesting case study for testing the EKC hypothesis, nonetheless, few studies have examined the EKC hypothesis in Algeria. (Bouznit & Pablo-Romero, 2016) conducted a study utilizing annual data from 1970 to 2010 on various variables including CO₂ emissions, GDP, energy consumption, electricity consumption, imports, and exports. They employed the ARDL bounds test cointegration method with breakpoints to examine the EKC hypothesis, their findings indicated that GDP, energy consumption, electricity consumption, and imports have positive impacts on CO₂ emissions, whereas exports have a negative impact on CO₂ emissions. The presence of a positive coefficient for GDP and a negative coefficient for GDP squared in the long run confirms the existence of the EKC. To enhance energy efficiency and regulate energy demand, the authors suggested the promotion of energy efficiency measures and reduction of energy subsidies. Additionally, (Latifa et al., 2014) aimed to test the presence of the EKC utilizing the ARDL bounds test cointegration methodology and the vector error correction model (VECM)-based causality test. The study revealed cointegration between CO₂ emissions per capita and GDP per

capita, confirming the EKC hypothesis. The causality test demonstrated unidirectional causality from income to CO₂ emissions - both in the short and long run. Similar results were found by Touitou, (2021) by using the VECM method for economic growth and environmental degradation, utilizing three environmental indicators (CO₂, SO₂, and NO_x) for the 1980-2017 period.

Controversy, Lacheheb et al. (2015) adopted the (Narayan & Narayan, 2010) approach to examine the EKC assumption by comparing short-run income and long-run one elasticities during 1971-2009. The authors examined the relationship between GDP per capita, gross fixed capital formation, imports, exports, population and CO₂ emissions from three sources: CO₂ from solid fuel consumption, CO₂ from liquid fuel consumption, and CO₂ from electricity/heat consumption, using the ARDL bounds testing method. They found that both income and population had a significant impact on CO₂ emissions, particularly CO₂ from solid fuel consumption and CO₂ from electricity/heat production. However, only population had a significant impact on CO₂ emissions from liquid fuel consumption. In addition, they found no evidence supporting the EKC hypothesis in Algeria and suggested that Algeria should urgently transition towards a service-intensive economy and adopt renewable energy sources to mitigate environmental degradation and stimulate economic growth. Similarly, (Layachi, 2019) has conducted a study that has supported the absence of the EKC in Algeria. The study examined the impact of three energy source prices (oil, natural gas, and fuel oil) and GDP on CO₂ emissions using the ARDL bounds test cointegration method. The study revealed that GDP had a positive and significant impact on CO₂ emissions, while all energy prices (oil, fuel oil, and natural gas) had a negative and significant impact on CO₂ emissions.

Research Gap

The literature on the EKC hypothesis provides a rich foundation for investigating the relationship between per capita income and environmental quality. By addressing methodological gaps, such as the omission of structural breaks, researchers can contribute to a more nuanced understanding of how economic development impacts the environment. Ignoring structural breaks can lead to biased estimations and incorrect inferences about the relationship between economic growth and environmental degradation, potentially resulting in inaccurate conclusions regarding the validity of the EKC hypothesis.

In the Algerian case, most of the studies did not take structural changes into account when modeling EKC hypothesis. Ignoring structural changes in the model can lead to spurious relationship between variables, inaccurate forecasting and misleading policy recommendations (Hansen, 2001; McNown et al., 2018). This oversight undermines the reliability of policy recommendations derived from such studies, as they do not fully capture the dynamic nature of the economic-environmental relationship in Algeria. By considering structural changes and utilizing advanced econometric techniques, researchers can enhance the robustness of their analyses and better inform policy decisions. For these reasons, our approach provides a more robust and reliable analysis of the EKC hypothesis in Algeria.

2. Data and Methods

2.1. Data source

For this study, we use annual data on carbon dioxide (CO₂) emissions per capita (measured in metric tons) and GDP per capita (measured in constant 2010 U.S dollars). These data are derived from the World Bank database (WDI) for the period 1962-2014. The variables are transformed into logarithmic form.

2.2. Model specification

In the literature, the general form of the EKC hypothesis is typically formulated as follows:

$$\ln E = f(\ln Y, (\ln Y)^2, \ln Z) \dots\dots\dots \text{(Eq.1)}$$

Where, ln: the natural logarithm, E: represents an indicator of environmental quality, and Y: represents gross domestic product per capita, and Z includes other variables that can influence environmental deterioration.

Among greenhouse gases, CO₂ is the main component (IEA, 2018). For this reason, most studies regarding the EKC hypothesis use CO₂ emissions as an indicator of environmental pollution, as adopted in this study.

To measure the direct and indirect effects of economic growth on CO₂ emissions, we employed the reduced form of the EKC equation (Eq.2) as outlined by List & Gallet, (1999):

$$\ln CO_{2t} = \beta_0 + \beta_1 \ln Y_t + \beta_2 [\ln Y_t]^2 + \epsilon_t \dots\dots\dots \text{(Eq.2)}$$

Where, CO₂: carbon dioxide emissions per capita to measure environmental pollution, Y: GDP per capita, ϵ : the random error term, t: time index from 1962 to 2014, β_i , $i = 0, 1, 2$: estimated coefficients. The quadratic term $(\ln Y)^2$ is included in the equation to capture the inverse U-shape of the EKC curve. If $\beta_1 > 0$ and $\beta_2 < 0$, the curve takes an inverse U shape, so the EKC hypothesis is valid. If this were the case, the inflection point can be calculated as follows: $Y^* = \exp\left(-\frac{\beta_1}{2\beta_2}\right)$.

2.3. ARDL Bounds test for cointegration

To examine the existence of a long-run equilibrium relationship between CO₂ per capita emissions and GDP per capita, we adopt the ARDL bounds test of Pesaran et al., (2001). This cointegration method:

- is flexible regarding the integration order of variables: the ARDL bounds test procedure can be applied to variables that are integrated of order zero I(0), order one I(1), or mixture of both, but not order two I(2). This flexibility enhances the accuracy of the estimation process, especially when analysing complex macroeconomic data.
- incorporates both short-term and long-term relationships into a single equation known as the unrestricted error correction model (UECM) without losing long-term information.
- the optimal selection of the lag for the UECM avoids both autocorrelation and endogeneity problems.

The ARDL representation under the UECM for the reduced form of the EKC formulated as follows:

$$\Delta \ln CO2_t = \alpha_0 + \sum_{i=1}^{p1} \alpha_{1i} \Delta \ln CO2_{t-i} + \sum_{i=0}^{p2} \alpha_{2i} \Delta \ln Y_{t-i} + \sum_{i=0}^{p3} \alpha_{3i} \Delta [\ln Y_{t-i}]^2 + \phi_1 \ln CO2_{t-1} + \phi_2 \ln Y_{t-1} + \phi_3 [\ln Y_{t-1}]^2 + \omega DM_t + v_t \dots \dots \quad (\text{Eq.3})$$

α_0 : constant term, $(\alpha_{1i}, \alpha_{2i}, \alpha_{3i})$; for $i=1, 2, 3$: short-run coefficients, ϕ_i ; for $i = 1, 2, 3$: long-run coefficients. DM: dummy variable that represents structural changes, Δ : first difference operator, $(p1, p2, p3)$: the optimal lag length for lagged variables $\Delta \ln CO2$, $\Delta \ln Y$ and $\Delta [\ln Y]^2$ respectively based on Schwarz Information criteria (SIC), t : time index, v_t : random error term.

To explore the existence of cointegration relationships between variables, Pesaran et al., (2001) propose testing the following null hypothesis of no cointegration:

$$H_0: \phi_1 = \phi_2 = \phi_3 = 0$$

against the alternative hypothesis of cointegration:

$$H_1: \phi_1 \neq \phi_2 \neq \phi_3 \neq 0$$

For this, we perform the F-Wald test and compare the F-statistic to the critical values tabulated by (Pesaran et al., 2001). They report two sets of critical values: lower bounds and upper bounds. Lower bounds assume that the variables are $I(0)$, while upper bounds correspond to $I(1)$.

If: F-statistic < $I(0)$, we cannot reject $H_0 \rightarrow$ no cointegration:

if: F-statistic > $I(1)$, we reject $H_0 \rightarrow$ cointegration;

if: $I(0) \leq \text{F-statistic} \leq I(1) \rightarrow$ inconclusive test.

However, the critical values of (Pesaran et al., 2001) are inapplicable to small samples as our sample (52 observations). For this, we use the critical values introduced by (Narayan, 2005) for small sample sizes spanning from 30 to 80 observations.

When the cointegration test indicates the existence of a cointegration relationship, we can derive the long and short run equations.

2.3.1. Long run equation

Equation2 (Eq.2) represents the long-run equation, also called the cointegration equation.

2.3.2. Short run equation

The short-run equation-called the error correction model-is formulated as follows:

$$\Delta \ln CO2_t = \varphi_0 + \sum_{i=1}^{p1} \varphi_{1i} \Delta \ln CO2_{t-i} + \sum_{i=0}^{p2} \varphi_{2i} \Delta \ln Y_{t-i} + \sum_{i=0}^{p3} \varphi_{3i} \Delta [\ln Y_{t-i}]^2 + \delta ECT_{t-1} + \gamma DM_t + e_t \dots \dots \quad (\text{Eq.4})$$

Where, ECT_{t-1} indicates error correction term lagged one period. The ECT is the residuals of estimated long-run relationship (Eq.4). Hence, $ECT_t = \epsilon_t$ is the speed of adjustment towards the long-run equilibrium. In order to confirm the long run relationship among

variables, the *ECT* coefficient should be negative and statistically significant (Banerjee et al., 1998).

To ensure the reliability of the model, it is important to verify the residual diagnostic tests. These tests are the normality test, the Breusch-Godfrey test for autocorrelation, and the Breusch-Pagan-Godfrey test for heteroscedasticity. Furthermore, to ensure the stability of the estimated coefficients over the study period, the cumulative sum (CUSUM) and cumulative sum squared (CUSUMSQ) tests of recursive residuals are used.

3. Empirical results and discussion

The starting point of the cointegration analysis is the examination of stationarity properties of the time series under study to ascertain its order of integration.

3.1. Stationarity analysis

As a first step, we used conventional unit root tests such as the augmented Dickey-Fuller test (ADF test) and the Phillips-Perron test (PP test). The results of these tests are summarized in Table 1. The ADF test indicated that the $\ln CO_2$ and $\ln Y$ series are significantly stationary in their first difference at the 1% level. While the PP test indicated the stationarity of the series in their levels. When the results of the ADF and PP tests conflict for low-frequency data, such as annual data, we prioritize the PP test due to its higher test power (Maddala & Kim, 1999) Therefore, the time series of the study are integrated of order zero, $I(0)$.

Table 1. Conventional unit root test results

	ADF test				PP test				I(d)
	Level		1st difference		Level		1st difference		
	trend & intercept	intercept	trend & intercept	intercept	trend & intercept	intercept	trend & intercept	Intercept	
$\ln CO_{2t}$	-1,91 (0,63)	-2,43 (0,13)	-8,44 (0,00)	-7,97 (0,00)	-1,796 (0,69)	-2,78 (0,068)			I(0)
$\ln Y_t$	-1,59 (0,78)	-1,48 (0,53)	-9,9 (0,00)	-9,92 (0,00)	-3,54 (0,045)	-3,39 (0,016)			I(0)
$[\ln Y_t]^2$	-3,93 (0,018)	-1,39 (0,58)	-	-	-3,33 (0,072)	-3,26 (0,02)			I(0)

Notes: Values in parentheses represent p-values.

Source: Own Elaboration based on *Eviews 10* output.

However, when a possible structural breakpoint may occur in the series, the usual unit root tests can lead to biased estimates, because these tests ignore the existence of structural breakpoints when they exist. To address this issue, we apply a unit root test that considers a breakpoint with gradual changes based on the minimum Dickey-Fuller t value to determine the breakpoint. The results are provided in Table 2.

The results indicate that evidence of unit root was found for the $\ln CO_{2t}$ series when considering a structural break in the intercept (Model A), and the break occurred in 1969. For the $\ln Y_t$ and $[\ln Y_t]^2$ series, the test indicates that they are significantly stationary at their levels and that the break is located in 1975.

Table 2. Unit root tests with breakpoint

	Model-type	Level		1st difference		I(d)
		t-statistic	break date	t-statistic	break date	
$\ln CO_2_t$	Model A	4,587	1969	9,445***	1973	I(1)
$\ln Y_t$	Model C	5,195***	1975			I(0)
$[\ln Y_t]^2$	Model C	5,118***	1975			I(0)

Notes: *** signifies 5% level of significance, Model A: with constant, Model C: with trend.

Source: Own Elaboration based on *Eviews 10* output.

Generally, unit root tests indicate that there is a mixture of I(1) and I(0) variables, but not I(2). Therefore, the ARDL approach of cointegration is applicable.

3.2. Cointegration analysis:

As demonstrated by the unit root tests in the previous sub-section, the dependent variable is stationary at its first difference. This is the condition that (Pesaran et al., 2001) assumed to avoid the degenerate case. As outlined by (Pesaran et al., 2001), degenerate case means absence of cointegration. The ARDL bounds test results are provided in Table 3.

Table 3. ARDL bounds test results

Optimal lag lenght:	(1, 0, 0)		
F-statistic =	4,77		
Critical values (Narayan, 2005):			
	1%	5%	10%
Lower bounds I(0)	4,61	3,303	2,748
Upper bounds I(1)	5,563	4.1	3,495

Notes: Lag selection is based on SBC. Critical values are obtained from Narayan (2005), Tables, case II: restricted constant and no trend.

Source: Own Elaboration based on *Eviews 10*.

The optimal lag length selection based on the Schwarz Bayesian criterion (SBC) is (1, 0, 0) for the variables $\ln CO_2$, $\ln Y$, and $(\ln Y)^2$, respectively. Because the sample size of our study is small (52 observations), we use the critical values of (Narayan, 2005) for testing the bounds of the F statistic rather than (Pesaran et al., 2001). The results indicate that the F statistic is greater than I(1) bounds at the 5% significance level, which implies the existence of cointegration between the variables $\ln CO_2$, $\ln Y$, and $(\ln Y)^2$.

Table 4. Diagnostic tests for conditional error correction model (Eq.3)

Diagnostic test	Null Hypothesis	Statistic	Decision
Normality test	H0: Normality	JB = 0,74 (0,69)	Accept H0
Breush-Godfrey serial correlation test	H0: No autocorrelation	LM = 0,625 (0,73)	Accept H0
Breush-Pagan-Godfrey test	H0: Homoskedasticity	LM = 6,7 (0,152)	Accept H0

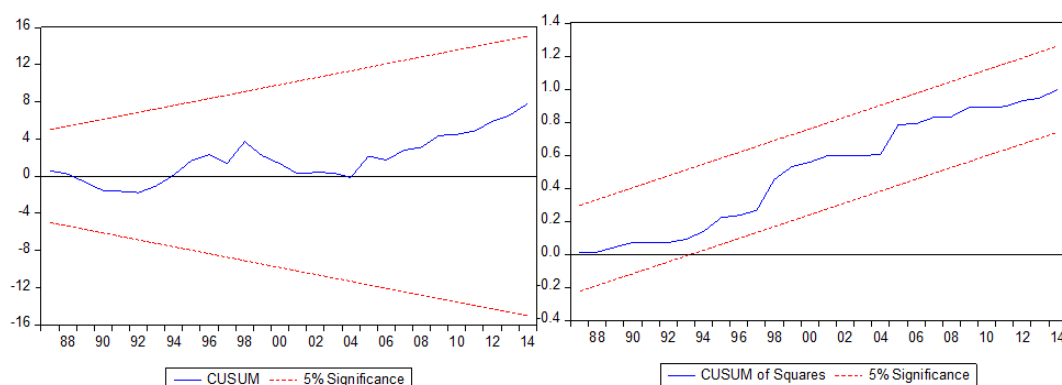
Notes: Values in parentheses represent p-values.

Source: Own Elaboration based on *Eviews 10* output.

The results of the diagnostic tests of the residuals of the UECM model (Eq. 3) are presented in Table 4. These results indicate that the estimated model passes the diagnostic tests for normality, autocorrelation, and heteroskedasticity. Thus, the estimated model is accepted. Additionally, Figure 2 shows that the CUSUM and CUSUMSQ tests are within the 5% critical limits, indicating the stability of the UECM model coefficients over the study period. Compared with Figure 3, in which the model coefficients appear to be unstable, the

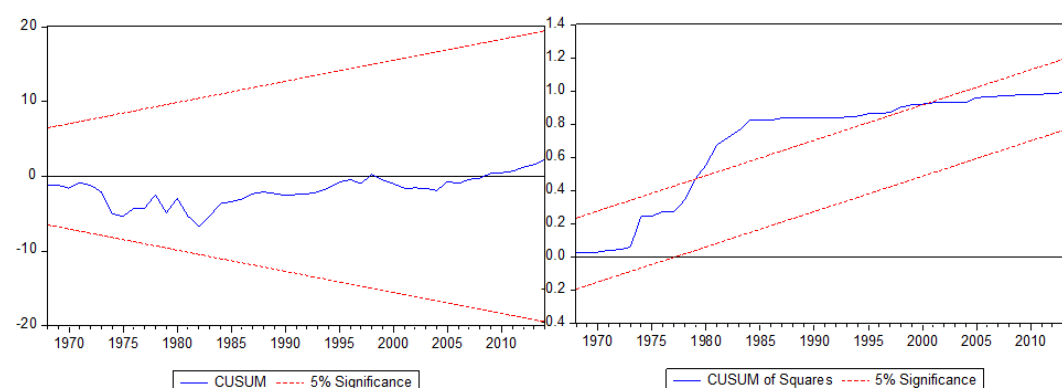
inclusion of structural changes led to model stability. Therefore, the model is considered reliable and flawless for policy-related purposes.

Figure 2. Plot of Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUM of Squares) of Recursive Residuals with structural breakpoint.



Source: Eviews 10 output and our elaboration.

Figure 3. Plot of Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUM of Squares) of Recursive Residuals without structural breakpoint.



Source: Eviews 10 output and our elaboration.

3.2.1. Long run estimations

Once the cointegration relationship between the variables has been confirmed, the next step involves estimating the long-term (Eq. 2) and the short-term (Eq. 4) equations. Table 5 illustrates the estimation results of Eq. 2 and Eq. 4. The long-term estimates indicate that the coefficients of GDP per capita and GDP per capita squared have significant values at the 1% level with positive and negative signs, respectively, thus confirming the presence of the EKC hypothesis in Algeria during the period 1962-2014. By using the long-term equation (Eq. 2), we construct the graph in Fig. 4. It is clear from this graph that an increase in GDP per capita initially leads to an increase in per capita CO₂ emissions up to a certain

threshold of GDP per capita, which constitutes the turning point. After this point, this relationship reverses and a further increase in GDP per capita leads to a decrease in per capita CO₂ emissions, resulting in an inverted U-shaped graph. This result is consistent with research carried out in Algeria by (Bouznit & Pablo-Romero, 2016), (Latifa et al., 2014), and (Touitou, 2021), in Qatar by (Mrabet & Alsamara, 2017), in China and India by (Adebola Solarin et al., 2017), in France by (Ang, 2007), in Brazil by (Pao & Tsai, 2011), in 11 Commonwealth countries by (Apergis & Payne, 2010), in Malaysia by (Saboori et al., 2012), in South Africa by (Kohler, 2013), in Canada by (Hamit-Hagggar, 2012), in Romania by (Shahbaz et al., 2013), and in Spain by (Esteve & Tamarit, 2012). On the other hand, these results differ from those obtained in Algeria by (Lacheheb et al., 2015b) and (Layachi, 2019), in Tunisia by (Farhani & Ozturk, 2015), in Saudi Arabia by (Alshehry & Belloumi, 2017), in China by (Wang et al., 2011), in Turkey by (Acaravci & Ozturk, 2010), and in Russia by (Pao et al., 2011).

Although there is similarity between this study and (Bouznit & Pablo-Romero, 2016) in terms of the methodology used and the results obtained, findings of Bouznit & Pablo-Romero (2016) are questionable because they violated one of the basic assumptions of the ARDL approach of (Pesaran et al., 2001), which is the I(1) dependent variable. Bouznit & Pablo-Romero (2016) study indicated that the dependent variable is I(0), while in this study there is evidence that the dependent variable is I(1), as Pesaran et al. (2001) recommended, to avoid falling into a degenerate case that implies absence of cointegration.

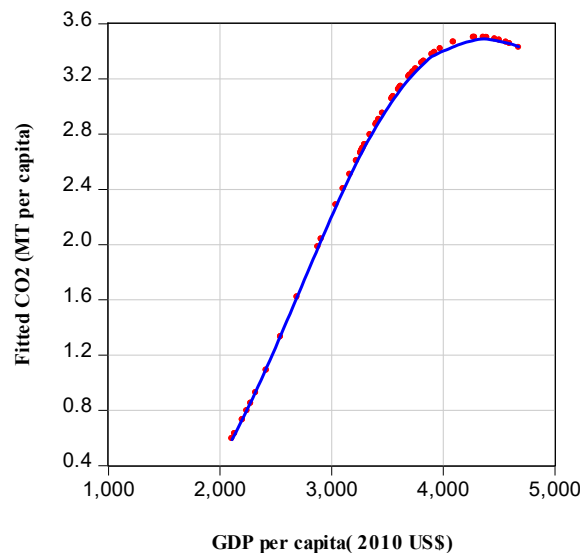
Table 5. ARDL long run and short run results.

Variable	Coefficient	t-statistic
Long-run(Eq.2)		
LnY_t	65,23	3,46***
$(LnY_t)^2$	-3,914	-3,35***
β_0	-270,57	-3,56***
Short-run(Eq.4)		
DM	0,0017	0,033
ECT_{t-1}	-0,35	-4,5***
$DW = 2,15 ; R^2 = 0,24$		

Notes: *** indicates 1% level of significance, DW: Durbin-Watson statistic, R^2 : coefficient of détermination.

Source: Eviews 10 output.

The income turning point, that is, the level of per capita income where per capita CO₂ emissions begin to decline, has been estimated at approximately \$4125.58 (in constant 2010 \$). Algeria reached this level of GDP per capita in 2005 and has since succeeded in reducing its CO₂ emissions.

Figure 4. *Plot of fitted EKC in Algeria during the period 1962-2014*

Source: Own Elaboration.

3.2.2. Short run estimations

The results obtained from the short term estimates revealed that GDP per capita has no effect on CO₂ emissions per capita. This confirms the idea that the EKC is a long-term phenomenon, rather than a short-term phenomenon, and that it is indeed applicable in Algeria. Since growth and development are long-term processes, it follows that the period we adopted in this study can be considered a long-term period and sufficient to reveal the phenomenon of the EKC. This statement is consistent with the findings of (Dinda, 2004), (Nasir & Ur Rehman, 2011), (Saboori & Sulaiman, 2013), and (Ahmad et al., 2017), who all argue that the EKC is a long-term phenomenon and its validity needs to be assessed over a long period of time. The dummy variable, which represents structural changes, affects CO₂ emissions significantly in the short term. The most influential structural changes occurred in Algeria in the early 1980s. The break of the early 1980s coincided with the 1986 oil crisis that led to a recession in the country. Our analysis revealed that the speed of adjustment, as measured by the ECT, is negative and significant at 1% level. The ECT coefficient (0.35) confirms that in the possible short-term shock, the model would move towards the long-term trajectory at a yearly rate of adjustment of 35%. This implies that the adjustment takes about three years to restore the long-term equilibrium level.

4. Conclusion

This study had two goals. Firstly, we test the validity of the EKC hypothesis in Algeria. Secondly, we examine the effect of structural breaks on the stability of the relationship between CO₂ emissions per capita and GDP per capita during the period 1962-2014. To

achieve these objectives, ARDL approach of cointegration with structural breaks is carried out, followed by stability tests of CUSUM and CUSUM square. The main results of this study are as follows:

- 1) The ARDL bounds test indicated the existence of a cointegration relationship between CO₂ emissions per capita and GDP per capita.
- 2) The long term estimation results show that the coefficients of GDP per capita and GDP squared per capita affect CO₂ emissions per capita significantly with positive and negative signs respectively. This implies the validity of the EKC hypothesis for Algeria during the period 1962-2014.
- 3) In the long term, CO₂ emissions are more income elastic, since a 1% increase in GDP per capita leads to a 65% increase in CO₂ emissions per capita.
- 4) The turning point of GDP per capita is approximately equal to \$4125.58 (constant 2010 \$). Algeria attained this per capita income level in 2005. According to the logic of the EKC, Algeria moved to a service-intensive economy.
- 5) In the case of a possible short-term shock, the variables adjust towards their equilibrium levels at a speed of 35% each year, requiring approximately three years to return to equilibrium.
- 6) Short-term results show the absence of the EKC, as it is a long-term phenomenon.
- 7) The inclusion of structural changes in modelling the relationship between the environment and growth leads to model stability.

These results imply that economic growth in Algeria can be a solution to environmental pollution, but only if it is accompanied by a drop in emissions through the promotion of clean energy. The introduction of clean energy into the production process can not only support and promote growth and development, but also contribute to the reduction of carbon emissions. Other determinants of carbon dioxide emissions, such as the use of biofuels for energy production, advanced technologies to control CO₂ emissions, environmental awareness, urbanization, foreign direct investment, and employment, could be explored in future research.

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Dynamic interactions among selected world stock indices: a VAR approach

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Abstract. *The present study focused on examining the dynamic and causal relationships among selected world stock market indices. The growing importance of dynamic interactions among the stock indices have emerged as a focal point of research, driven by the recognition that financial markets are interconnected and interdependent. To achieve the above stated objective, multivariate vector autoregressive (VAR) approach is applied. For which the monthly time series data on the selected indices are obtained for the period 2010-2024. The required data was sourced from yahoofinance.com and the analysis was conducted using RStudio software version 2022.12.0+353 and MS Excel. We found that almost all the indices exhibit a positive and significant impact from their own past values on their future values and they are expected to increase over the next eight months. The impulse response function analysis reveals that only shocks in NSE are positively influenced by their own past values, along with the past values of other indices. Additionally, the FEVD test results indicate that most of the variance in each index is attributable to their own shocks, with the exception of TSX and DAX.*

Keywords: causality, forecasts, indices, shocks, stationarity.

JEL Classification: C51, C53, C58.

1. Introduction

The world of stock markets is a dynamic ecosystem where various indices represent the performance of different economies. Stock markets serve as critical indicators of economic health, reflecting the collective sentiments and expectations of investors worldwide. The interconnectedness of global financial markets has intensified with the advent of globalization, prompting analysts to closely monitor the behavior and interactions of various stock market indices across the world. Dynamic interactions among the stock indices have emerged as a focal point of research, driven by the recognition that financial markets are interconnected and interdependent. This interconnectedness gives rise to complex relationships, characterized by response loops, spillover effects, and contagion risks. Since the fluctuations in one market can swiftly spread across borders, impacting the performance of other markets. Such dynamics underscore the need for advanced analytical tools capable of capturing the details of these interactions. However, studying the dynamic interactions among world stock market indices is not without its challenges. A deeper understanding of the dynamic interactions among world stock market indices can enable investors to construct more resilient portfolios that are better equipped to weather market turbulence. Traditional econometric methods basically depend on linear models to analyze the relationships among variables. These methods, such as Ordinary Least Squares (OLS) regression, time series analysis, and panel data techniques, have been extensively used in financial econometrics to study the behavior of stock market indices. Furthermore, factors such as market volatility, investor behavior, and macroeconomic shocks further complicate the analysis. In this context, Vector Autoregression (VAR) emerges as a powerful technique for modeling the dynamic interactions among multiple time series variables. These models capture the lagged dependencies and endogenous interactions among these variables. Sadorsky (1999) utilized a VAR approach to investigate the relationship between the three-month U.S. Treasury rate, the S&P 500 stock index, stock returns, and oil prices. The study revealed empirical evidence indicating that increases in oil prices exerted a negative impact on actual stock prices. Alalaya et al. (2021), compared VAR model predicting accuracy to machine learning approaches like random forest and gradient boosting. Bohte and Rossini (2019), used Bayesian models with constant and time-varying volatility, including stochastic volatility and Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model in forecasting the ability of four major cryptocurrencies. The results demonstrate that stochastic volatility outperforms the benchmark of VAR in both point and density forecasting, and that employing a student-t distribution for stochastic volatility errors is more effective than the standard normal approach. Catania et al. (2019), indicate significant improvements in point forecasting using combinations of univariate models and in density forecasting using the selection of multivariate models. The VAR model outperforms other traditional forecasting approaches in terms of forecasting accuracy (Chang et al. 2021). Hafner et al. (2021), noticed that the VAR model outperformed the traditional time-series models in terms of forecasting accuracy. Ibrahim et al. (2020), showed that the VAR models achieved better performance compared to the traditional autoregression models and the BVAR models. Li and Li (2020), conclude that VAR models are a suitable option for forecasting. Yang et al. (2020) found that the VAR model offered accurate forecasts and outperforms other forecasting models

such as the ARIMA model. Adebisi et al. (2009) employed the VAR methodology to assess the influence of oil prices, exchange rates, interest rates, and industrial production indices on the stock price index in Nigeria. Their findings echoed those of Sadorsky, demonstrating a negative correlation between world oil prices and the Nigerian stock price index. This suggests that as oil prices rise, the stock price index in Nigeria tends to decline. The VAR models have found extensive application in macroeconomic forecasting and analysis, serving as valuable tools for policymakers. While estimating the model is sufficient for one-period ahead forecasting, the interest often extends to multi-period forecasting scenarios. In such cases, two primary methods are commonly employed: the direct forecast method and the iterated forecast method. The debate over which method is superior for multi-period forecasting has spurred theoretical research by scholars such as Bhansali (1996, 1997), Clements and Hendry (1996), Kang (2003), Chevillon and Hendry (2005), Ing (2003), among others. The VAR model offers a flexible framework for understanding the evolving dynamics of stock market indices. Hence, an attempt has been made to investigate the dynamic interactions among selected world stock market indices using a Vector Autoregression approach. This study aims to unravel the complex relationships and interdependencies that characterize global financial markets.

2. Data and Methodology

The study employed an empirical approach to construct multiple VAR models with Variance Decomposition for individual companies within the selected stock indices. This paper involves a comparative study of six major stock indices (listed in Table 1) to investigate the interrelationships among them. The study examined monthly time series data for the chosen indices over a period of 158 months, from 1st January 2010 to 1st February 2024. The required data were sourced from yahoofinance.com. The analysis was conducted using RStudio software version 2022.12.0+353 and MS Excel. Below are the randomly selected stock indices:

Table 1. *Selected indices*

Sl. No.	Index	Symbol	Country
1	Nifty 50	NSE	India
2	NYSE Composite (DJ)	NYSE	USA
3	SSE Composite Index	SSE	China
4	Nikkei 225	Nikkei	Japan
5	S&P/TSX Composite index	TSX	Canada
6	DAX Performance Index	DAX	Germany

The process of constructing VAR model involves several steps, outlined as follows:

2.1. Stationarity Test

The notion of stationarity holds considerable importance when analyzing time series data. This study employs the Augmented Dickey-Fuller (ADF) test to assess the stationarity of selected indices. The ADF test is an extension of the original Dickey-Fuller test, pioneered by David Dickey and Wayne Fuller in 1979. The null hypothesis of the test posits that the

time series under examination possesses a unit root. The ADF test statistic is calculated as follows:

$$ADF = (Y_t - Y_{t-1}) - \lambda \times \Delta Y_{t-1}$$

Where: Y_t stands for the time series at time t , Y_{t-1} is the time series at time $t-1$, ΔY_{t-1} , represents the first difference of the time series at time $t-1$, and λ , indicates the coefficient.

2.2. Optimum Lag Selection

Constructing a VAR model requires a critical step of carefully selecting the optimal lag order. This process involves determining the most suitable number of lags for each variable in the VAR model. Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and Hannan-Quinn Criterion (HQ) are commonly used for this purpose. These criteria serve as measures of the relative goodness of fit of a statistical model, penalizing excessive complexity by accounting for the number of parameters and the sample size.

2.3. Estimation technique

The casual links among the selected indices will be examined using the Vector Autoregression (VAR) model, developed by Christopher Sims (1980), is a widely applied stochastic process for multivariate time series analysis. It proves vital in comprehending and forecasting economic and financial time series behavior (Campbell et al., 1996). The VAR model extends the univariate autoregression model to multivariate time series data, wherein each variable is expressed as a linear function of its own past lags as well as those of other variables. The general equation of the VAR model with p lags can be represented as follows:

$$Y_t = \alpha_i + \beta_1(X_{t-1}) + \beta_2(X_{t-1}) \dots \dots \dots + \beta_p(X_{t-p}) + \varepsilon_t$$

Where: Y_t stands for vector of endogenous variables at time t , α_i is a constant terms, β_1 , β_2 , and β_p , are the coefficient corresponding to the lagged values of the endogenous, and ε_t is the error terms assumed to be white noise.

Below are the equations representing the VAR models corresponding to the results depicted in Table 5.

$$NSE_t = \alpha_i + \beta_1(NSE_{t-1}) + \beta_2(NYSE_{t-1}) + \beta_3(SSE_{t-1}) + \beta_4(Nikkei_{t-1}) \\ + \beta_5(TSX_{t-1}) + \beta_6(DAX_{t-1}) + \varepsilon_t$$

$$NYSE_t = \alpha_i + \beta_1(NSE_{t-1}) + \beta_2(NYSE_{t-1}) + \beta_3(SSE_{t-1}) + \beta_4(Nikkei_{t-1}) \\ + \beta_5(TSX_{t-1}) + \beta_6(DAX_{t-1}) + \varepsilon_t$$

$$SSE_t = \alpha_i + \beta_1(NSE_{t-1}) + \beta_2(NYSE_{t-1}) + \beta_3(SSE_{t-1}) + \beta_4(Nikkei_{t-1}) \\ + \beta_5(TSX_{t-1}) + \beta_6(DAX_{t-1}) + \varepsilon_t$$

$$Nikkei_t = \alpha_i + \beta_1(NSE_{t-1}) + \beta_2(NYSE_{t-1}) + \beta_3(SSE_{t-1}) + \beta_4(Nikkei_{t-1}) \\ + \beta_5(TSX_{t-1}) + \beta_6(DAX_{t-1}) + \varepsilon_t$$

$$TSX_t = \alpha_i + \beta_1(NSE_{t-1}) + \beta_2(NYSE_{t-1}) + \beta_3(SSE_{t-1}) + \beta_4(Nikkei_{t-1}) \\ + \beta_5(TSX_{t-1}) + \beta_6(DAX_{t-1}) + \varepsilon_t$$

$$DAX_t = \alpha_i + \beta_1(NSE_{t-1}) + \beta_2(NYSE_{t-1}) + \beta_3(SSE_{t-1}) + \beta_4(Nikkei_{t-1}) \\ + \beta_5(TSX_{t-1}) + \beta_6(DAX_{t-1}) + \varepsilon_t$$

This paper employs the VAR methodology due to its effectiveness in addressing endogeneity concerns, a significant challenge in econometric modeling using time series data. Additionally, the VAR approach allows for the generation of impulse response functions and the decomposition of forecast error variances, enhancing analytical insights. The VAR technique offers a flexible framework ideal for this study by treating all variables in the equation system as endogenous.

3. Results and Discussion

Table 2. Descriptive statistics for the selected indices

	NSE	NYSE	SSE	Nikkei	TSX	DAX
Mean	10602.025	11956.862	2926.736	20060.011	15821.680	11348.793
σ	4571.623	2741.678	512.240	6918.087	2780.737	2883.164
CV	0.431	0.229	0.175	0.345	0.176	0.254
CAGR	0.009	0.005	0.000	0.008	0.003	0.006
Kurtosis	-0.526	-0.897	0.167	-0.589	-0.745	-0.789
Skewness	0.733	0.238	0.016	0.114	0.556	-0.084
JB test	15.856 (0.000)***	6.874 (0.032)*	0.108 (0.947)	2.767 (0.251)	11.787 (0.003)**	4.414 (0.110)

Note: value in parentheses are p-values, σ represents the standard deviation, CV indicates the coefficient of variation, CAGR stands for the compound annual growth rate, and JB denotes the Jarque-Bera.

Source: Author(s) calculation.

Figure 1. Monthly time series plot for the actual ($I(0)$) data

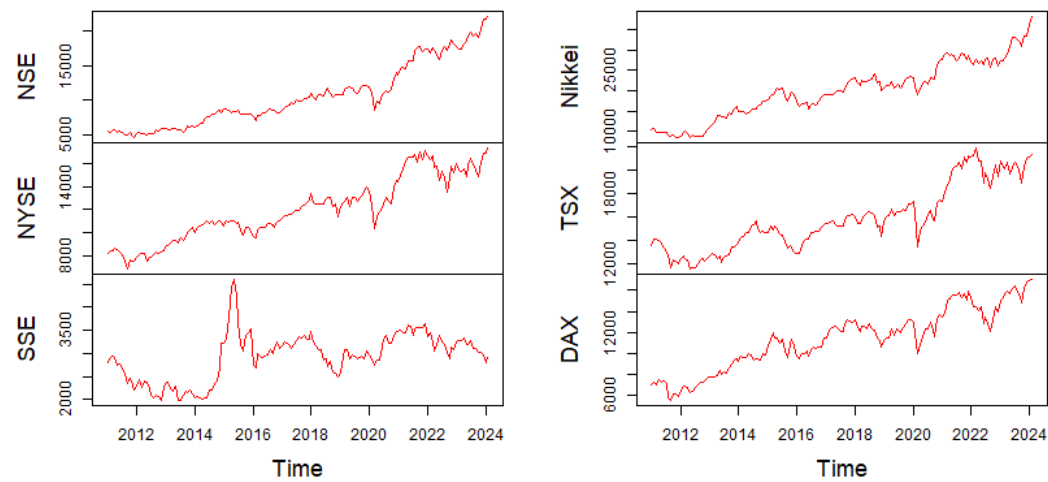
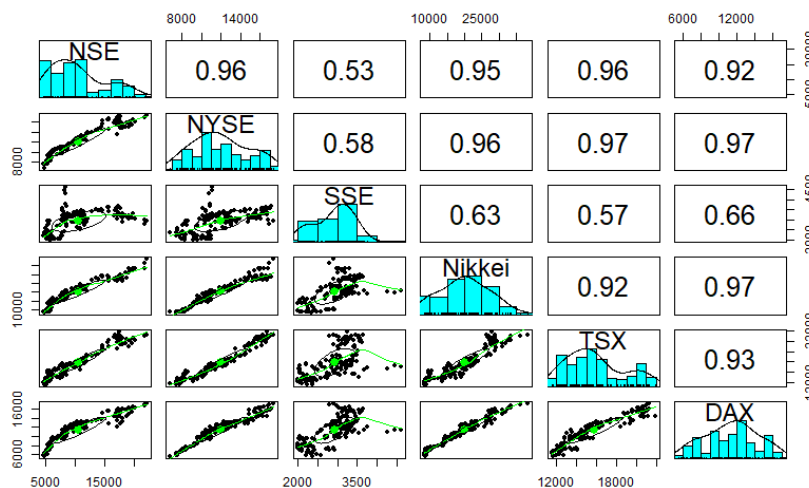


Table 2 presents significant descriptions of the behavior of the selected stock market indices for time series analysis. The mean values of the indices range between 2926.74 and 20060.01, with the SSE revealing the lowest mean and volatility, while the Nikkei has the highest mean and volatility. Almost all indices have coefficients of variation (CV) below 1, indicating stable performance relative to the mean. The NSE and Nikkei demonstrate stronger long-term growth potential, as evidenced by their higher compound annual growth rate (CAGR) values. The distributions of the majority of indices are flat and right-skewed. Additionally, half of the indices show deviations from normality, representing potential non-randomness in the series.

Figure 2. Correlation matrix



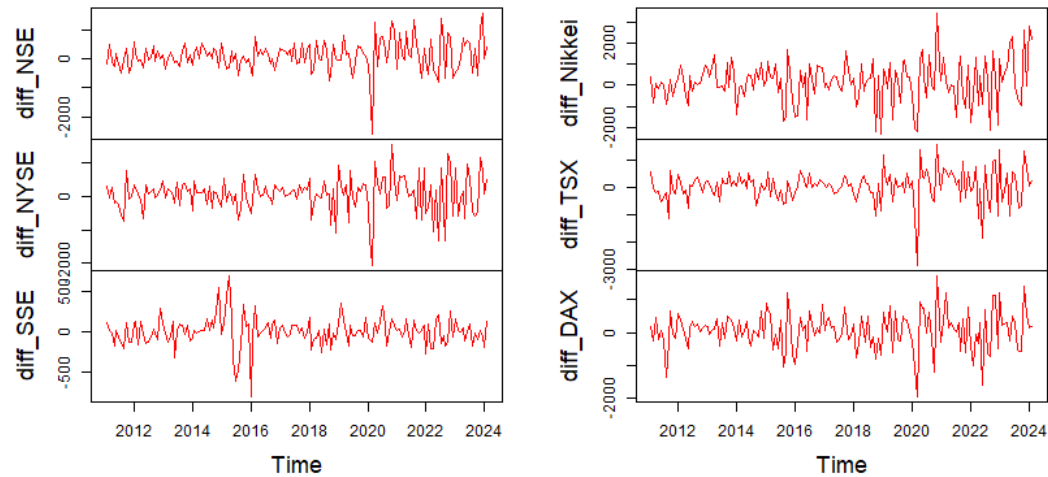
With the exception of SSE, all the other indices exhibit very high associations with each other, indicating strong degree of similarity in their movements in the global stock markets. On the other hand, SSE has moderate associations with the rest of the indices, ranging between 52.9% (between SSE and NSE) and 66.4% (between SSE and DAX).

Table 3. Augmented Dickey-Fuller (ADF) test

Exogenous: Trend and Constant	ADF test (I(0))		ADF test (I(1))	
	t-stat	p-value	t-stat	p-value
NSE	-1.0973	0.92	-5.6514	0.01
NYSE	-3.2661	0.08	-5.4112	0.01
SSE	-2.9256	0.19	-4.5441	0.01
Nikkei	-2.2173	0.49	-5.2794	0.01
TSX	-3.0828	0.13	-5.6658	0.01
DAX	-3.2947	0.08	-5.9236	0.01

Note: (I(0)) indicates that the time series is integrated at order 0, while (I(1)) indicates that the time series is integrated at order 1.

Source: Author(s) calculation.

Figure 3. Monthly time series plot for the first differenced (I(1)) data

It is evident that for all the indices, the ADF test with first-order differencing (I(1)) results in t-statistics ranging from -4.5441 to -5.9236, with corresponding p-values of 0.01. This specifies that the indices are stationary after differencing once. Hence, they do not exhibit a unit root and are suitable for modeling using a VAR model.

Table 4. Optimum lag order selection criteria

Lag	Log L	LR	FPE	AIC	SC	HQ
0	-7261.764	NA	1.81E+35	98.213	98.335	98.262
1	-6418.015	1607.69	3.30E+30*	87.298*	88.148*	87.643*
2	-6398.503	35.60	4.13E+30	87.520	89.100	88.162
3	-6383.879	25.49	5.55E+30	87.809	90.118	88.747
4	-6356.847	44.93	6.33E+30	87.930	90.968	89.165
5	-6322.628	54.10	6.60E+30	87.954	91.721	89.485
6	-6287.730	52.35*	6.89E+30	87.969	92.465	89.796
7	-6265.787	31.13	8.65E+30	88.159	93.384	90.282
8	-6231.129	46.37	9.28E+30	88.177	94.131	90.596
9	-6208.084	28.96	1.18E+31	88.352	95.035	91.068
10	-6186.376	25.52	1.57E+31	88.546	95.958	91.557

Note: Log L represents the logarithm of the likelihood function, LR stands for the likelihood Ratio, FPE denotes the final prediction error, AIC indicates the Akaike information criterion, SC is the Schwarz Criterion, and HQ denotes to the Hannan-Quinn Criterion.

Source: Author(s) calculation.

Selection of optimum lag order is important in time series analysis, since it has direct impact on the accuracy and predictive power of the model. In this study, several criteria are used to evaluate different lag orders, as depicted in Table 4. FPE measures forecast error variance, with the lower values signify the better forecasting performance. It is evident that the lag order 1 has the minimum FPE value, suggesting that this lag order may offer the most accurate forecasts. In line with these findings, the low values of AIC, SC, and HQ also confirm that a lag order of 1 has the potential to be the preferred choice. Hence, the optimum lag order of 1 is used for the estimation of VAR model to capture the essence of interconnected global financial markets.

Table 5. *Vector autoregression (VAR) model estimates*

	NSE	NYSE	SSE	Nikkei	TSX	DAX
NSE _(t-1)	0.950 (0.000)***	0.092 (0.078)	-0.008 (0.631)	0.251 (0.013)*	0.137 (0.017)*	0.105 (0.066)
NYSE _(t-1)	-0.115 (0.332)	0.890 (0.000)***	-0.039 (0.335)	-0.264 (0.252)	0.172 (0.189)	0.040 (0.758)
SSE _(t-1)	-0.142 (0.246)	-0.094 (0.442)	0.880 (0.000)***	-0.154 (0.515)	-0.012 (0.928)	0.023 (0.862)
Nikkei _(t-1)	0.088 (0.036)*	0.027 (0.516)	-0.005 (0.741)	0.898 (0.000)***	-0.029 (0.533)	0.017 (0.716)
TSX _(t-1)	0.071 (0.464)	-0.133 (0.174)	0.023 (0.491)	-0.173 (0.360)	0.673 (0.000)***	-0.159 (0.137)
DAX _(t-1)	-0.056 (0.503)	0.029 (0.729)	0.052 (0.068)	0.302 (0.061)	0.002 (0.984)	0.898 (0.000)***
α	167.436 (0.770)	1909.606 (0.001)**	54.329 (0.780)	2475.975 (0.027)*	2299.343 (0.000)***	1745.386 (0.006)**
Std. error	507.400	508.200	172.200	983.900	557.900	556.200
R ²	0.988	0.967	0.892	0.980	0.961	0.964
Adj. R ²	0.988	0.965	0.888	0.980	0.960	0.963
F-stat	2082.46	727.21	206.51	1251.88	622.35	668.23
p-value	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Log likelihood	-1197.19	-1197.43	-1027.51	-1301.17	-1212.08	-1211.61
AIC	15.340	15.343	13.178	16.665	15.530	15.524
SC	15.476	15.479	13.315	16.801	15.666	15.660

Note: value in parentheses are p-values.

Source: Author(s) calculation.

The estimated results of the VAR model among various stock market indices, namely NSE, NYSE, SSE, Nikkei, TSX, and DAX, are presented in Table 5. Except for the models using NSE and SSE as response variables, all other models exhibit positive and significant intercept values. However, the intercept values for the models with NYSE, Nikkei, TSX, and DAX as response variables, are higher than those for NSE and SSE. Almost all the indices experience positive and significant impact of their own past value (lag 1) on their future value, indicating strong autoregressive behavior, where its own past value is a good predictor of future values. The cross-market influences are also evident, notably for NSE influenced by Nikkei's past value and TSX influenced by NSE's past value. Furthermore, the F-statistics with associated p-values validate the overall significance of the models and their predictive power is extremely high, ranging from 89% to 99% across all the indices.

Table 6. *Forecasts for the selected indices using VAR model*

Month	NSE	NYSE	SSE	Nikkei	TSX	DAX
1/3/2024	22721.49	17871.50	2938.34	39031.07	21529.04	17438.47
1/4/2024	23283.27	18324.00	2961.24	39616.04	21858.91	17797.17
1/5/2024	23816.74	18758.45	2982.35	40210.79	22219.38	18154.09
1/6/2024	24328.79	19170.54	3003.38	40806.45	22593.21	18500.98
1/7/2024	24824.66	19558.77	3025.17	41398.13	22969.22	18833.63
1/8/2024	25308.40	19923.39	3048.02	41983.70	23340.46	19150.43
1/9/2024	25783.19	20265.81	3071.94	42562.83	23702.89	19451.47
1/10/2024	26251.57	20588.08	3096.74	43136.41	24054.48	19737.84

Source: Author(s) calculation.

The predictions for selected stock market indices using VAR model are presented in Table 6. It is noticed that the prices of all the indices are expected to increase over the next eight months. NSE and NYSE are expected to grow by roughly 2.10% per month, while all other indices, except SSE, are forecasted to increase by more than 1% and less than 2% per month.

Table 7. *Granger Causality test*

Sl. No.	Pairs	P-value	Pairs	P-value	Causality
1	NSE/NYSE	0.862	NYSE/NSE	0.019*	Uni-directional
2	NSE/SSE	0.638	SSE/NSE	0.382	No Causality
3	NSE/Nikkei	0.195	Nikkei/NSE	0.097	No Causality
4	NSE/TSX	0.405	TSX/NSE	0.001***	Uni-directional
5	NSE/DAX	0.870	DAX/NSE	0.056	No Causality
6	NYSE/SSE	0.550	SSE/NYSE	0.266	No Causality
7	NYSE/Nikkei	0.005**	Nikkei/NYSE	0.368	Uni-directional
8	NYSE/TSX	0.281	TSX/NYSE	0.025*	Uni-directional
9	NYSE/DAX	0.247	DAX/NYSE	0.686	No Causality
10	SSE/Nikkei	0.288	Nikkei/SSE	0.373	No Causality
11	SSE/TSX	0.271	TSX/SSE	0.653	No Causality
12	SSE/DAX	0.122	DAX/SSE	0.593	No Causality
13	Nikkei/TSX	0.855	TSX/Nikkei	0.017*	Uni-directional
14	Nikkei/DAX	0.933	DAX/Nikkei	0.018*	Uni-directional
15	TSX/DAX	0.115	DAX/TSX	0.925	No Causality

Source: Author(s) calculation.

Table 7 presents the results of the Granger Causality test conducted on various pairs of stock market indices. Majority of the pairs showing no causality between each other imply that there is no significant directional influence between those particular indices. Therefore, the movements or behaviors of these indices are basically independent of each other. The presence of unidirectional causality is noticed from NYSE, TSX and DAX to Nikkei, and from NYSE, TSX to NSE. Hence, it is evident that the past movements in these indices influence changes in the Nikkei and NSE, but not vice versa. Similarly, NYSE also exhibits unidirectional causality only from TSX.

In order to examine the interconnectedness and dynamics of global financial markets, the impulse response analysis is conducted, and its coefficients for various stock exchanges are presented in Table A1. These coefficients represent the response of each stock exchange to one-unit shock in itself and other exchanges. The shocks in NSE are positively influenced by its own past values along with the past values of other indices. Notably, the impact of Nikkei on NSE shocks shows an increasing trend from lag 1 to 11. Furthermore, NSE is the most responsive index, as it is responded by the shocks of all indices. The NYSE exhibits high responsiveness to the shocks resulting from the past five values of all the other indices (including its own previous values), with the exception of NSE. However, as the lag order increases, the magnitude of this effect begins to decrease. SSE, Nikkei, and TSX are extremely responsive to the shocks resulting from their own previous values compared to those of other indices. Interestingly, there is an upward trend in the coefficients with the increase in lag order for all the indices (except for their own past values) in affecting the shocks of Nikkei.

It can be observed from Table A2 that 100% of the variance in NSE is explained by its own shocks in the immediate period. As the lag increases, the proportion of variance explained by NSE's own shocks gradually decreases, while the contributions from other stock exchanges increase. However, by lag 10, around 85% of the variance in NSE is still explained by its own shocks, while the remaining 15% is attributed to the shocks from other exchanges. Similarly, for NYSE, 57.1% of the variance is explained by its own shocks, while 42.9% is attributed to the shocks from NSE at lag 1. With the increase in lag order, the proportion of variance explained by NYSE's own shocks decreases gradually, while the contributions from NSE and other stock exchanges increase. On an average, 78% of the movements in SSE are primarily driven by its own shocks, while NYSE, NSE and DAX contribute relatively lower proportions at 13%, 5% and 4%, respectively. More than half of the variance in Nikkei is described by its own shocks remains relatively stable around 49-52%, while the contributions from NSE range between 29-41%. Around 88% of the variance in TSX movements is described by shocks from NSE and NYSE, while only 10% is attributed to its own past shocks. Apart from the previous shocks from NSE, NYSE, and DAX, none of the other indices contribute at least 10% to the variations in DAX.

4. Conclusion

This study aims to explore the dynamic interactions among selected world stock market indices, namely the NSE, NYSE, SSE, Nikkei, TSX, and DAX, using the VAR approach. Monthly time series data spanning a period of 158 months, from 2010 to 2024, are studied. The results indicate that almost all the indices have strong associations with each other, except for the SSE, which shows moderate associations with the rest of the indices. Also, the results of the ADF test reveal that the indices become stationary at the first difference. An optimum lag order of one is chosen for estimating the VAR model to capture the essence of interconnected global financial markets, as indicated by the low values of FPE, AIC, SC, and HQ. The estimated results from the VAR model depict that almost all the indices exhibit a positive and significant impact from their own past values on their future values. Additionally, cross-market influences are observed between NSE and Nikkei, along with TSX and NSE. The predictive power of the model is extremely high across all indices. Moreover, the F-statistics and associated p-values confirm the overall significance of the models. The findings of forecast series suggest that the prices of all the indices are expected to increase over the next eight months. From the empirical results of the Granger causality test, the study found statistically significant evidence to conclude that the majority of pairs exhibit no significant directional influence between the particular indices. Unidirectional causality is observed only from NYSE, TSX, and DAX to Nikkei, from TSX to NYSE, and from NYSE and TSX to NSE. Empirical results from the impulse response function analysis reveal that only shocks in NSE are positively influenced by its own past values, along with the past values of other indices. With the exception of TSX and DAX, the forecast error variance decomposition (FEVD) test results indicate that most of the variance in each index is attributable to its own shocks.

While this study provides valuable insights, it is not without limitations. Its scope is constrained in terms of wider applicability, as it focuses solely on six major stock indices across the world. Consequently, the results may not be readily generalizable. As a future direction for research, it is recommended that other researchers expand the scope of the study to include additional stock indices.

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Table A1. Impulse Response Analysis

Impulse Response of Stock Market Indices to NSE Shocks							Impulse Response of Stock Market Indices to NYSE Shocks					
Lag	NSE	NYSE	SSE	Nikkei	TSX	DAX	NSE	NYSE	SSE	Nikkei	TSX	DAX
1	507.38	333.03	31.93	529.30	356.52	329.00	0.00	383.82	53.15	418.91	354.09	318.45
2	492.92	316.40	33.49	547.70	351.83	314.82	-7.37	310.11	54.39	301.76	292.48	253.34
3	482.95	300.84	34.70	561.28	343.26	300.99	-17.15	246.84	54.19	204.93	240.50	199.01
4	476.47	287.07	35.49	572.21	333.02	288.51	-28.33	192.37	53.02	124.79	195.94	153.31
5	472.70	275.44	35.85	581.92	322.52	277.90	-40.20	145.41	51.21	58.45	157.26	114.62
6	471.12	266.07	35.82	591.33	312.64	269.35	-52.26	104.92	48.97	3.56	123.34	81.75
7	471.30	258.90	35.45	600.99	303.87	262.85	-64.16	70.06	46.47	-41.81	93.42	53.77
8	472.94	253.81	34.83	611.21	296.47	258.29	-75.66	40.12	43.81	-79.24	66.93	29.94
9	475.79	250.62	34.02	622.14	290.54	255.49	-86.62	14.49	41.07	-110.05	43.41	9.66
10	479.69	249.12	33.07	633.84	286.09	254.25	-96.96	-7.37	38.31	-135.36	22.55	-7.57
11	484.49	249.10	32.04	646.25	283.04	254.36	-106.62	-25.92	35.57	-156.08	4.05	-22.17
Impulse Response of Stock Market Indices to SSE Shocks							Impulse Response of Stock Market Indices to Nikkei Shocks					
Lag	NSE	NYSE	SSE	Nikkei	TSX	DAX	NSE	NYSE	SSE	Nikkei	TSX	DAX
1	0.00	0.00	160.62	101.85	-5.29	34.17	0.00	0.00	0.00	708.58	-46.66	103.59
2	-16.09	-10.66	142.53	77.96	-8.37	36.97	53.40	28.35	0.98	676.00	-51.47	112.20
3	-30.07	-20.08	127.35	59.45	-13.57	37.04	97.03	58.39	0.78	655.91	-41.59	126.91
4	-42.11	-28.12	114.44	45.07	-19.89	35.43	133.17	87.70	0.14	643.64	-23.20	143.98
5	-52.42	-34.77	103.33	33.85	-26.61	32.86	163.49	114.88	-0.51	636.00	-0.44	161.13
6	-61.19	-40.07	93.67	25.04	-33.24	29.84	189.26	139.18	-0.95	630.92	23.97	177.04
7	-68.63	-44.14	85.18	18.05	-39.45	26.67	211.41	160.29	-1.11	627.05	48.29	191.03
8	-74.91	-47.09	77.66	12.41	-45.05	23.56	230.65	178.19	-0.96	623.59	71.46	202.82
9	-80.18	-49.09	70.95	7.73	-49.94	20.61	247.54	193.05	-0.53	620.13	92.89	212.42
10	-84.61	-50.29	64.92	3.72	-54.09	17.87	262.50	205.11	0.12	616.45	112.30	219.94
11	-88.32	-50.83	59.48	0.14	-57.51	15.35	275.87	214.71	0.94	612.53	129.60	225.62
Impulse Response of Stock Market Indices to TSX Shocks							Impulse Response of Stock Market Indices to DAX Shocks					
Lag	NSE	NYSE	SSE	Nikkei	TSX	DAX	NSE	NYSE	SSE	Nikkei	TSX	DAX
1	0.00	0.00	0.00	0.00	237.77	44.33	0.00	0.00	0.00	0.00	0.00	292.98
2	14.46	-30.24	7.69	-27.68	160.17	2.04	-16.26	8.41	15.13	88.58	0.52	263.16
3	24.99	-48.23	11.70	-41.48	105.31	-23.60	-25.33	14.45	26.31	150.42	-2.66	236.74
4	32.80	-57.49	13.33	-45.38	67.01	-37.67	-29.54	19.29	34.27	192.94	-6.96	214.09
5	38.77	-60.60	13.49	-42.37	40.77	-43.80	-30.53	23.53	39.66	221.48	-10.95	195.08
6	43.51	-59.45	12.76	-34.68	23.28	-44.58	-29.43	27.46	43.04	239.86	-13.95	179.31
7	47.47	-55.41	11.57	-24.00	12.13	-41.85	-27.04	31.18	44.88	250.84	-15.74	166.27
8	50.93	-49.50	10.16	-11.53	5.58	-36.90	-23.90	34.70	45.57	256.39	-16.33	155.47
9	54.09	-42.45	8.72	1.81	2.33	-30.64	-20.37	37.98	45.42	257.98	-15.89	146.44
10	57.08	-34.77	7.33	15.41	1.44	-23.71	-16.70	40.96	44.66	256.64	-14.60	138.78
11	59.99	-26.85	6.06	28.81	2.21	-16.52	-13.05	43.58	43.49	253.14	-12.68	132.16

Source: Author(s) calculation.

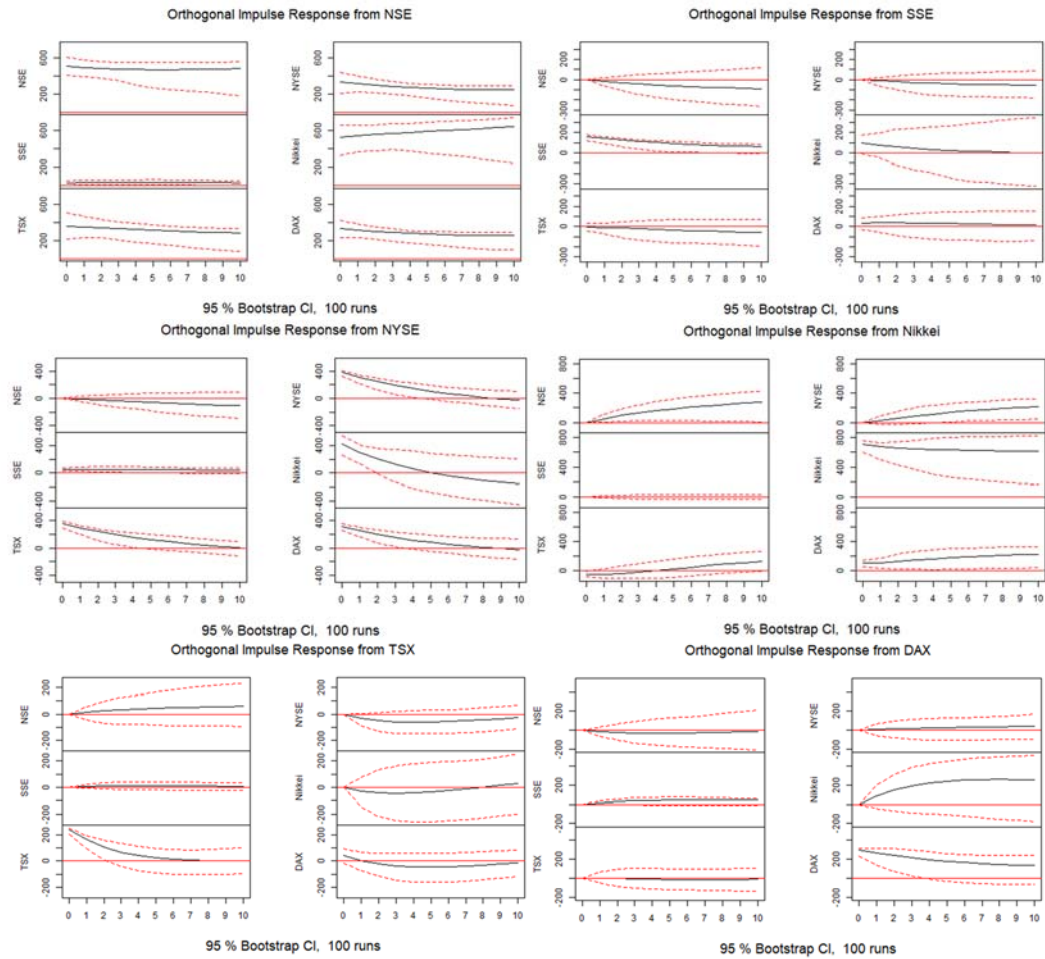
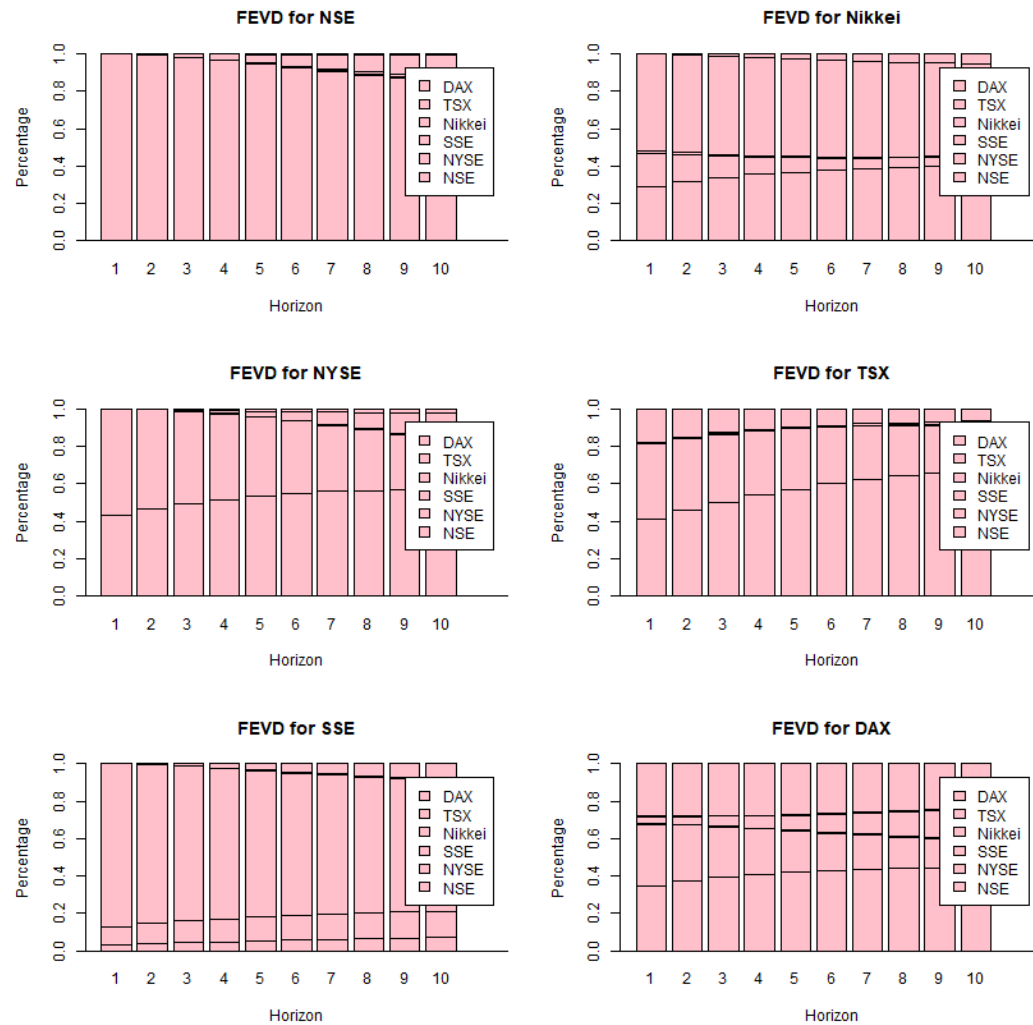
Figure A1. Graphical representation of Impulse Response Analysis

Table A2. *Forecast Error Variance Decomposition (FEVD) Analysis*

Variance Decomposition of NSE							Variance Decomposition of NYSE					
Lag	NSE	NYSE	SSE	Nikkei	TSX	DAX	NSE	NYSE	SSE	Nikkei	TSX	DAX
1	1.000	0.000	0.000	0.000	0.000	0.000	0.429	0.571	0.000	0.000	0.000	0.000
2	0.993	0.000	0.001	0.006	0.000	0.001	0.462	0.533	0.000	0.002	0.002	0.000
3	0.979	0.000	0.002	0.016	0.001	0.001	0.491	0.496	0.001	0.007	0.005	0.000
4	0.962	0.001	0.003	0.030	0.002	0.002	0.515	0.458	0.002	0.016	0.009	0.001
5	0.943	0.002	0.005	0.045	0.003	0.002	0.534	0.421	0.003	0.029	0.012	0.001
6	0.924	0.004	0.006	0.061	0.003	0.002	0.548	0.386	0.004	0.046	0.014	0.002
7	0.904	0.005	0.008	0.076	0.004	0.002	0.557	0.353	0.006	0.065	0.016	0.003
8	0.885	0.007	0.009	0.091	0.005	0.002	0.563	0.323	0.007	0.087	0.016	0.004
9	0.867	0.010	0.011	0.105	0.005	0.002	0.566	0.297	0.008	0.109	0.016	0.004
10	0.850	0.012	0.012	0.118	0.006	0.002	0.566	0.273	0.010	0.130	0.016	0.005
Variance Decomposition of SSE							Variance Decomposition of Nikkei					
Lag	NSE	NYSE	SSE	Nikkei	TSX	DAX	NSE	NYSE	SSE	Nikkei	TSX	DAX
1	0.034	0.095	0.870	0.000	0.000	0.000	0.289	0.181	0.011	0.519	0.000	0.000
2	0.039	0.106	0.849	0.000	0.001	0.004	0.317	0.146	0.009	0.524	0.000	0.004
3	0.044	0.115	0.825	0.000	0.003	0.012	0.338	0.117	0.008	0.525	0.001	0.012
4	0.049	0.123	0.802	0.000	0.004	0.022	0.355	0.094	0.006	0.524	0.001	0.020
5	0.053	0.128	0.780	0.000	0.005	0.033	0.368	0.077	0.005	0.520	0.001	0.028
6	0.057	0.133	0.760	0.000	0.006	0.044	0.378	0.065	0.005	0.516	0.001	0.035
7	0.061	0.136	0.742	0.000	0.006	0.055	0.387	0.056	0.004	0.511	0.001	0.040
8	0.065	0.138	0.726	0.000	0.006	0.064	0.395	0.050	0.004	0.505	0.001	0.045
9	0.068	0.140	0.712	0.000	0.006	0.073	0.401	0.046	0.003	0.499	0.001	0.049
10	0.071	0.142	0.700	0.000	0.006	0.081	0.408	0.043	0.003	0.493	0.001	0.052
Variance Decomposition of TSX							Variance Decomposition of DAX					
Lag	NSE	NYSE	SSE	Nikkei	TSX	DAX	NSE	NYSE	SSE	Nikkei	TSX	DAX
1	0.408	0.403	0.000	0.007	0.182	0.000	0.350	0.328	0.004	0.035	0.006	0.277
2	0.457	0.384	0.000	0.009	0.150	0.000	0.373	0.298	0.005	0.042	0.004	0.279
3	0.500	0.364	0.000	0.009	0.126	0.000	0.392	0.270	0.005	0.052	0.003	0.278
4	0.537	0.344	0.001	0.008	0.110	0.000	0.407	0.244	0.006	0.064	0.004	0.275
5	0.570	0.324	0.001	0.007	0.097	0.000	0.419	0.221	0.006	0.079	0.005	0.270
6	0.598	0.305	0.002	0.007	0.088	0.000	0.429	0.201	0.006	0.095	0.006	0.264
7	0.622	0.286	0.003	0.008	0.080	0.000	0.436	0.182	0.006	0.112	0.007	0.258
8	0.641	0.268	0.005	0.011	0.075	0.001	0.441	0.167	0.006	0.129	0.007	0.251
9	0.656	0.251	0.006	0.016	0.069	0.001	0.445	0.153	0.005	0.146	0.007	0.243
10	0.667	0.236	0.007	0.024	0.065	0.001	0.448	0.142	0.005	0.162	0.007	0.236

Source: Author(s) calculation.

Figure A2. Graphical representation of Forecast Error Variance Decomposition (FEVD)

Boosting human capital: how the COVID-19 pandemic accelerated agile methodology adoption in software development

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Abstract. *COVID-19 Pandemic period has changed the way business operate and forced workers and companies to adapt new ways of working and new business practices, being faced to new challenges.*

One of the most important shifts, consisting in working remotely, has also increased the usage of Agile Methodology, especially in software development. Agile Methodology consists in a dynamic and flexible way of working, capable of creating a working environment that empowers worker, creativity, autonomy, constant feedback, efficient communication, and iterative work. The paper aims to discuss the positive correlation between the increase in usage of Agile Methodology, due to social distancing procedures during COVID-19 Pandemic, and the Human Capital - particularly in IT development workforce area.

Keywords: COVID-19, Pandemy, Social distancing, Waterfall Methodology, Agile Methodology, Human Capital.

JEL Classification: J010, I000, O350, O390, Z130.

Introduction

COVID-19 Pandemic period has changed the way business operate and forced workers and companies to adapt new ways of working and new business practices, being faced to new challenges.

One of the most important shifts, consisting in working remotely, has also increased the usage of Agile Methodology, a dynamic and flexible way of working, capable of creating a working environment that empowers worker, creativity, autonomy, constant feedback, efficient communication, and iterative work.

Before COVID-19 Pandemic, many IT delivery projects were divided between using Waterfall or Agile methodologies. During and after pandemic, the use of Agile methodology has increased. The details of this shift and the dependencies with the human capital will be further detailed in the following article.

Agile Methodology is focused on iterative progress, constant proactivity and reactivity to any challenges and changes that may occur. Since worldwide the market has known many fluctuations in terms of traditional processes, Agile methodology has proven to be a way of working that allowed the quick fixes, quick adjustments to any unplanned shifts that needed to occur, combining this progress with effective communication and feedback across the companies and in relationship to the markets.

This article aims to describe, with applicability in IT domain, that Agile Methodology usage has increased, naturally, among development teams and among companies and together with this increase workers human capital has also grown. By encouraging an environment with continuous flexibility, adaptability, continuous learning, agile methodology has enabled workers to aim and to gain new skills, to enhance their abilities. The agile framework is consistently helping the team to strengthen teamwork and communication, therefore activating new skillsets and capabilities of the workforce.

Waterfall Methodology. Description and challenges during COVID-19 Pandemic.

The waterfall methodology is a project management approach that defines a linear, sequential progression of a project. The project follows clear, strict phases throughout its development, with well-defined and formalized procedures for deviations. Each phase must be completed before moving on to the next. This approach requires all stages to be synchronized and planned progressively to be completed linearly over time.

The most well-known stages of the waterfall methodology are as follows: Analysis and Requirements Specification Phase, Solution Design/ Architecture, Implementation, Testing and Acceptance Phase, Solution Installation Phase, Maintenance Phase.

In Analysis and Requirements Specification Phase, the final product to be achieved is outlined. Business and development workflows are defined, and the resources to be used in the project are identified. The requirements specification, work methods, and business processes are defined from both technical and non-technical/functional perspectives. The implementation team and the product reception team work intensively to establish the acceptance criteria for the product to be delivered.

In Solution Design and Architecture phase, the architecture of the solution to be implemented is outlined and agreed upon. In the waterfall methodology, the phases follow one another linearly and are interdependent. Therefore, phase 2 uses the complete and analyzed information from phase 1 to fully define the product of the second phase.

The third phase is the implementation phase, where technical and functional resources distribute the work equitably so that the final product can be delivered as officially agreed upon in the previous phases. This phase itself has its own granularity, depending on the project, to ensure that deliverables and the product are synchronized technically and functionally into a consistent final product.

In the Testing and Acceptance Phase, after the previous implementation phase is completed, the final product is tested. The goal is to confirm that the product meets expectations (according to the previous phases) and is fully functional. Once this stage is completed, the project moves on to the next phase.

In the Solution Installation phase, once the product has been accepted by the client, it is installed in the client's production environment. This is the point at which the product is delivered.

During Maintenance phase, the product has been delivered into the production environment, and end-users begin to use it. The delivery team remains available for a defined period to fix any errors and support end-users as they adapt to the new product.

Given the clear, linear nature of the waterfall methodology, certain strengths and disadvantages can be delineated. Among the clear advantages of using the waterfall methodology are the clarity regarding the product and each phase that has occurred, is occurring, and will occur, as well as the existence of clear, progressively developed documentation.

The disadvantages include inflexibility and the need to adopt a clear risk management strategy (each phase is dependent on the previous one and conditions the next one). Most importantly, for the waterfall methodology to work in favor of the project and not hinder its progress, it must be chosen carefully, documented thoroughly, and applied to the specific needs of the project in question.

The decrease in usage of Waterfall methodology, during COVID-19 Pandemic and after it has, in conclusion, multiple reasons:

- Waterfall methodology can lead to inflexibility in changing environments, because it stands for a linear development approach that makes it difficult to adapt to quick changes. On the opposite side, the pandemic imposed fast and risky changes, in order to keep many development project on track and efficient.
- Waterfall Methodology can face challenges faced to remote work context. Waterfall methodology has its bases on upfront planning and linear execution, beginning one phase only after finishing another, with strong documented dependencies and organized synchronization between the phases. This can be challenging in a period such as Covid-19 Pandemy, given the high risk and challenges also involved by the remote work settlement, considering aspects such as communication, challenges, risk management and stress management that converges from the rapid shifts that need to happen worldwide.
- Feedback is not naturally encouraged by the model. Waterfall methodology strenghts does not rely on feedback and iterative work. It relies on upfront planning, strong risk management, linear development. During COVID-19 pandemic, due to recurrent changes that occurred not only in IT sector, but also worldwide, the need to keep the attention to feedback and to integrate it inside fast changes has been an important asset for the teams working in Agile Methodology environment. On the other hand. Waterfall methodology has lost sympathy also because of this lack of reactivity and encouragement of feedback gathering and adoption.

COVID-19 pandemic has increased the risk intensity and types, in IT development projects. Agile methodology incremental development allows an easier and more efficient set-up and development changes due to short term appeared risks. Waterfall methodology, being more strict, linear, rigid, has lost sympathy.

Agile Methodology. Description and advantages in usage during COVID-19 Pandemic

The Agile methodology is a project management approach that defines an incremental, iterative progression. Throughout its development, the project consists of phases that overlap and interweave, allowing continuous integration, advancing flexibly and collaboratively, and continuously improving, with the ability to make changes to both requirements and work priorities. Agile methodology emphasizes flexibility, recurring feedback, and responsiveness to the work being done.

Within the Agile methodology, several frameworks are defined, including Scrum, Kanban, and Extreme Programming. Depending on the framework, specific processes and ceremonies are established to facilitate continuous collaboration and sustained communication. Together, these create a model that matures over time, naturally encouraging the team towards collaboration, flexibility, and evolving work ideas to achieve objectives.

Regardless of the chosen framework, Agile methodology follows the Agile Manifesto, which outlines the ideals of the model and facilitates its adoption as an ideology. The Agile Manifesto supports and proposes: Individuals and interactions over processes and tools, Working software over comprehensive documentation, Customer collaboration over contract negotiations, Responding to change over following a plan. Additionally, Agile methodology includes a set of 12 principles highlighted by each practice proposed by Agile frameworks.

Therefore, among the advantages of using Agile in software development we can count on flexibility, permissiveness, continuous collaboration, and the presence of a framework of ceremonies and communication that facilitates collaborative, iterative, and constantly evolving work.

In the context of remote work and social distancing, among with the stress of facing a life threatening social context, the Agile Methodology in software development increased, due to its pillar principles that acted properly for the entire social and workforce context of the Pandemic.

The flexibility that stands for the Agile Methodology is the only solution for the changing context of the Pandemic, in software development labour market. The permissiveness, the continuous collaboration and the facilitated ceremonies and communication framework allow quick fix solutions, in a continuous changing social and working environment. Considering the iterative pillar principle, Agile Methodology allows objectives to be changed directly in order to make them fit for the continuous evolving market.

Direct correlation between Human Capital and Agile Methodology

According to the accepted terminology in specialized literature, human capital encompasses the capabilities of individuals, which are unique to each person, and either remain the same or grow in complexity in any social environment. These capabilities can be leveraged in the labor market in exchange for economic resources of any kind.

We can further refine the definition of human capital to be more quantifiable. The most accepted method in the literature for aggregating human capital involves two main components: educational capital (formal schooling and related education) and biological capital (biological endowments, which are significant factors in an individual's adaptability).

By delving deeper into these two measurable components, we can outline some aggregate indicators representing and measuring the elements of human capital. These indicators can be accumulated individually or collectively.

The measure of educational capital, a major component of human capital, can be assessed through the following indicators: preventive health, formal education based on mandatory institutional study outcomes, formal education based on optional study outcomes, financial literacy (measurable by the allocation of financial resources across different consumption areas), proactive health culture, formal education regarding continuous study, social skills, cognitive skills, practical skills, adaptability skills, corrective health, and others.

On the other hand, measuring biological capital, another major component of human capital, is challenging but is also influenced by educational capital. Educated individuals often have better access to quality healthcare services.

Clearly, each of these discussed components encompasses various other relevant indicators at different levels.

The impact of human capital on the labor market and, consequently, on a country's economic level, is immense, especially today. For example, consider the aggregate indicator of cognitive ability. Suppose an employee works in the IT & Telecommunications sector. Their approach to work, in terms of acquiring and processing new information, can be crucial for their professional and financial development. New technologies are constantly emerging, both in response to and in anticipation of reality. This individual must stay attuned to societal needs and the technical tools for their work (new programming technologies, new tools). They must also inspire their clients to increase their receptivity and cognitive abilities to ensure the longevity of their work. By inspiring clients to learn and adapt, they secure long-term clientele.

It is evident that their cognitive abilities will enhance their work quality and complexity, thus impacting the company. Consequently, their professional and financial status will also improve. Extrapolating this to the entire IT and Telecommunications labor market, the impact of cognitive abilities (or their measurement) will determine the direction and scope of the labor market in this field.

The same link can be further taken into consideration when discussing about Agile methodology increase usage during Pandemic and the involvement of this increase upon human capital of the IT and Telecommunication work market.

Agile Methodology and the Human capital can be easily correlated, as Agile methodology practices are mainly focusing on the workers skills and resources to create a work mechanism to increase communication, efficiency and efficacy.

Agile Methodology practices aim to create, based on the team resources and together with them, a working mechanism, that would evolve into empowering the team and the teamwork, hand in hand with the human behaviour and conduite. The success of the adoption consists into the success of adaptability of the team members to a new mechanism. A mature and successful team will be able to empower each team member and to provide

the needed autonomy, to be creative, but consistent and organized in a working mechanism. The result upon the worker is that it will feel more empowered, more responsible, and even more motivated, leading to increased creativity, work satisfaction and autonomy. This results into increased human capital.

In the way of working proposed by the principles of the Agile Methodology, there are several ceremonies/meetings that will be held across the team. This can be, for example, retrospective meeting, Sprint Planning, Sprint Demo and so on. Given the recurrence of the ceremonies, the worker is enforced to a continuous learning, being recurrently provoked to deliver, to be present and to take part upon the 360 ideas that are exchanged inside the team, for the project to advance in the respective iterations. This continuous learning encourages the worker to gain new skills, new perspectives, to keep growing and accepting challenges. This working mechanism increases a culture of development, of growing, being continuously in deep connection to the project and among the team. The results are, naturally, first handed upon human capital. The worker will be part of a continuous growing environment, receptive, that is recurrently asking the individual to step forward and to demonstrate what he has achieved, during controlled and efficient team ceremonies.

One of the key tools of implementing and maturing an Agile team development is the communication between team members and with the delivery environment. Agile Methodology best practices propose and encourage the team to be collaborative, to communicate frequently, to be aware constantly of the 360 degrees dimension of the delivery. In agile methodology there is a strong importance of communication, and there are many communication methods proposed. Among them, the tools existent, currently, are matching the needed requirements for the agile team in order to mature, also considering the communication dimension. On one hand, the need to accommodate to the communication best practices across the team and with the team environment increase the communication skills of the worker, increasing accordingly the human capital. On the other hand, the need to understand also and accommodate with the respective tools encouraged by the model (e.g. JIRA, Azure DevOps) help the worker to increase the adaptability component of the human capital, among with his continuous learning skills and the actual learning benefit.

One of Agile Methodology principles, as also described above, is the customer focus. Agile practices describe processes where the link with the client is constantly maintained, the feedback is provoked and beneficial for the team, to correct or to increase developments in the time, for the future iterations. The result is also naturally beneficial upon the worker because, based on the continuously received feedback, he is encouraged to grow, to upskill, to change and correct in the areas where improvements are needed. Receiving and understanding feedback, among with the corrective attitude imposed by it, represent high assets for the human capital of the worker.

Agile methodology encourages flexibility, along with adaptability and reactivity and proactivity to change. The qualities that increase in this flexible, adaptable work environment is beneficial for the human capital of the worker.

The focus of the Agile methodology is to use and increase human capital of the worker, in order to create a working mechanism that will increase the efficiency of the delivery, along with the efficiency of the team. Strong collaboration, feedback, proactivity, satisfaction, consistency, autonomy, empowerment, are just a few of the main common focus points of the model with Human capital of the worker.

COVID-19 pandemic has increased the usage of Agile methodology in software implementation

The COVID-19 pandemic brought about significant changes in work methods, particularly through the imposition of social distancing. As a result, remote work and online collaboration were encouraged, as well as remote interactions with public institutions.

The principles underlying Agile methodology supported effective remote work. Adaptability to change, a cornerstone of Agile methodology, facilitated necessary changes in projects already underway amidst the presence of risk.

The Agile work model's ability to reallocate tasks and resources quickly to achieve efficiency and effectiveness came to the forefront. During the pandemic, due to shifts at all levels—both in terms of the labor market and working conditions, as well as the market for products and services—demand and supply underwent changes imposed by new risks.

The Agile work model, with its premise of working incrementally and allowing for short-term changes, enabled project trajectory adjustments while maintaining balance within the delivery team and the entire project.

Additionally, Agile emphasizes frequent delivery. One of Agile's tools is sequential, frequent deliveries. For example, in the SCRUM framework, work is conducted in iterations called sprints, typically lasting two weeks. The delivery team undertakes as much work as it can handle during the iteration, and at the end, a demo is presented to the client, followed by a delivery. Thus, the Agile model, and specifically SCRUM, allows for quick changes and rapid deliveries in response to unforeseen situations, all within the project's guiding principles.

At its core, the Agile model involves collaborative work, continuous feedback, and ongoing communication. From the beginning, certain recurring or on-demand ceremonies are established to create a cohesive work mechanism. Initially, the team members support the work mechanism, but as the project matures, the mechanism itself propels the team, particularly in terms of continuous feedback and communication. Due to the persistence of

remote work caused by the COVID-19 pandemic, the tools provided by Agile methodology proved to be valuable assets for teams already working in an Agile manner. The facilitation of ceremonies (Retrospectives, Backlog Refinement, Sprint Planning, Daily Meetings) allowed many Agile teams to feel the effects of remote work more gently.

The iterative work model promoted by Agile enabled teams to foster autonomy and trust in individuals to manage their own work. The mechanisms for feedback, communication, and collaboration through recurring ceremonies, as well as continuous delivery, provided granularity and transparency in work, benefiting both development teams and clients during the COVID-19 pandemic.

Indeed, the choice of work methodology, whether Waterfall or Agile, primarily depends on the project's purpose and type. However, during the COVID-19 pandemic, the Agile methodology proved to be more suitable, beyond the intrinsic reasons for its selection.

Conclusions

The COVID-19 pandemic has encouraged the use of the Agile methodology over Waterfall in IT development projects. The reasons are numerous and are rooted in the core principles of the Agile model, which perfectly aligned with the needs during and after the pandemic. This period highlighted the strengths of the Agile model and motivated workers to evolve.

The increased use of the Agile methodology has also led to growth in the human capital of workers, aspects highlighted and described in the existing paper, with focus on the preliminary determinants of the Agile model: enhanced flexibility and adaptability, improved collaboration and communication, frequent feedback and iterative progress, empowerment and autonomy, focus on delivering continuous value. Overall, the agile methodology's principles and practices create a long term working environment that empowers continuous learning and improvement, significantly contributing to the growth of human capital.

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Do gold, oil and bitcoins
possess safe heaven attributes in times of crisis?
Empirical evidence using a wavelet-based
time-frequency dependency approach
from the pandemic to the Russia–Ukraine crisis

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Abstract. *In the context of two important global events, i.e., the health crisis arising from the COVID-19 pandemic and the geopolitical tension resulting from the Russia-Ukraine war, the present study examines the existence of safe haven attributes of gold, oil and bitcoins against equities from five major countries i.e. US, China, India, Europe and Japan. Using daily observations from 1st January, 2020 to 31st December, 2023 and the wavelet coherence methodology the study finds persistent and strong correlations between gold, oil, and bitcoin returns vis-à-vis stock returns during periods of tranquility and turmoil. Gold exhibits safe haven features only over a long-term investment horizon, acting as a portfolio diversifier against stock market risk in short-term and medium-term periods. Both oil and bitcoins, on the contrary, are highly correlated with equities, suggesting they are viable diversifiers in turmoil and as hedges, but not as safe havens to mitigate stock market risk. Nevertheless, under normal circumstances, all examined assets possess the capacity to function as hedging assets and diversifiers against equities across different investing horizons.*

Keywords: wavelet analysis, cryptocurrency, stock market, safe haven, hedge, Russia–Ukraine war.

JEL Classification: C22, G01, G11, G15.

1. Introduction

A common feature of the global financial market is its risk, volatility, and great level of unpredictability during times of crisis. The recent COVID-19 epidemic in 2020 and the Russia-Ukraine war in 2022 are notable examples of how crises can disrupt markets and result in a massive loss of value for investors worldwide (Pandey and Kumari, 2021). This unprecedented increase in the volatility has sparked resurgence in the hedging, diversification, and safe haven instruments. Investors and portfolio managers mostly use risk-mitigation measures such as hedging or diversification, whereas investment in safe havens happens mostly during periods of extreme market circumstances and crises (Baur and Lucey, 2010). Numerous empirical and theoretical studies have highlighted gold, commodities, and most recently, cryptocurrencies, as alternative assets for portfolio risk management (Yousfi, Farhani and Bouzgarrou, 2024). Gold, also known as yellow metal, has always outperformed other asset classes; the literature has consistently documented its hedge and safe-haven property against stock indices (Baur and Lucey, 2010; Bouri *et al.*, 2020; Hussain Shahzad *et al.*, 2020; Mensi *et al.*, 2023; Velip, Jambotkar and Velip, 2023; Yousfi, Farhani and Bouzgarrou, 2024). The empirical literature also suggest alternative assets such as oil and other commodities, as well as cryptocurrency, as desirable safe havens and effective hedges (Shahzad *et al.*, 2019; Ali *et al.*, 2022; Boubaker and Larbi, 2022). While (Hussain Shahzad *et al.*, 2020) vouches for gold to be superior and most desirable safe haven and hedge, (Selmi *et al.*, 2018; Bouri *et al.*, 2020) suggest that cryptocurrency such as bitcoins exhibits superior hedge and safe haven properties over traditional assets such as gold and oil. In contrast, (Kliber *et al.*, 2019; Smales, 2019; Conlon and McGee, 2020) suggest that bitcoins do not offer any significant safe haven or hedge attributes as well as diversification benefits to investors in comparison to gold and commodities. Building on these findings, it is worth noting that the crisis phase can have a substantial impact on the performance of alternative assets that could serve as hedges, diversifiers, or safe havens. The current study intends to investigate the prevalence of safe haven features in gold, oil, and cryptocurrency in light of two significant global events: the health crisis caused by the COVID-19 pandemic and the geopolitical tension caused by the Russia-Ukraine war, this research will contribute to a better understanding of their role in investors' portfolios.

2. Data and Methods

The study considers daily prices of three potential safe-haven assets namely gold, oil and Bitcoin alongside the stock market indices of three major gold consuming countries USA, China and India for empirical analysis. The data pertaining to the stock indices and oil prices are sourced from (www.investing.com), while the data for gold in respective currencies is sourced from (www.gold.org) and the data for the bitcoin is sourced from website (www.coinmarketcap.com) in US dollars. The sample period is considered from 1st January, 2020 to 31st December, 2023 covering a period of COVID-19 and the Russia-Ukraine War. The daily price series for each variable is transformed into returns using the function $R_t = \ln (P_t/P_{t-1}) * 100$.

Subsequently, a robust method of wavelet coherence (WTC) is applied to measure the relationship between two time series i.e. stock and gold, stock and oil and stock and bitcoin. This method allows detecting significant co-movement on a time frequency domain. Following (Torrence and Compo, 1998) a cross-wavelet power of two distinct time series $x(t)$ and $y(t)$ is estimated using the continuous wavelet transform $W_x(\tau, s) = W_x(\tau, s) \cdot W_y^*(\tau, s)$ where, $W_x(\tau, s)$ are continuous wavelet transforms and τ and s are the position index and scale.

Based on the above the squared wavelet coherence between x and y time series is defined as:

$$R_{xy}^2(\tau, s) = \frac{|S(s^{-1}W_{xy}(\tau, s))|^2}{S(s^{-1}|W_x(\tau, s)|^2 \cdot S(s^{-1}|W_y(\tau, s)|^2))} \quad (1)$$

The R_{xy}^2 represents the squared coherence Following (Torrence and Compo, 1998). The squared coherence fluctuates between 0 and 1 where value close to 1 indicates strong co-movement while a 0 represents no co-movement. Furthermore the lead and lag relationship within the coherence of the time series is drawn using the wavelet phase angle difference following the technique proposed by (Torrence and Webster, 1999) as:

$$\phi_{x,y}(\tau, s) = \arctan\left(\frac{I(W_{xy}(\tau, s))}{R(W_{xy}(\tau, s))}\right) \quad (2)$$

Where R and I corresponds to the real and imaginary parts of the wavelet coherence plot and the difference phase arrows are indicated in the wavelet coherence spectrum plot.

Additionally, to analyze the dynamic interconnectedness in the time series and cross validate the results from the wavelet coherence the study adopts the TVP-VAR ("Time-Varying Parameter Vector Autoregressive") directional pairwise connectedness approach proposed by (Antonakakis, Chatziantoniou and Gabauer, 2020; Gabauer, 2021) based on (Diebold and Yilmaz, 2015) is adopted.

3. Results and Discussion

Table 1 presents the descriptive statistics. The mean values of all the assets indicate positive returns, including market returns, except for the market returns of the S&P 500 and SSEI Index. All the variables possess a significant coefficient for the Jarque-Bera test, suggesting that they are normally distributed. The ADF test reveals that all the series under examination are stationery and fit for estimation.

Wavelet coherence analysis

The study adopts the wavelet squared coherence approach to gauge the pairwise comovements between stock indices and the probable safe haven assets. The phase difference and phase arrows are included in the plots alongside the period shown on the left vertical axis, while the frequency domain is shown on the horizontal axis. The color bars show the magnitude of comovement, ranging from 0 to 1, where 0 is indicated by the

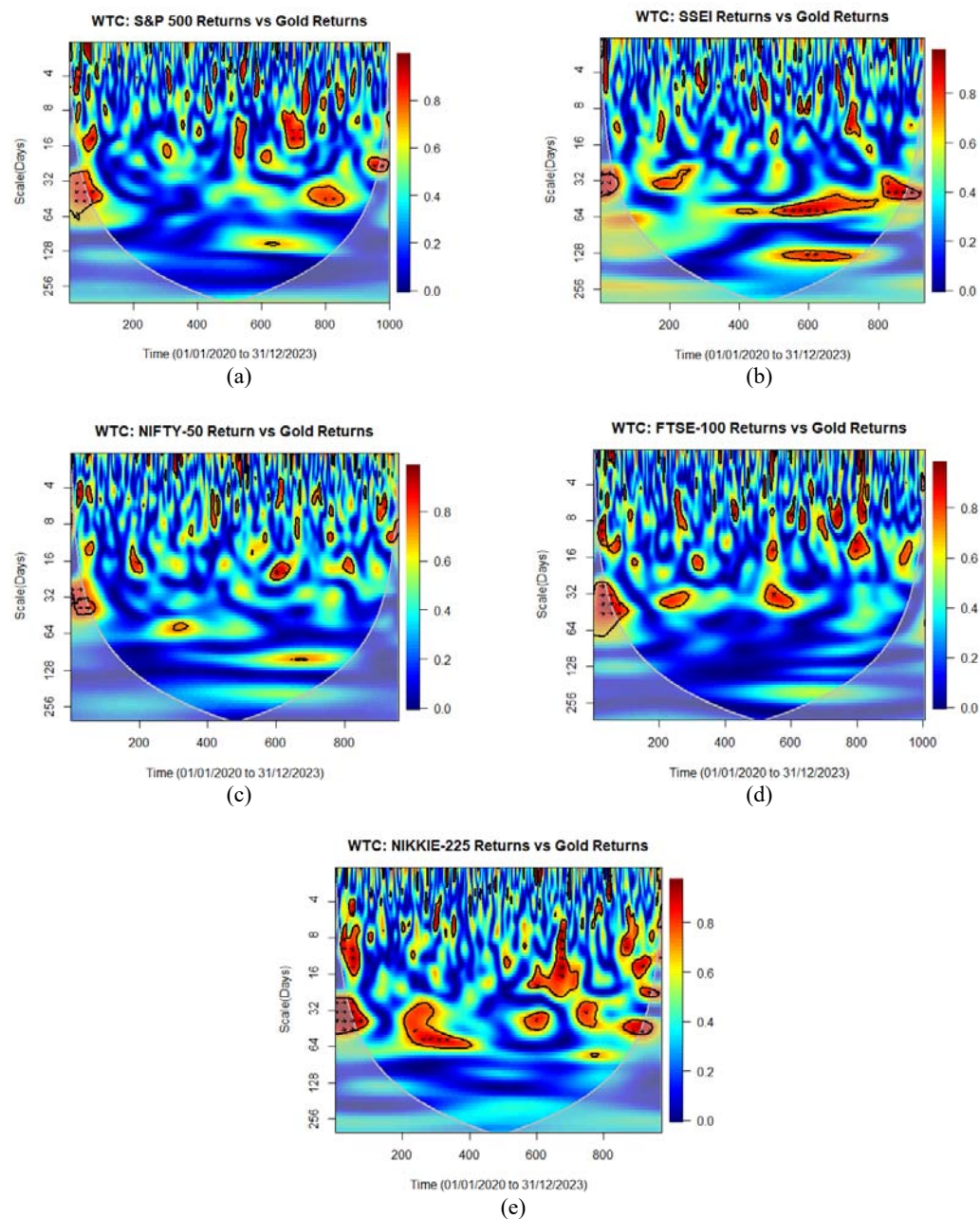
deep blue color, which signifies weak comovement, while 1 indicated by a deep red color corresponds to strong comovement. The directional arrows point out to the direction of comovement. Right-pointing arrows and left-pointing arrows indicate inphase (positive comovement) and antiphase (negative comovement). The directional arrows pointing right upward and left downwards indicate that the first variable stock returns lead and the second variable gold, oil, and bitcoin returns lag, whereas right pointing downward and left pointing upward suggest that the second variables gold, oil, and bitcoin returns leading and stock returns lag. The bright red color palette within the black line pocket indicates coherence distortion at the 5% level of significance. The time scales of 5 days per week are interpreted based on Owusu Junior et al. (2019) wherein “2–4 days (intra-week scales), 4–8 days (weekly scale), 8–16 days (fortnightly scale), 16–32 days (monthly scale), 32–64 days (monthly to quarterly scale), 64–128 days (quarterly to biannual scale), and 128–256 days (biannual to annual scale)”.

Table 1. Descriptive Statistics

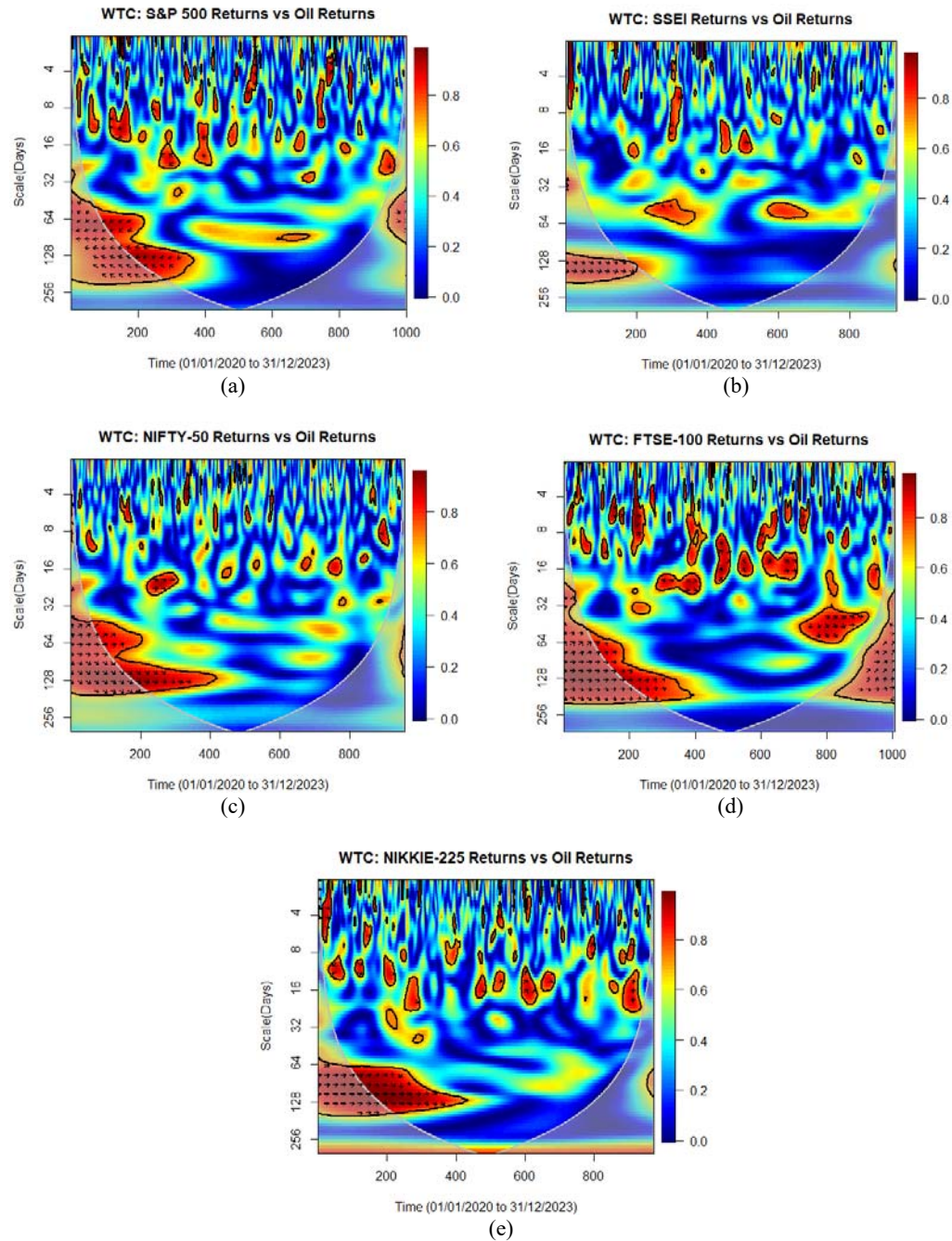
	Mean	Std. dev.	Min.	Max.	Skewness	Kurtosis	Jarque-Bera	ADF test	Obs.
United States									
S&P-500	-0.0004	0.0145	-0.0896	0.1276	0.7813	12.6097	6766.9 ^a	-09.22 ^a	1001
Gold	0.0003	0.0099	-0.0526	0.0513	-0.3354	3.4749	526.25 ^a	-10.52 ^a	1001
Oil	0.0009	0.0407	-0.2813	0.4258	1.1458	29.7500	3729.7 ^a	-09.24 ^a	1001
BTC	0.0017	0.0433	-0.4972	0.1918	-1.7320	20.0228	1730.1 ^a	-09.77 ^a	1001
China									
SSEI	-0.0001	0.1007	-0.0800	0.0754	-0.4681	7.2557	2093.2 ^a	-10.35 ^a	933
Gold	0.0035	0.0094	-0.0548	0.0473	-0.4369	3.8863	621.42 ^a	-10.28 ^a	933
Oil	0.0009	0.0427	-0.2813	0.4258	1.0545	26.9725	2859.1 ^a	-8.78 ^a	933
BTC	0.0016	0.0438	-0.4972	0.1918	-1.7926	20.4610	1685.7 ^a	-9.35 ^a	933
India									
NIFTY-50	0.0006	0.0130	-0.1390	0.0840	-1.7413	20.4049	1718.5 ^a	-8.57 ^a	958
Gold	0.0004	0.0099	-0.0568	0.0484	-0.3757	3.5328	535.66 ^a	-10.28 ^a	958
Oil	0.0009	0.0426	-0.2813	0.4258	1.3333	29.1499	3435.9 ^a	-8.15 ^a	958
BTC	0.0019	0.0435	-0.4972	0.1918	-1.7551	20.3618	1712.3 ^a	-9.03 ^a	958
Europe									
FTSE-100	0.0001	0.0119	-0.1151	0.0866	-1.1437	14.3032	8845.6 ^a	-9.13 ^a	1007
Gold	0.0003	0.0095	-0.0562	0.0508	-0.2709	4.5576	525.66 ^a	-10.28 ^a	1007
Oil	0.0008	0.0406	-0.2813	0.4258	1.1399	29.9714	3435.9 ^a	-8.15 ^a	1007
BTC	0.0017	0.0440	-0.1918	0.4972	1.6582	18.8033	1712.3 ^a	-9.03 ^a	1007
Japan									
NIKKEI-225	0.0004	0.0129	-0.0627	0.0773	0.0452	3.0579	382.93 ^a	-10.33 ^a	974
Gold	0.0005	0.0107	-0.0653	0.0535	-0.3769	4.8773	994.97 ^a	-11.11 ^a	974
Oil	0.0007	0.0416	-0.2813	0.4387	2.1517	37.7927	589.76 ^a	-8.89 ^a	974
BTC	0.0021	0.0446	-0.4772	0.1918	-1.6739	18.6434	146.30 ^a	-9.48 ^a	974

Notes: The Jarque-Bera test statistics represent normality test; ADF denotes Augmented Dickey Fuller test; ^a means indicates a Rejection of the null hypothesis at the 1% significance level.

The classification of an asset as a hedge, diversifier, or safe haven is based on (Baur and Lucey, 2010; Bouri *et al.*, 2017, 2020), wherein an asset is a diversifier having a weak positive correlation with another asset in the portfolio, while a hedge can be weak (strong) having no correlation (negative correlation) with other assets on average. However, assets that are uncorrelated (negatively correlated) with other assets during crises or turmoil's, such as the period of COVID-19 and the Russia-Ukraine War, are considered safe havens.

Figure 1. Wavelet Coherence – Gold

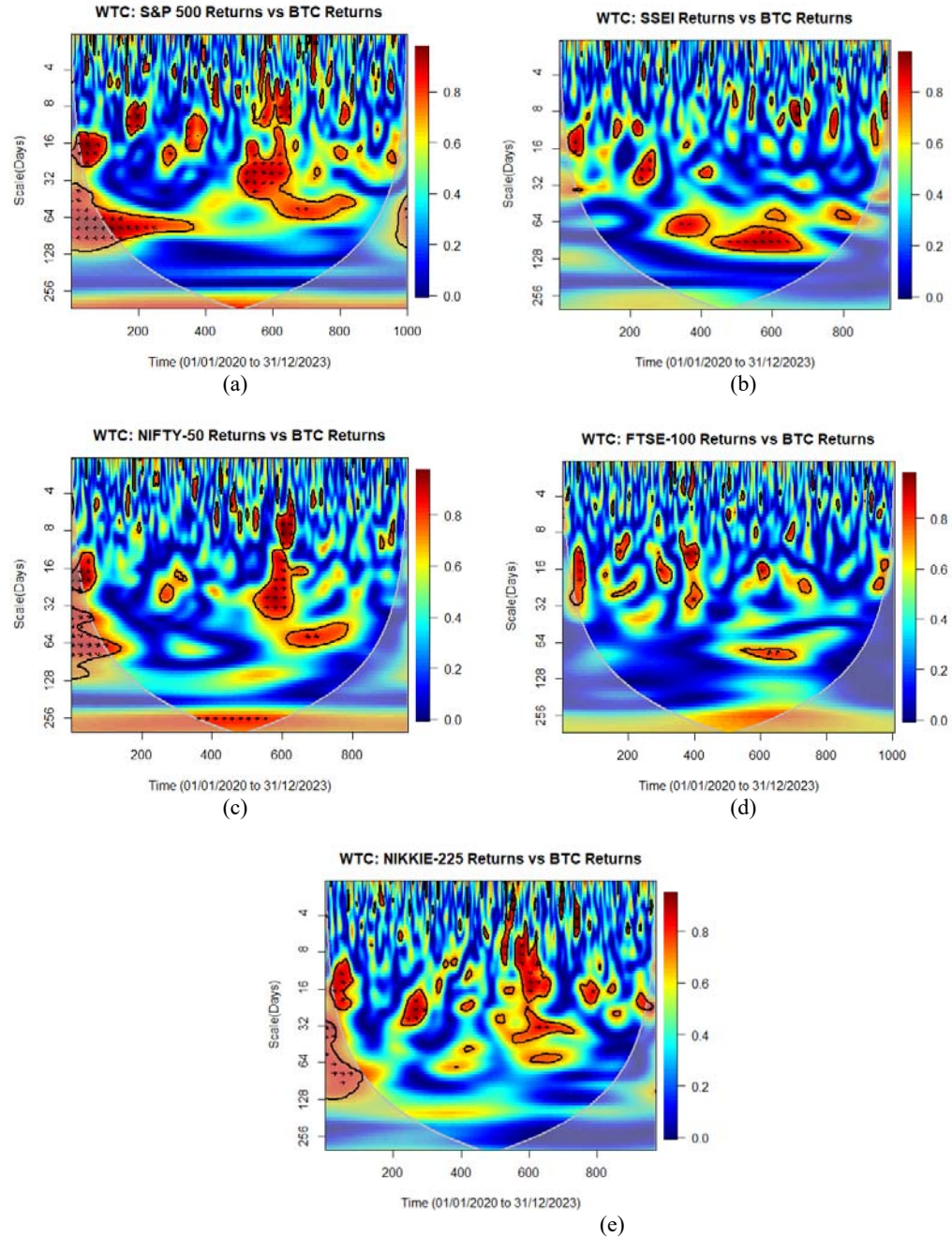
(a) USA - WTC: S&P 500 and Gold. (b) China-WTC: SSEI and Gold. (c) India-WTC: Nifty-50 and Gold
 (d) Europe-WTC: FTSE-100 and Gold (e) WTC: WTC: NIKKEI-100 and Gold.

Figure 2. Wavelet Coherence – Oil

(a) USA - WTC: S&P 500 and Oil. (b) China-WTC: SSEI and Oil. (c) India-WTC: Nifty-50 and Oil
 (d) Europe-WTC: FTSE-100 and Oil (e) WTC: WTC: NIKKEI-100 and Oil.

Figure 1 depicts the coherency results for gold and stock market indices across time and frequency domains, which do not appear to vary considerably between markets, with a deep blue colour dominating the majority of the plot region. However, in the short-term investment horizon (up to 16 days), there are a number of black contours across the crisis period, indicating a robust correlation between gold and stock market returns. The medium-term and long-term investment horizons, on the other hand, have different consequences. For both crisis periods, the US, India, and European markets exhibit less volatility than Japan and China. During the medium-term horizon, all markets except the US show an in-phase direction of arrows facing rightward during the crisis, indicating a positive dependency between stocks and gold, whereas US markets show left-ward arrows, indicating a negative correlation, demonstrating the presence of safe haven characteristics for gold in US markets (Baur and Lucey, 2010). The long-term horizon for all markets is dominated by a deep blue colour, indicating no association, especially during times of crisis. We can suitably conclude that gold exhibits safe haven features only over a long-term investment horizon, while primarily acting as a portfolio diversifier against stock market risk. This findings corroborate the pervious findings of (Paramati, Abedi Shamsabadi and Reddy Kummitha, 2023; Velip, Jambotkar and Velip, 2023).

The representations in Figure 2 reveal strong comovements and dependency between stock returns and oil returns across markets. The presence of large red contours in the short, medium, and long-term investment horizons with right-facing arrows during the COVID-19 period (2020–2021) for China, India, Europe, and Japan strongly suggests the existence of high dependency, suggesting that oil can be used as a diversifier in turmoil and for the short run as a hedge but does not act as a safe haven for stock market risk. Interestingly, the US stock market reveals a negative correlation with oil, which points to the safe haven phenomenon of oil with equities in the COVID-19 period but not during the war period. Besides the prevalence of a strong association during the COVID-19 period, such a trend was not evident during the Russia-Ukraine war, except for Europe. This indicates that market volatility was not as persistent during the Russia-Ukraine war as compared to the period of COVID-19, and markets regained momentum in the short term.

Figure 3. Wavelet Coherence – Bitcoin

(a) USA - WTC: S&P 500 and Bitcoin. (b) China-WTC: SSEI and Bitcoin. (c) India-WTC: Nifty-50 and Bitcoin (d) Europe-WTC: FTSE-100 and Bitcoin (e) WTC: WTC: NIKKEI-100 and Bitcoin.

Figure 3 depicts the presence of strong safe haven attributes for bitcoin in the United States and China during both crisis periods, with the effects being stronger during the Covid-19 pandemic, whereas the safe haven phenomenon is only visible for medium-term and long investment horizons during the Russia-Ukraine war. Furthermore, bitcoin is viewed as a diversifier or hedge in the markets of India, Europe, and Japan, rather than a safe haven during both crisis eras. This finding is consistent with (Bouri *et al.*, 2017; Kliber *et al.*, 2019), who found cryptocurrency as a hedge or diversification tool rather than a safe haven.

Pair-wise connectedness analysis

The robustness of the estimates from the wavelet coherence is established using the TVP-VAR-based directional pairwise connectedness approach proposed by (Antonakakis, Chatziantoniou and Gabauer, 2020; Gabauer, 2021). Figure A1 – A3 (see Appendix) presents the graphical representation of the connectedness, which ranges from 0 to 100, where a higher value indicates strong interconnectedness between two variables across the time domain plotted on the horizontal x-axis. The bilateral connectedness across stock market indices and gold, oil, and bitcoins demonstrates similar patterns. There is strong evidence to suggest a strong connectedness and the beginning of 2020, which is the onset of the COVID-19 pandemic, and a spike in the onset of the Russia-Ukraine war in 2022. This finding yields similar results as the wavelets measure and support the hedge, diversifier, and safe haven characteristics of gold, oil, and bitcoin returns.

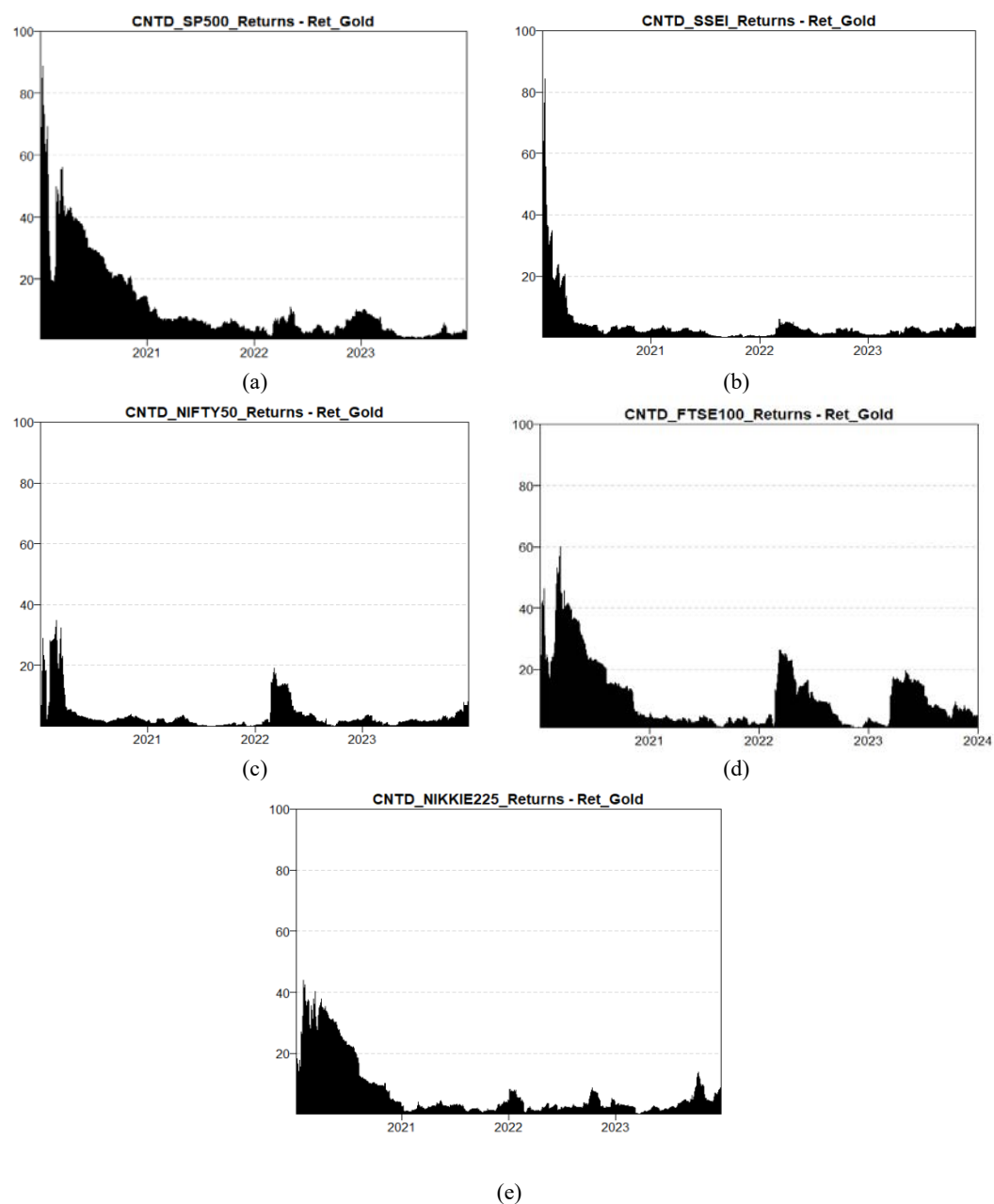
4. Conclusion

The aim of the present study is to evaluate the existence of safe haven attributes of gold, oil, and cryptocurrency against equities from five major countries, trailing two important global events, i.e., the health crisis arising from the COVID-19 pandemic and the geopolitical tension resulting from the Russia-Ukraine war. The study relies heavily on the novel wavelet coherence methodology and revealed persistent and strong correlations between gold, oil, and bitcoin returns vis-à-vis stock returns during periods of tranquility and turmoil. Gold exhibits safe haven features only over a long-term investment horizon, acting as a portfolio diversifier against stock market risk in short-term and medium-term periods. Both oil and bitcoins, on the contrary, are highly correlated with equities, suggesting they are viable diversifiers in turmoil and as hedges, but not as safe havens for stock market risk. The presence of all the assets as safe havens is found to be true only for the US, while bitcoins are for China. Nevertheless, under normal circumstances, all examined assets possess the capacity to function as hedging assets and diversifiers against equities across different investing horizons. The findings of this study will help to enhance the knowledge of the investor community, policymakers, and portfolio managers worldwide over safe haven assets and portfolio construction across various economic scenarios and investment horizons. The present study is limited and focused on selective assets; future research can be carried out on digital assets, exotic assets, and green assets alongside different economic events and time horizons.

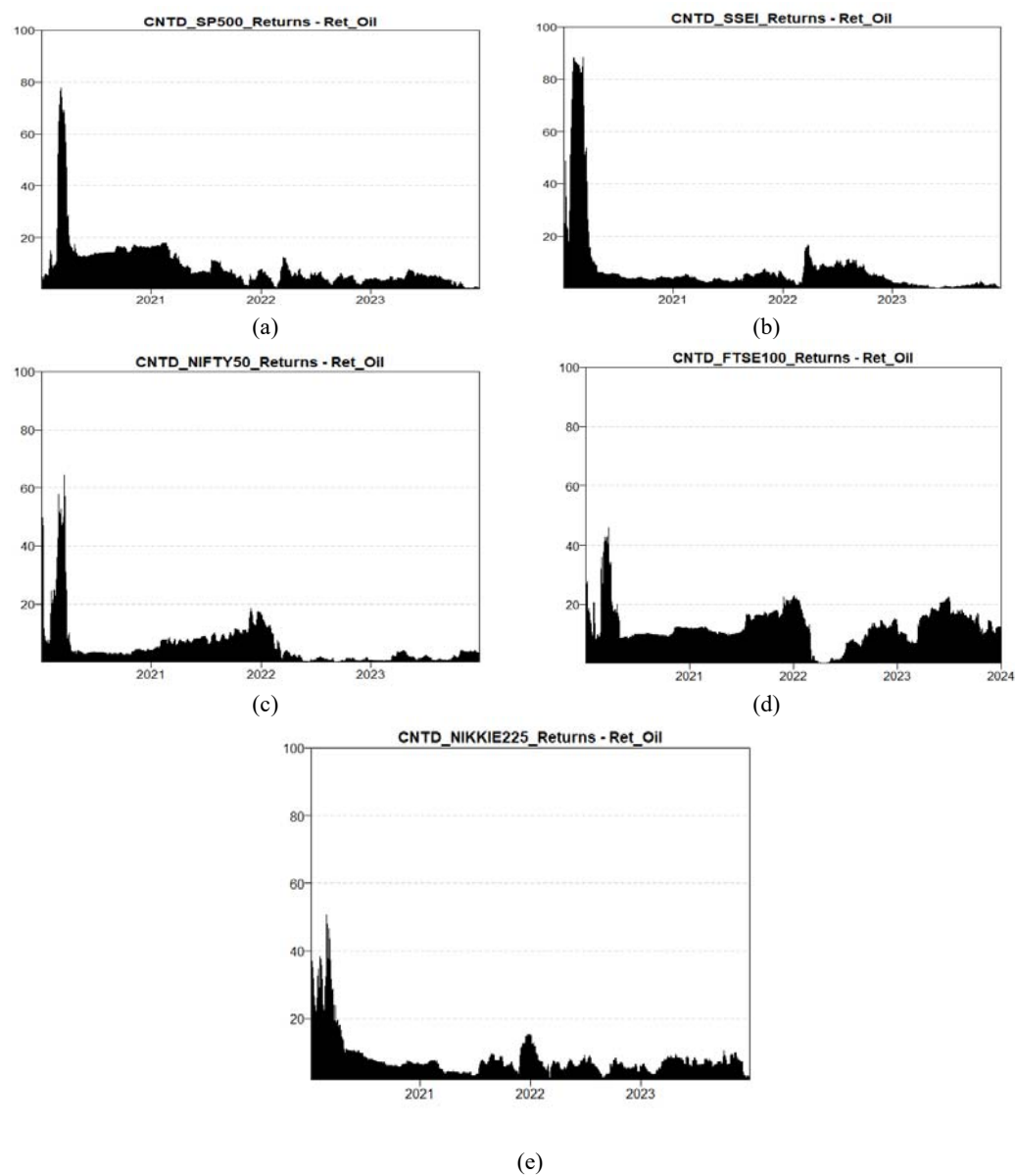
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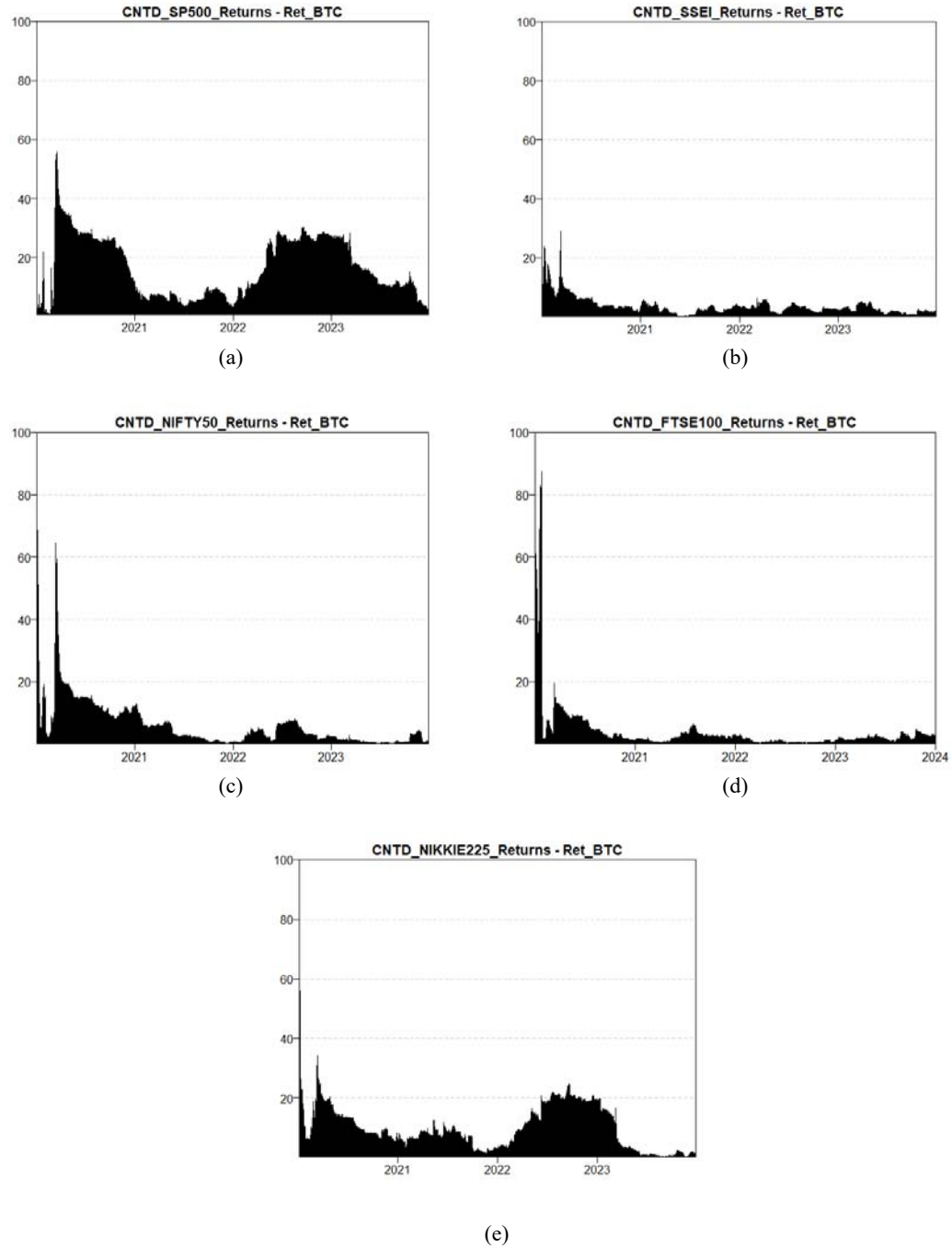
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Figure A1. *Dynamic pairwise connectedness plot– Gold*

(a) USA - CNTD: S&P 500 and Gold. (b) China - CNTD: SSEI and Gold. (c) India - CNTD: Nifty-50 and Gold
 (d) Europe - CNTD: FTSE-100 and Gold (e) Japan - CNTD: NIKKEI-100 and Gold.

Figure A2. *Dynamic pairwise connectedness plot– Oil*

(a) USA - CNTD: S&P 500 and Oil. (b) China- CNTD: SSEI and Oil. (c) India - CNTD: Nifty-50 and Oil
 (d) Europe - CNTD: FTSE-100 and Oil (e) Japan - CNTD: NIKKEI-100 and Oil.

Figure 21. *Dynamic pairwise connectedness plot– Bitcoin*

(a) USA - CNTD: S&P 500 and Gold. (b) China - CNTD: SSEI and Bitcoin. (c) India - CNTD: Nifty-50 and Bitcoin (d) Europe- CNTD: FTSE-100 and Bitcoin (e) Japan - CNTD: NIKKEI-100 and Bitcoin.

Financial contagion and the circular economy paradigm: opportunities and challenges for Romania

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Abstract. *This study investigates the relationship between financial contagion and the transition to a circular economy in Romania, analyzing the impact of economic and environmental factors on CO₂ emissions. Using an ARDL model, the study examines the short-term and long-term influence of variables such as GDP, recycling rate, resource productivity, foreign direct investment, and renewable energy consumption on CO₂ emissions. The results show that, in the short term, resource productivity and foreign investments have a significant impact on emissions, while GDP has a positive influence on them. In the long term, although the analyzed variables suggest a potential for reducing emissions, the statistical significance is limited. The diagnostic tests confirm the stability and correct specification of the model, and the analysis suggests that the transition to a circular economy may be affected by Romania's vulnerability to external financial shocks and underdeveloped infrastructure. The conclusions underline the importance of coherent policies and sustainable investment in support of sustainable development in Romania.*

Keywords: circular economy, financial contagion, green finance, financial stability, Romania.

JEL Classification: Q53, Q56, E44, F36, Q13, C32.

1. Introduction

Financial crises and increasing awareness of the negative impact of economic activities on the environment have marked the world economy in recent decades. In this context, the idea of Circular Economy (CE) has become increasingly popular as an alternative and sustainable economic development model. The CE mitigates the impact on the environment by minimizing waste and promoting the reuse, reconditioning and recycling of resources.

Instead, financial contagion threatens national and global economic stability. Financial contagion phenomena can spread instability between economic sectors or between nations, amplifying the negative consequences of financial shocks. In this context, it is essential to understand how the CE can affect and interact with financial contagion and systemic risks.

In the current global context, the transition to a CE has become a priority objective for most countries, especially for the member states of the European Union (EU), which have adopted ambitious policies aimed at economic sustainability and reducing CO_2 emissions. The European Green Deal (European Commission 2019), for example, underlines the importance of implementing CE models to limit the impact of climate change and promote resource efficiency. In this dynamic, Romania, as part of the EU, has the responsibility to adjust its economic and environmental policies to contribute to common sustainability goals. However, this transition is not without challenges, especially regarding the underdeveloped infrastructure for recycling and the efficient management of resources.

In parallel with these green transition efforts, Romania remains vulnerable to global economic and financial shocks, having an economy strongly connected to international markets. Financial contagion phenomena, generated by external economic crises, can significantly disrupt investments in CE projects, creating an unstable economic environment for the implementation of these initiatives. In this context, it is essential to understand how these two dimensions, financial contagion and the transition to a CE, interact and what the implications are for the sustainable economic development of Romania.

Although there are numerous studies analyzing CE or financial contagion separately, this paper makes a unique contribution by addressing the interconnection of these two phenomena in the context of an emerging economy, such as Romania.

Our research is structured as follows. In Section 2, the specialized literature explores the concepts of financial contagion and the CE, providing an overview of existing research. This section also analyzes the connection between financial contagion and the CE, highlighting how financial crises can impact investments in sustainability and how the CE can enhance economic resilience. Section 3 details the methodology and data collection, explaining the use of the Autoregressive Distributed Lag (ARDL) model to investigate the short-term and long-term relationships between economic and environmental variables. In Section 4, the results of the econometric analysis are presented, highlighting the impact of the selected variables on CO_2 emissions. In Section 5, the conclusions summarize the main findings of the research and provide policy recommendations to support the transition to a circular economy, along with discussions on the limitations of the research and future directions for exploration.

2. Literature review

2.1. Financial Contagion

Financial contagion refers to the phenomenon by which economic shocks in one country or region quickly spread to other economies, impacting global financial markets. This phenomenon has been extensively studied in the context of financial crises, such as the Asian crisis of 1997 or the global financial crisis of 2008. Allen and Gale (2000) highlighted the vulnerabilities created by financial interdependencies and the domino effect that contagion can have on emerging economies. In Romania, studies (Nica and Chiriță 2020; Țilică 2021; Ionescu et al. 2023; Nica et al. 2023b, 2024) have shown that the effects of contagion are amplified by the country's dependence on external capital and the volatility of the global financial market. For example, Ionescu et al. (2023) analyze in their study financial contagion in the mortgage market in Romania, focusing on a specific type of contagion called residual contagion. In the context of economic uncertainties, the complexity of economic systems, and the evolution of digital technology and artificial intelligence, the phenomenon of financial contagion can arise and spread, causing economic crises similar to a domino effect. The study uses agent-based modeling and machine learning techniques to analyze systemic risks in the Romanian mortgage market in 2022, referencing the financial crisis of 2007-2009, which was significantly influenced by the mortgage crisis.

In another study conducted by Galati et al. (2024), the extent to which the collapse of a digital token can spread contagion in cryptocurrency markets is investigated, focusing on the collapse of the FTX cryptocurrency exchange and its token, FFT. The results indicate the existence of contagion between cryptocurrency exchanges and highlight the effects of an informational cascade on other crypto assets, especially when withdrawals from FTX were almost completely prohibited. The study finds the existence of abnormal returns for major digital assets, suggesting a flight to safety by investors from less reliable assets to those considered safer. The implications of this phenomenon are discussed from the perspective of traders, stock exchanges, and policymakers. Camera and Gioffré (2024), on the other hand, analyze political interventions in situations of extreme financial shocks, such as the “bank holiday” in the USA in 1933, when financial activities were widely suspended. Using a random matching framework, the research explicitly describes the process of financial contagion and how an initial shock propagates through the financial system. The study suggests that the forced closure of certain businesses or even a financial lockdown at the economic level can only be justified when businesses are financially vulnerable and political institutions are not functioning effectively.

Nica et al. (2023) conduct an interesting study that explores the impact of financial contagion on the financial stability of Romania in a globally interconnected and volatile economic context. The model used for analysis is the ARDL, which examines both conventional and unconventional channels of financial contagion transmission, highlighting their sensitivity to factors such as geopolitical events and investor sentiment. By combining traditional econometric methodologies with advanced modeling techniques, the study provides a robust framework for understanding the complex nature of financial contagion and its implications for the national economy and social welfare.

2.2. Circular Economy

CE has become a central concept in sustainable development strategies, providing an alternative model to the linear economy, through which resources are kept in the economic circuit for as long as possible (Ellen MacArthur Foundation 2013). According to the research by Ghisellini et al. (2016), the transition to a CE involves not only economic efficiency but also technological innovation and significant structural adaptations. In Romania, the CE is still in its early stages, but European policy, including the Green Pact, is exerting increasing pressure for the implementation of circular solutions (Dobre-Baron et al. 2022). Nica et al. (2023a) explore in their study Romania's transition to a CE, analyzing its impact on the economy, society, and the environment. The study uses economic cybernetics and adaptive complex systems to uncover the interactions between the components of the CE. Using multiple linear regression (MLR) and ARDL models, researchers assess the influence of factors such as recycling rates, labor productivity, and the use of circular materials on GDP per capita and waste generation. The results show how these variables affect economic performance and environmental health. The study recommends that Romania's future policies align with the National Strategy for the CE to facilitate a sustainable transition and reduce environmental impact.

The CE is a sustainable economic model focused on minimizing resource waste, maximizing material use, and lowering environmental impact via the efficient and sustainable design, production, use, and recycling of goods. Within the framework of Romania, the CE has considerable capacity to enhance sustainable economic growth and environmental conservation. In recent years, the idea of the CE and its implementation in Romania has emerged as a significant topic in specialist literature, but it remains a rather nascent process considering the current level of CE integration in the nation.

2.2. The connection between financial contagion and the CE

In the specialized literature, there is a growing interest in analyzing the relationship between financial contagion and the implementation of the CE, considering the financial vulnerabilities and uncertainties in global financial markets. Recent studies highlight how financial factors influence the adoption and success of CE practices across different economic sectors and countries. According to Patra et al. (2024), supply chain financing is an emerging field that impacts the financial performance of companies within supply chains, and the adoption of CE practices in this area is still in its early stages. The integration of these circular practices into financial supply chains can contribute to enhancing the regenerative and restorative capacity of companies, ensuring sustainable long-term development. However, financial uncertainties and contagion risks can affect the availability of resources for such circular innovations, especially during times of economic crisis. In this context, financial contagion can reduce the appetite for investment in sustainable solutions.

The study conducted by Zahid et al. (2024) examines the role of the banking industry in Pakistan in supporting the transition to a CE and in implementing the Sustainable Development Goals. This emphasizes that banks play a crucial role in financing circular initiatives, but the instability of financial markets can jeopardize the flow of capital needed

for such projects. This connection between the risks of financial contagion and the financing of the CE is essential for understanding how emerging economies, such as Pakistan, can navigate between economic crises and the implementation of sustainable circular solutions.

Feiferytė-Skirienė and Stasiškienė (2023) analyze the effects of the global financial crisis of 2008-2009 and the COVID-19 pandemic on the transition to a CE. This study shows that during periods of financial crisis, economic priorities tend to shift from sustainability to immediate economic solutions, negatively impacting the implementation of CE policies. For example, the crisis of 2008-2009 had a short-term impact on environmental degradation, but sustainable goals were overshadowed by more urgent economic interests. Similarly, the war between Russia and Ukraine and the COVID-19 pandemic have led to a temporary shift from a CE to traditional linear models.

In a recent study, Ha (2024) investigates the link between financialization and circularity performance in Europe. The study highlights that financial institutions play an important role in promoting the CE by financing recycling projects and using circular materials. It is also shown that the development of the financial market, although positive, does not have a significant impact on circular performance. Financial crises, caused by market instabilities, can slow down these processes, especially in regions more vulnerable to financial contagion.

Thus, according to the specialized literature, financial contagion negatively influences the transition to a CE, particularly by reducing available resources and prioritizing quicker economic solutions during times of crisis. However, financial institutions play a key role in facilitating the transition, and appropriate policies can mitigate these effects, contributing to a more resilient and sustainable economic environment.

3. Methodology and data collection

In order to achieve the goal of this research, we will analyze whether there is a short-term and long-term relationship between CO_2 emissions and GDP, RRMW, RP, FDI, and RNEC. These variables have been described in Table 1. We considered that CO_2 emissions provide a direct measure of the pressure on the environment and indicate progress or regression in achieving sustainability goals. The choice of GDP is based on the fact that it can express the relationship between economic growth and CO_2 emissions, taking into account the controversial discussion related to the environmental Kuznets curve, according to which economic development initially increases emissions but later reduces them with technological advancement and an increase in the standard of living. The RRMW variable is an essential measure of progress towards a CE, indicating how effectively Romania manages to reduce the volume of waste sent to landfills and recycle resources. The RP variable reflects how efficiently natural resources are used to produce economic value. The high productivity of resources is a key indicator of the sustainability of the CE, reducing pressure on natural resources. In a globalized economy, foreign investment flows have a significant impact on economic performance and innovation in green technologies. Thus, the FDI variable can support the transition to a CE through the transfer of technologies and

financial resources. In conclusion, the RNEC variable reflects the extent to which the economy depends on renewable energy sources, an essential element for reducing CO_2 emissions and achieving climate goals.

Table 1. Description of the variable used

Variables	Abbreviation	Unit of measurement	Source
Real GDP per capita	GDP	Constant 2015 USD	World Bank
Annual CO_2 emissions (per capita)	CO_2	Metric tons per capita	World Bank
Recycling rate of municipal waste	RRMW	(%)	Eurostat
Resource Productivity	RP	Euro per kilogram, chain linked volumes (2015)	Eurostat
Foreign direct investments	FDI	Net inflows (%) of GDP	World Bank
Renewable Energy Consumption	RNEC	% of total final energy consumption	World Bank

To model the short-term and long-term interactions between the selected variables, we will use the ARDL model. The ARDL econometric model is a statistical approach that is employed to investigate the long-term relationships between economic variables. It allows researchers to evaluate the long-term effects of specific factors on other variables and to establish causal relationships between them (Georgescu et al. 2024). The ARDL model is implemented for variables that are stationary at $I(0)$, $I(1)$, or a combination of $I(0)$ and $I(1)$ (Androniceanu et al. 2023).

The equation for the generalized ARDL model is as follows:

$$A_t = a_0 + \sum_{i=1}^p b_i A_{t-i} + \sum_{i=0}^q c_i B_{t-i} + \varepsilon_t \quad (1)$$

In equation (1), the dependent variable, A_t , is captured as a function of its lagged values and the lagged values of the independent variables contained in the vector B_t . The Akaike Information Criterion (AIC) is frequently employed to determine p and q . Parameters b and c are short-run coefficients, which are constants. The optimal latency numbers for the dependent and independent variables are p and q , respectively. ε_t is the error term, with the errors being serially uncorrelated or independent.

Guidelines for the methodology that has been implemented:

Step 1: Check the stationarity;

Step 2: Cointegration;

Step 3: Diagnostic and stability tests.

4. Results

In the context of climate change and environmental pressures, the CE has become a central topic in sustainable development policies. In a world where sustainability is a priority, Romania faces significant challenges regarding resource management, greenhouse gas emissions, and the integration of foreign investments into strategies that support the transition to a CE. Furthermore, in light of global and regional financial crises, financial contagion is a phenomenon that can significantly influence a country's ability to implement sustainable economic changes and reduce vulnerability to external shocks. The present study analyzes the connection between financial contagion and the paradigm of the CE, highlighting the opportunities and challenges that Romania faces in this process. The SWOT analysis from figure 1 for financial contagion and the CE in Romania highlights a

number of strengths, including European support and national commitments to sustainability. Nevertheless, vulnerability to external financial shocks and the challenges related to implementing CE infrastructure remain significant obstacles. Opportunities for access to green funds and the increasing demand for sustainable products can stimulate progress, but there are risks from global financial crises and political instability that must be managed carefully.

Figure 1. SWOT Analysis



Source: Authors' own research results.

The selection of variables in the ARDL model is based on their relevance in assessing both economic dynamics and environmental impact. Per capita **CO₂** emissions are the dependent variable, providing a direct measure of environmental pressure and indicating progress or regression in achieving sustainability goals.

Table 2 presents the descriptive statistics of the variables included in the model. GDP has a moderate variation, and the distribution is relatively symmetrical. **CO₂** emissions have a slightly right-skewed distribution. RRMW has an average of 7.56%, but it varies greatly between a minimum of 0.01% and a maximum of 14.8%, suggesting a slight negative distribution. The RP shows a more pronounced positive asymmetry according to the Skewness value of 1.54 and a high flattening according to the Kurtosis of 5.20. RNEC is relatively uniformly distributed, with a minor negative bias, whereas FDI has a slightly right-skewed distribution.

Table 2. Summary Statistics

Variables	Mean	Median	Maximum	Minimum	Std. dev.	Skewness	Kurtosis
GDP	21907.56	21953.32	32495.91	12176.63	5912.72	0.08	2.07
CO ₂	4.36	4.25	5.25	3.73	0.46	0.47	2.10
RRMW	7.56	11.30	14.80	0.01	5.98	-0.21	1.14
RP	0.39	0.37	0.54	0.32	0.05	1.54	5.20
FDI	3.61	2.86	9.02	1.23	2.17	1.29	3.63
RNEC	20.78	22.10	24.40	13.40	3.54	-0.69	2.08

In Table 3, the lag order selection test for VAR was conducted to select the optimal ARDL model. The test results suggest that the optimal lag for our ARDL model is 2, according to the AIC, SC, and HQ. These selection criteria for the lags indicate that the model with 2 lags has the lowest value for each of these measures (AIC = -11.87, SC = -7.99, HQ = -11.03), which signals that this is the most efficient model.

Table 3. VAR Lag Order Selection Criteria

Lag	LogL	LR test statistic	Final prediction error	Akaike information criterion	Schwarz information criterion	Hannan-Quinn information criterion
0	44.53	N/A	1.03×10^{-9}	-3.66	-3.37	-3.60
1	133.16	118.18	8×10^{-12}	-8.68	-6.59	-8.22
2	202.72	52.99*	9.78×10^{-13} *	-11.87*	-7.99*	-11.03*

* indicates lag order selected by the criterion

Source: Authors' own research results.

The variables are dependent on the ARDL model as indicated by equation (2):

$$CO_{2t} = f(GDP_t, RRMW_t, RP_t, FDI_t, RNEC_t) + \varepsilon_t \quad (2)$$

The error term in equation (2) is denoted by ε_t .

The ADF unit root test is implemented to verify data stationarity. Table 4 demonstrates that the RP variable is the only one that is integrated of order 0, indicating that it is stationary from the outset. In contrast, the other variables become stationary after a first order of integration.

Table 4. ADF unit root test

Variables	Level	First difference	Order of Integration
	T-statistics	T-statistics	
GDP	0.00 (0.94)	-4.97 (0.00)	I (1)
CO ₂	-0.33 (0.90)	-4.76 (0.00)	I (1)
RRMW	-1.36 (0.59)	-5.25 (0.00)	I (1)
RP	-5.33 (0.00)	-4.50 (0.00)	I (0)
FDI	-2.48 (0.13)	-2.27 (0.02)	I (1)
RNEC	-1.13 (0.68)	-5.23 (0.00)	I (1)

Source: Authors' own research results.

In order to determine whether there is a long-term causal relationship, the bounds cointegration test is followed. The model that has been chosen is ARDL (1, 2, 2, 0, 1, 1).

Table 5 presents the results of the limit test for cointegration, which indicates whether there is a cointegration relationship among the variables in our ARDL model. Since the F-statistic value exceeds the upper critical value at all significance levels, we can reject the null hypothesis which states that there is no cointegration relationship. Thus, the test indicates that the model is suitable for examining long-term relationships between variables.

Table 5. Result of cointegration bounds test

Statistic Test	Value	Number of Regressors (K)
F-statistic	5.63	5
Critical Value Bounds (Finite Sample N=1000)		
Significance	I (0)	I (1)
10%	2.08	3
5%	2.39	3.38
2.5%	2.7	3.73
1%	3.06	4.15

Source: Authors' own research results.

The long-run estimated coefficients are presented in Table 6. We observe that in the long term, none of the variables seem to influence CO_2 emissions. Although the coefficients suggest the direction of long-term relationships between the independent variables and CO_2 emissions, none of them, except for the constant, are statistically significant. This indicates that, based on this model and the available data, we cannot draw clear conclusions about the long-term influences of the explanatory variables on CO_2 emissions.

Table 6. *ARDL long-run model*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RP	-7.30	6.19	-1.17	0.72
FDI	0.09	0.08	1.12	0.29
RNEC	-0.16	0.11	-1.47	0.17
GDP	-5.07×10^{-5}	3.28×10^{-5}	-1.54	0.16
RRMW	0.06	0.06	1.03	0.33
C	10.62	3.88	2.73	0.02

Source: Authors' own research results.

The short-run ARDL coefficients are presented in Table 7. We observe that RP has a significant effect on reducing emissions in the short term, although the delayed effects suggest a more complex impact. FDI have a significant delayed effect on reducing emissions, while GDP has a positive effect on emissions in the short term, reflecting economic intensity and increased emissions. RRMW seems to increase emissions in the short term, a result that requires further investigation. This result could indicate challenges in the implementation of recycling programs that, in the short term, do not lead to a reduction in emissions. Regarding the error correction term (CointEq), the coefficient of -0.48 is statistically significant, indicating that approximately 48% of the imbalance between the current value and the long-term equilibrium value is corrected in each period. This shows that there is a cointegration relationship between the variables and that the model adjusts in the short term towards long-term equilibrium. The value of 0.88 for R-squared indicates that 88% of the variation in CO_2 emissions is explained by the model, suggesting a good fit of the data. The Durbin-Watson value of 2.70 suggests that there is no significant autocorrelation of the errors.

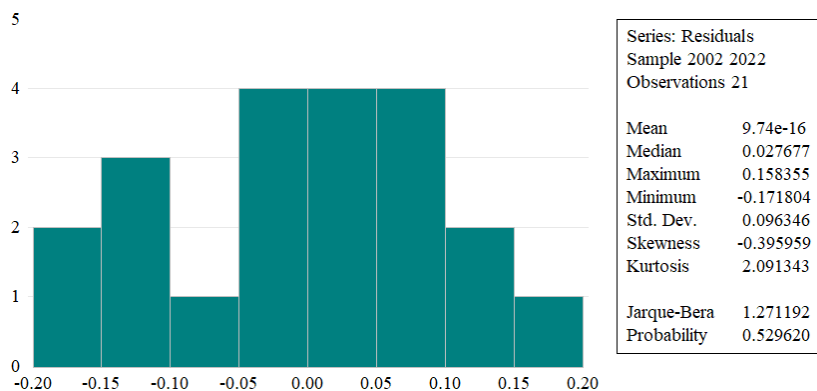
Table 7. *ARDL short-run model*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D (RP)	-3.55	0.66	-5.32	0.00
D (RP (-1))	1.33	0.47	2.83	0.02
D (FDI)	-0.01	0.01	-1.12	0.29
D (FDI (-1))	-0.06	0.01	-3.83	0.00
D (GDP)	0.01	2.30×10^{-5}	5.24	0.00
D (RRMW)	0.06	0.01	4.90	0.00
CointEq (-1)	-0.48	0.05	-8.30	0.00
R-squared	0.88			
Adjusted R-squared	0.83			
Durbin-Watson stat	2.70			
Akaike info criterion	-1.22			
Schwartz criterion	-0.87			
Hannan-Quinn criterion	-1.14			

Source: Authors' own research results.

In Figure 2, the histogram of the residuals was created. The mean of the residuals is very small, almost zero, which indicates that the model is well calibrated. The median is very close to 0, which confirms that the residuals are symmetrically distributed around the central value, indicating that the ARDL model is correctly specified. The maximum and minimum values suggest that the variability of the residuals is small and well-contained between -0.17 and 0.15, indicating that there are no significant deviations from the model's predictions. A small standard deviation indicates that the residuals are well concentrated around the mean, which shows stability in the model's predictions. The Jarque-Bera test has a p-value of 0.52, which is much higher than the standard significance threshold of 0.05. This means that we cannot reject the null hypothesis that the residuals follow a normal distribution. In other words, the residuals are normally distributed, which confirms the validity of the model.

Figure 2. Histogram of residuals – normality test



Source: Authors' own research results.

Table 8 presents the results of the stability and diagnostic tests for the ARDL model. The ARDL model successfully passes all diagnostic and stability tests, indicating that there are no issues of serial correlation, heteroscedasticity, abnormal distribution of residuals, or incorrect model specification.

Table 8. Diagnostic and stability test

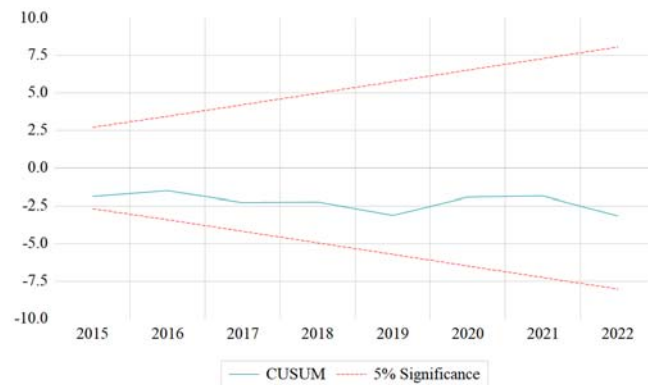
Test	H_0	Statistics	p-value	Decision
Breusch-Godfrey Serial Correlation test	There is no serial correlation in the residuals	3.28	0.10	Accept H_0
Breusch-Pagan-Godfrey test	There is no autoregressive conditional heteroscedasticity	0.82	0.63	Accept H_0
Jarque-Bera test	Normal Distribution	1.27	0.52	Accept H_0
Ramsey Reset test	Absence of model misspecification	1.88	0.23	Accept H_0

Source: Authors' own research results.

Figures 3 and 4 present the CUSUM and CUSUM of Squares tests that check the stability of the model parameters in the long and short term. The CUSUM test analyzes the long-term stability of the coefficients in the model. The CUSUM chart represents the cumulative sum of recursive residuals over time, compared to control limits where we can observe that the CUSUM line remains within the significance limits, indicating that the model is

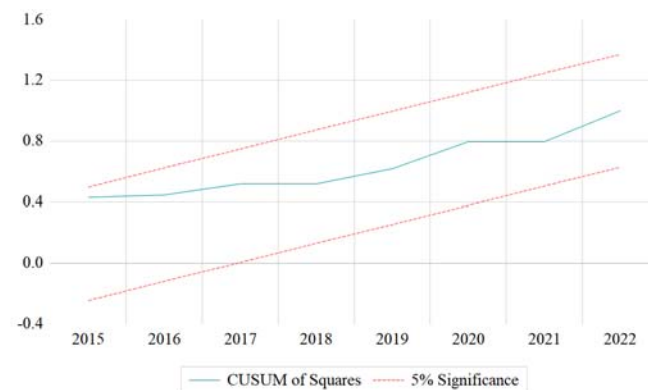
considered stable in the long term. The CUSUM of Squares test checks the variability of residuals and is useful for detecting possible structural changes in the variability of the model. In this case, the stability of the model is validated.

Figure 3. CUSUM graphs at 5% level of significance



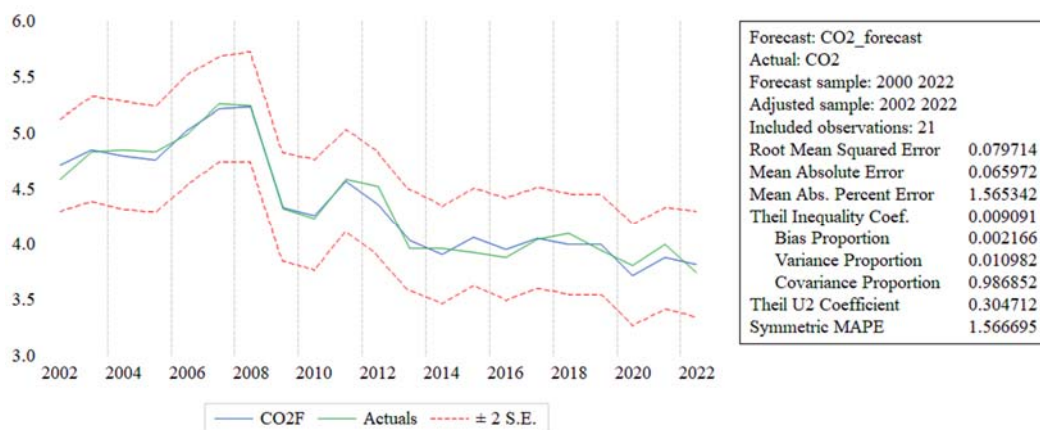
Source: Authors' own research results.

Figure 4. CUSUM of Squares graphs at 5% level of significance



Source: Authors' own research results.

In Figure 5, the forecast of the dependent variable CO_2 has been made. Root Mean Squared Error (RMSE) measures the average deviation of predicted values from actual values, where a value of 0.07 indicates a small error, suggesting that the model is accurate. A Mean Absolute Error (MAE) of 0.06 indicates the average absolute error between the predicted values and the actual values, highlighting that the prediction is quite close to the real values. Mean Absolute Percentage Error (MAPE) measures the average percentage error between predicted values and actual values. A MAPE of 1.56% is very low, indicating that the forecasting errors are less than 2% of the actual values. This is a sign that the model has very good predictive capacity. Symmetric MAPE is an adjusted version of MAPE that treats overestimations and underestimations equally. A value of 1.56% also indicates a very good accuracy of the model, with no significant differences between overestimations and underestimations.

Figure 5. Predicted vs Actual CO_2 Emissions: Model Performance and Forecast Accuracy

Source: Authors' own research results.

5. Conclusions

This study analyzed the interdependencies between financial contagion and the CE in the context of Romania, using an ARDL model to examine the relationship between CO_2 emissions and key economic variables such as GDP, RRMW, RP, FDI, and RNEC. The results highlight a series of essential aspects that can guide future policies and economic strategies.

In the short term, the analysis showed that resource productivity and GDP had a significant impact on CO_2 emissions, while foreign direct investments had a delayed effect. Additionally, the recycling rate has shown a positive effect on short-term emissions, suggesting that recycling programs in Romania may face implementation challenges that could initially generate additional environmental costs.

In the long term, although the coefficients for resource productivity and renewable energy consumption indicated a possible reduction in emissions, they were not statistically significant. This result could suggest that, in order to have a significant impact on long-term emissions, Romania needs to intensify its efforts in implementing green technologies and the CE.

The diagnostic studies indicated the stability and validity of the model, confirming the absence of serial correlation and heteroscedasticity in the residuals, as well as a good specification of the model. The CUSUM and CUSUM of Squares tests indicated long-term stability of the parameters, suggesting that the model can be used for reliable forecasts of CO_2 emissions.

A well-structured government policy should include both measures for preventing and managing the risks of financial contagion, as well as strategies for promoting the CE. These measures should be integrated to support sustainable development and ensure economic stability in the face of international crises. According to the results obtained, a well-implemented CE can contribute to the economic resilience of Romania. By optimizing resources and reducing dependence on external raw materials, Romania could become less vulnerable to external financial shocks and economic contagion. This aspect could be essential for long-term economic stability.

As in any scientific work, it is important to acknowledge its limitations. First of all, although the ARDL model is suitable for capturing both short-term and long-term relationships, it may not fully capture the complexity of the connections between economic, social, and environmental variables. In particular, the interdependent effects between financial contagion and the CE may require more advanced models or combinations of methodologies. Secondly, the results obtained are influenced by the current macroeconomic context. Rapid changes in global financial markets, economic crises, or legislative changes can affect the applicability of long-term results. This is an important limitation, as Romania's economy is strongly integrated into international markets.

In the context of expanding this study, future research directions could explore the integration of new economic and environmental variables as additional factors influencing the transition to a CE and financial contagion, such as investments in green technologies, the level of technological innovation, specific sustainability legislation, and changes in fiscal policy. Additionally, expanding the research through comparisons between Romania and other similar economies or those in the region could provide valuable insights into how different economic and legislative contexts influence the transition to a CE and the risks of financial contagion.

Considering these results, it is clear that Romania has the potential to progress towards a CE, but it must address vulnerabilities to external financial shocks and improve infrastructure for resource management and recycling. Additionally, special attention must be paid to educating the public and businesses about the benefits of the CE, in order to raise awareness and engagement in adopting these practices. Foreign investments and economic growth provide an important opportunity to support this process; however, government policies must be coherent and focused on long-term sustainable development.

Notes

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- (2) Conflict of interest: The authors declare no conflicts of interest.
- (3) Data availability statement: The data presented in this study are available on request from the corresponding authors.
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The circular economy in Romania: a bibliometric study of innovation and sustainable practices

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Abstract. *This study provides a bibliometric analysis of the literature on circular economy in Romania, using data from the Web of Science database. The study covers the period from 1992 to 2023 and examines 741 articles from 253 different sources. The results show an annual growth rate of 15.86% in scientific production, highlighting a growing interest in sustainability, recycling, waste management, and renewable energy. The analysis also reveals an average of 12.52 citations per document and a total of 24,773 references, indicating the relevance of these studies in the academic community. Although the percentage of international collaborations is about 20%, partnerships with countries such as Italy, the USA, and Hungary demonstrate an expanding global interest in the circular economy in Romania. The study highlights the central role of Romanian academic institutions and researchers in promoting this field and provides valuable insights for the development of future research, with an emphasis on innovation and sustainability.*

Keywords: circular economy, Romania, sustainability, renewable energy, waste management, bibliometric analysis.

JEL Classification: Q01, Q53, Q56, F64, O13.

1. Introduction

In recent decades, increasing pressures on natural resources and the severe impact of climate change have forced countries around the world to rethink their economic models. The traditional linear economy, based on extraction, production, and consumption, has proven to be unsustainable in the long term, necessitating a fundamental shift towards models that reduce waste and utilize resources more efficiently. In this context, the Circular Economy (CE) has become a vital alternative to address these global challenges, being adopted as an essential pillar in the economic and environmental strategies of many nations.

For Romania, an economy in transition, the adoption of CE concepts comes with significant opportunities, but also with major challenges. The transition from a resource-intensive economic model to a circular one requires not only technological innovation and changes in consumer behavior but also a strategic vision at the national level. According to a study by Georgescu et al. (2024), Romania has made progress in implementing sustainable development strategies, decoupling economic growth from environmental impact, but challenges remain significant regarding recycling rates and waste management, which influence long-term CO_2 emissions. Additionally, the study conducted by Nica et al. (2023) emphasizes that Romania should align the development of national policies with the National Strategy for the Circular Economy, in order to facilitate the transition to sustainable practices, thereby reducing environmental impact and improving economic indicators. As the country seeks to align with the European Union's policies and commitments regarding carbon emission reduction and sustainable resource management, the CE is becoming a key element in achieving these goals. A study conducted by Chiriță and Georgescu (2024) highlights the long-term and short-term dependencies between renewable energy, GDP per capita, and net greenhouse gas emissions in Romania, demonstrating how the CE can be understood as part of a complex adaptive system governed by cybernetics principles.

Innovation plays an essential role in this transition, opening new opportunities for the implementation of circular practices across various sectors, from manufacturing to renewable energy and waste management. According to Nica and Ciocan (2023), Romania has begun to adopt the principles of the CE and is charting a path towards more sustainable development, conducting a bibliometric analysis and applying a multilinear regression model that highlights the role of the CE on economic growth, particularly through the rate of circularity and waste management. However, to better understand the evolution of this transformation, a detailed analysis of the scientific contributions in the field is necessary. Bibliometric studies provide valuable insight into how the CE has evolved in Romania, allowing for the identification of key research directions, significant innovations, and gaps that still require attention.

This study aims to analyze the specialized literature dedicated to the CE in Romania, using bibliometric tools to understand the trends and progress in this field. We will evaluate the main research themes, the impact of innovations on sustainable practices, and we will provide a synthesis of the scientific contributions that have shaped this field. This analysis will not only reflect the current state of the CE in Romania, but it will also provide a

foundation for identifying new development opportunities and policies that support the transition to a greener and more resilient economy.

2. Methodology and data collection

Bibliometric analysis utilizes specialized software tools and statistical methodologies to gather, analyze, and evaluate data regarding scientific output. It has been observed that bibliometric analysis has been employed in the research of a significant number of sectors of activity over the years through literature research. Included in this category are business (Khan et al. 2021), education (Marius Profiroiu et al. 2024), policymaking (Smith and Marinova 2005), medicine (Kokol et al. 2021), management and organization (Zupic and Čater 2015), engineering (Shukla et al. 2019), and cybernetics (Nica 2024).

In our bibliometric study, we will employ the RStudio (version 2024.04.2) information technology solution, the Bibliometrix package, and the "biblioshiny()" function to conduct a comprehensive analysis from the perspectives of authors, scientific documents, international collaborations, affiliations, and key words. Additionally, we will conduct mixed analyses, such as cluster and factorial analyses. The methodological flux that we will employ pertains to the research of Aria and Cuccurullo (2017), Zupic and Čater (2015), and Cobo et al. (2011). The following are the actions taken:

- Research project, identification of the narrative purpose of the works, and selection of keywords;
- Data collection by identifying the most representative scientific databases in accordance with the study's objective;
- Data analysis using bibliometric techniques;
- Visualization of the analyses conducted using the RStudio software;
- Interpretation of results.

In terms of data collection, we have chosen to utilize the Web of Science (WoS) database, which is one of the most significant scientific databases, containing over 18 million scientific articles, in accordance with the objectives of our study.

Table 1 presents a comprehensive summary of the technique used to collect relevant information on the CE in Romania. This systematic process ensures the selection of relevant articles from the WoS for the analysis of the CE in the context of Romania.

Table 1. Data selection steps

Steps	Questions on Web of Science	Description	Search Query	Query number	Count
1	Title	Contains one of the circular economy keywords in the title	(((((TI=("circular_econom*")) OR TI=("waste_*")) OR TI=("recycling_rate*")) OR TI=("reuse")) OR TI=("renewable"))	#1	238,639
2		Contains "Romania" in the title	TI=(Romania)	#2	21,978
3		Merging queries #1 and #2	#1 AND #2	#3	259
4	Abstract	Contains one of the circular economy keywords in the abstract	(((((AB=("circular_econom*")) OR AB=("waste_*")) OR AB=("recycling_rate*")) OR AB=("reuse")) OR AB=("renewable"))	#4	666,154
5		Contains "Romania" in the abstract	AB=(Romania)	#5	37,540
6		Merging queries #4 and #5	#4 AND #5	#6	1,261

Steps	Questions on Web of Science	Description	Search Query	Query number	Count
7	Authors' Keywords	Contains one of the circular economy keywords in the Authors' Keywords	(((((AK=("circular_econom*")) OR AK=("waste_*")) OR AK=("recycling_rate*")) OR AK=("reuse")) OR AK=("renewable"))	#7	223,009
8		Contains "Romania" in Authors' Keywords	AK=(Romania)	#8	6,967
9		Merging queries #7 and #8	#7 AND #8	#9	77
10	Title & Abstract & Authors' Keywords	Merging Queries #3, #6 and #9	#3 OR #6 OR #9	#10	1,340
11	Type of Document	Keeping just documents that are Articles	#10 AND DT=(Article)	#11	805
12	Language	Keeping just documents written in English	#11 AND LA=(English)	#12	795
13	Publication Year	Keeping just documents not published in 2024.	#12 NOT PY=(2024)	#13	741

As presented in Table 1, a total of 13 steps were followed in order to extract the database containing scientific articles related to the CE field, more specifically in Romania. A preliminary step, however, consists of establishing clearly which words should be included in the analysis. Therefore, the selected words were: "circular economy/economies", "waste(s)", "recycling rate(s)", "reuse" and "renewable". These were considered due to their inclusive nature in various contexts, restricting them to the CE field. To further granularize the results, the term "Romania" has been introduced, so that the focus of each article was on the Romanian territory. Starting with the title, a total of 259 articles were found, while using the abstract as a field of search, 1,261 articles were returned. Adding 77 articles to these, 1,340 articles were returned in total. Through further filtering, such as maintaining only scientific articles, those which were written in English and published before 2024, the final number of articles is 741.

3. Results

In this section, we analyzed the data obtained from queries conducted on the Web of Science database to provide a detailed overview of the scientific production related to the CE in Romania. We evaluated the main characteristics of the selected articles, including the number of publications, the annual growth rate, the number of authors, and international collaborations. We also examined the content of the documents, the keywords used, and the most relevant sources from which these articles originate. The analysis also includes a visual presentation of scientific production over the years, the relationships between keywords, and international collaborations. This assessment provides a comprehensive overview of the progress and trends in CE research in Romania.

Table 2 is used to reveal the main information regarding the databased resulted using the queries mentioned in Table 1. Spanning from 1992 until 2023, 741 articles were returned, from 253 different sources. The CE context in Romania is evidently gaining progress, as evidenced by the annual growth rate of 15.86%. Alternatively, authors are demonstrating a greater level of interest in this area. The average document age is of 6.97 years, with an

average of 12.52 citations per document. In total, an impressive number of 24,773 references were used in the whole dataset.

Table 2. *Main information about data*

Key data	Results
Timespan	1992:2023
Sources	253
Documents	741
Annual Growth Rate (%)	15.86
Document Average Age	6.97
Average citations per doc	12.52
References	24,773

Table 3 focuses on the documents' content, in other words, 1,281 words were found in the Keywords Plus category, while for the Author's Keywords, the quantity is nearly double of that, 2,364 to be more precise. These values further prove how extensive and hard to finely delimit is actually the field of CE.

Table 3. *Document content*

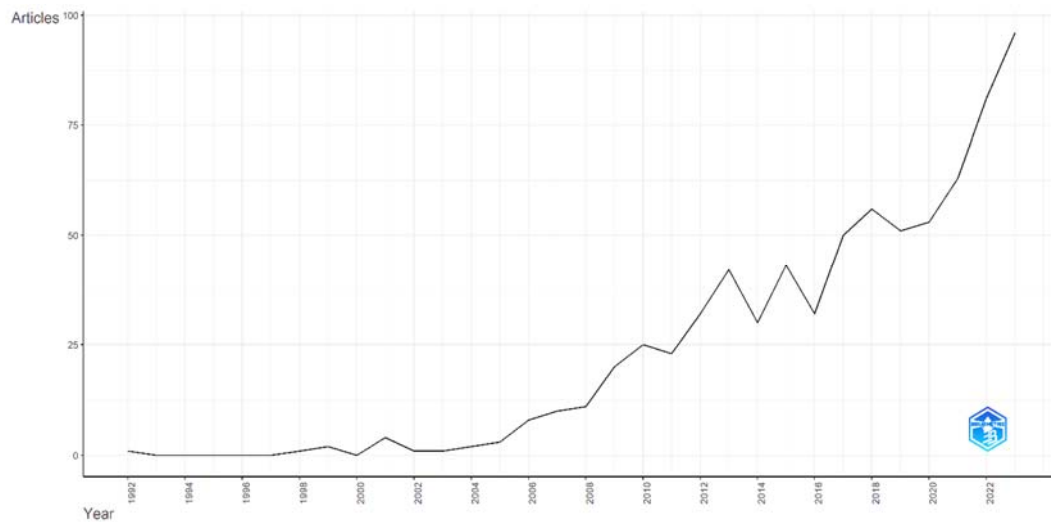
Key data	Results
Keywords Plus	1,281
Author's Keywords	2,364

The authors are the primary focus of Table 4, which includes a total of 2,403 unique authors. Given the substantial quantity of 741 articles, it is reasonable to anticipate that each document will have nearly four co-authors. Interestingly, this dataset only identified approximately 20% of international co-authorships. This indicates that a variety of authors from a variety of countries are beginning to express interest in the CE field in relation to Romania.

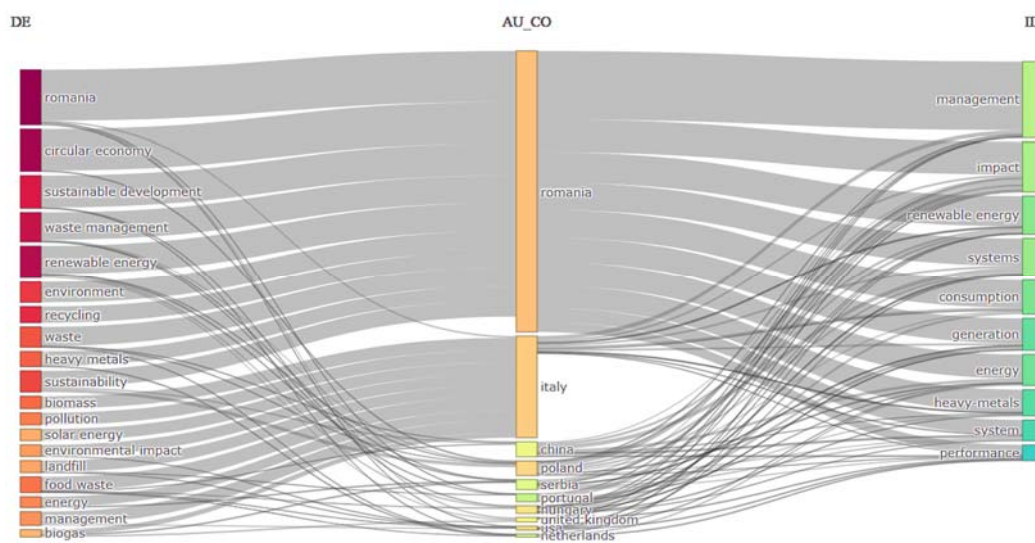
Table 3. *Authors*

Key data	Results
Authors	2,403
Authors of single-authored docs	79
Single-authors docs	90
Co-Authors per Doc	4.05
International co-authorships (%)	19.97

Figure 1 illustrates the annual scientific production output from 1992, the commencement of the dataset, to 2023. In 1992, the first document was published, followed by an absence of publications up until 1998. Following the global impact of the 2008 financial crisis, 20 documents were published in 2009, nearly double the number from 2008. Another notable timeframe is 2011-2013, which saw an increasing number of articles from year to year. However, the biggest increase took place post COVID-19, in 2020 53 articles being published. The following years marked a remarkable expansion, growing year to year, culminating with 96 documents published in 2023.

Figure 1. Annual Scientific Production

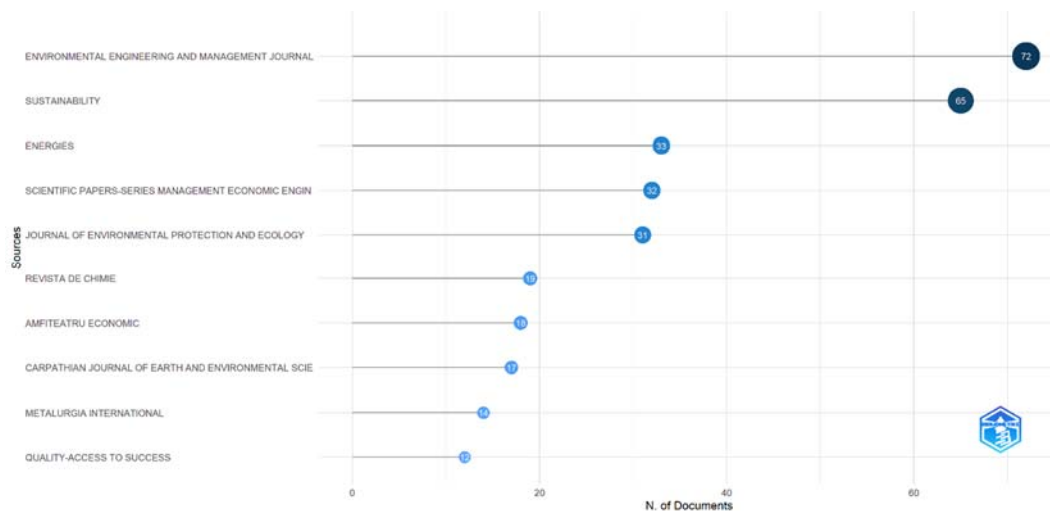
The three-field plot shown in Figure 2 is a great tool used to showcase the relationship between the keywords, the countries found in the analysis and the Keywords Plus. In other words, as expected, the word “Romania” is tightly connected to Romania, but with other mentions also in Italy, the USA, and the UK, to name a few. In addition to this, the “circular economy” term is also mentioned many times on the Romanian territory, alongside “sustainable development”, “waste management”, “renewable energy”, “environment” and so forth. Second after Romania is Italy, which brings into light other different terms, such as “biomass”, “pollution”, “solar energy”, and remarkably also “food waste”, which tends to be a worldwide issue in first world countries.

Figure 2. Three-Field Plot (middle field – countries; left field – Keywords; right field – Keywords Plus)

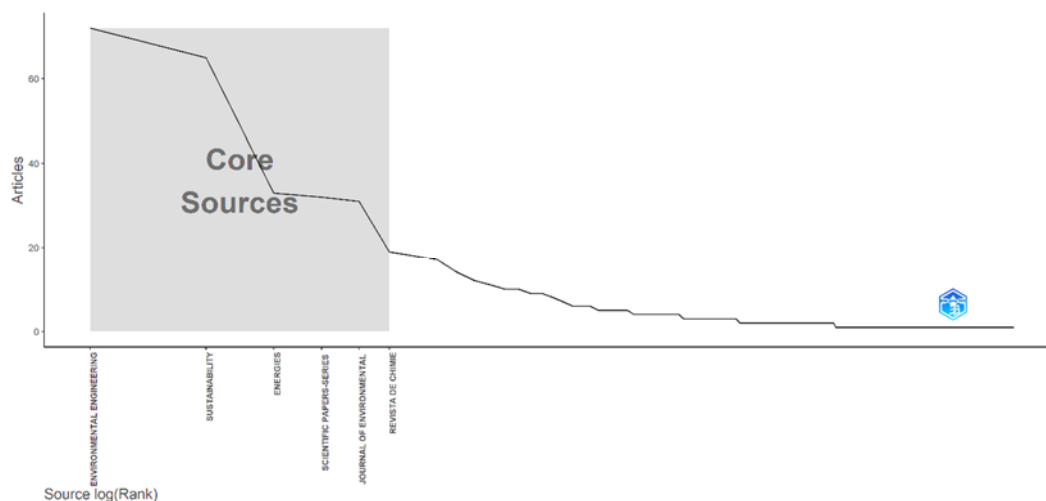
Furthermore, China, Poland, Serbia, Portugal, and Hungary are also countries that make an apparition in this study. Considering the Keywords Plus, words such as “management”, “impact”, “renewable energy”, “systems” and “consumption” are mentioned. Major differences between Keywords and Keywords Plus do not exist, the second category being a rather more extensive, while the first is a bit more restrictive.

The most relevant sources are visually represented in Figure 3, “Environmental Engineering and Management Journal” being the most relevant out of these, having a total of 72 documents. The second one is the “Sustainability” journal, with 65 documents. The difference between the third and second is nearly double the number of documents, an impressive one, when compared to the difference between the first and the second, which is of only 7. In other words, the third classified, “Energies” journal, has 33 documents, followed by “Scientific Paper-Series Management Economic Engineering” with 32 documents. Close after, is the “Journal of Environmental Protection and Ecology” with 31 documents. These three sources might change their positions between them, in the following years, depending on the volume of output of scientific articles regarding CE in Romania.

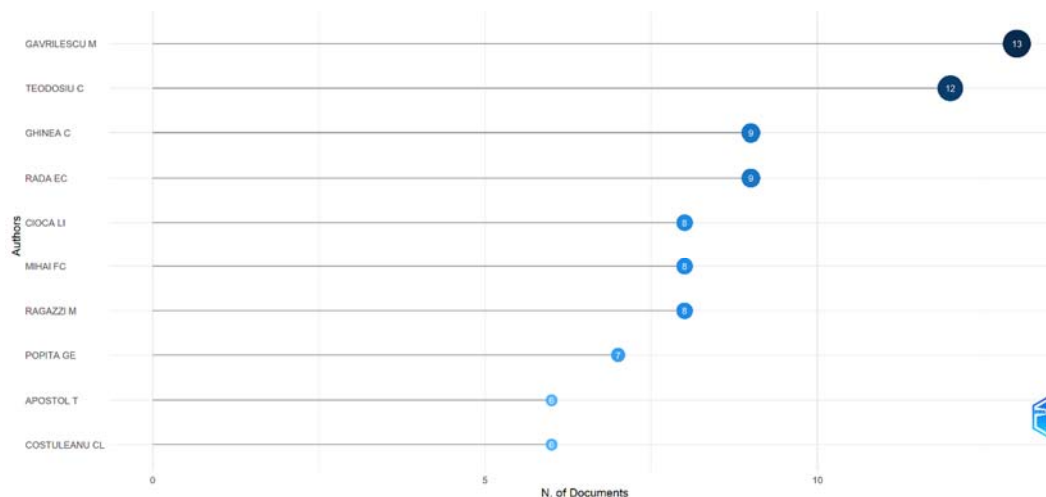
Figure 3. Most Relevant Sources



The first 6 sources from Figure 3 are considered as “core sources”, according to Figure 4. In other words, the core sources are the publications with a total number of articles ranging from 72 to 19. The last one is “Revista de Chimie”, a local chemistry scientific journal.

Figure 4. Core Sources by Bradford's Law

Trying to ascertain the most relevant authors, Gavrilescu M. is the author with the most documents written. According to Figure 5, the first place has a total of 13 documents, followed closely by Teodosiu C., with a difference of only one document. After the first two, are Ghinea C. and Rada EC., with a number of 9 documents. Three authors have each written a total of 8 documents, them being Cioca Li., Mihai FC., and Ragazzi M.

Figure 5. Most Relevant Authors

The total number of articles published is quantified by graphically representing the most significant affiliations in Figure 6. The first classified of this leaderboard is “Bucharest University of Economic Studies”, with a staggering amount of 99 articles. This imposing quantity serves as proof of this University’s interest in this ever-changing field. The second one is “National University of Science and Technology Politehnica Bucharest”, with a total of 84 articles, followed by “Babes Bolyai University from Cluj” with 78 articles. The

lowest classified, “Universitatea Politehnica Timisoara”, has 38 articles in total, which is still a remarkable number of scientific studies conducted in this domain.

Figure 6. Most Relevant Affiliations

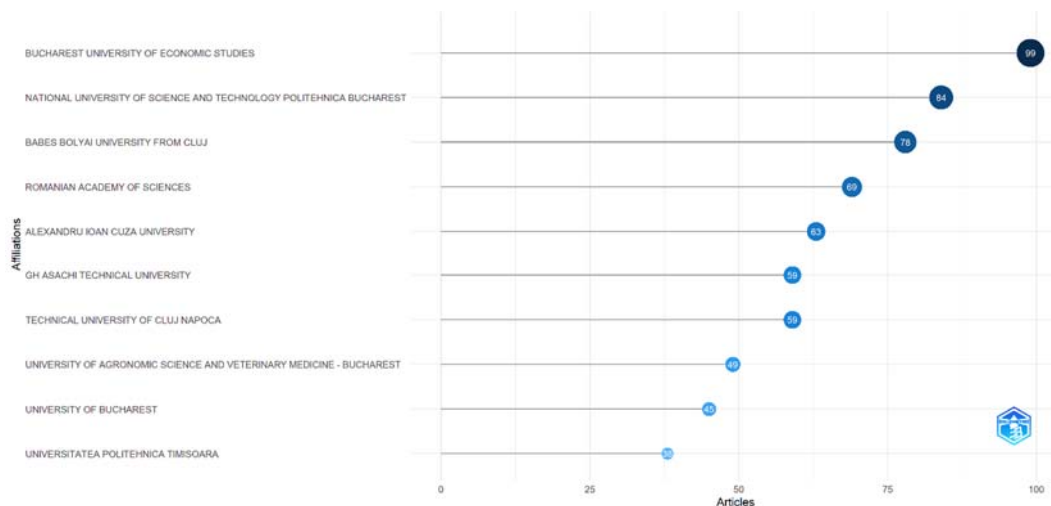


Table 5 is used to have an overview of the first 7 most globally cited documents. **Koçak and Şarkgüneşi (2017)** have the most cited document, with 276 citations in total. Transforming this value into total citations per year, the result is 34.50, which is impressive, to say the least. This high number of citations might be explained by their findings, which affirm that economic growth is impacted by renewable energy consumptions. **Visa's (2016)** article, which describes her discovery of newly synthesized zeolite materials, is the second most frequently cited document. This document is associated with a remarkable number of citations, a total of 235, with an average of 26.11 per year. **Wada et al.'s (2011)** article, which assessed water stress development, was a standout in the academic field, with the paper being referenced in 224 distinct articles.

Table 5. Most global cited documents

Authors (Year), Journal	Scope	Methodology	Main Findings
Koçak and Şarkgüneşi, (2017); Energy Policy;	Analyzing the relationship between use of renewable energy consumption and the trajectory of economic development	Heterogeneous panel causality analysis	There is a significant impact of renewable energy consumption on economic growth in Balkan countries
Visa (2016); Powder Technology	Treatment of wastewater through newly synthesized zeolite materials	Converting fly ashes into zeolite materials	Adsorption of heavy metals is more efficient through ZCET40 than ZDs40
Wada et al.; (2011) Hydrology and Earth System Sciences	Assessing water stress development from 1960-2001, considering various factors	Using past economic development, energy consumption and electricity production to estimate industrial and domestic water demand	The global population living under water-stressed conditions has increased significantly
Ferronato et al. (2019); Journal of Environmental Management	Examining key opportunities for enhancing solid waste management in large-scale urban development	Comparing Romania and Bolivia for their circular economy outlook, describing also a	The model of Circular Economy proved to be effective and is recommended for building big

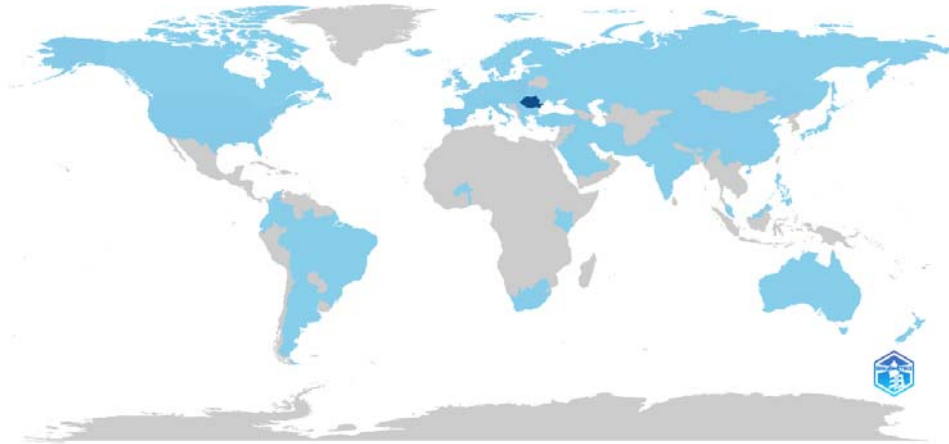
Authors (Year), Journal	Scope	Methodology	Main Findings
		theoretical circular economy model	cities, to base it on sustainable development key ideas
Emir and Bekun (2019); Energy & Environment	Examining the causality between energy intensity, carbon emissions, renewable energy consumption and economic growth	Determining an autoregressive distributive lag (ARDL) model for cointegration, combined with the Toda-Yamamoto model for testing direction of causality	Validating the hypothesis according to which the economy has been following an energy-led growth trend
Da Cruz et al. (2014); Waste Management.	Describing and examining the recycling of packaging waste policies in five EU countries	Analyzing the policies of recycling of packaging waste and comparing the costs and benefits of recycling	In three of the countries analyzed, the industry does not support the costs of packaging waste management
Visa and Chelaru (2014); Applied Surface Science	Synthesizing, characterizing and monitoring adsorption behavior of mesoporous material, obtained through various chemical steps.	Obtaining a new substrate with good adsorption capacity for dyes and heavy metals from wastewater	A modified nano-substrate composite with fly ash can efficiently and cost-effectively remove dyes and heavy metals

The word cloud depicted in Figure 7 illustrates the quantity of mentions each word has, with each word being more frequently mentioned as it becomes larger. Consequently, the word cloud, which is based on the Author's Keywords, displays the most occurrences of “Romania”, “renewable energy”, “circular economy”, “waste management”, and “sustainable development”. Romania's recent interest in adopting a more sustainable and environmentally friendly approach to pollution, refuse management, and other issues may be a contributing factor to this ranking.

Figure 7. Word Cloud by Author's Keywords



The countries' scientific production is pictured in Figure 8, the darker the hue of the blue, more articles are published in that country. The country that is easily remarked is Romania, being the darkest one in the entire map. Other countries remarked are South Africa, the USA, Canada, Australia, India, and even countries from South America, such as Argentina and Brazil. Moreso, nearly all of Europe is present in the dataset, exception being Belarus and Croatia, alongside Bosnia & Herzegovina.

Figure 8. Countries' Scientific Production

Depicted in Figure 9 are clusters labeled by Authors' Keywords. Documents were used as units of analysis, the coupling being measured by the number of references, and the impact being measured by the local citation score. A total of 8 clusters were determined. The red cluster has a centrality of 0.407 and an impact of 2.441, containing words such as “renewable energy”, “economic growth” and “sustainable development”, tying the already known phrases to economy and its growth. Next is the blue one, which stands perfectly in the middle of impact and centrality axis, having the values for these two of 1.867 and 0.380. In this cluster, words such as “circular economy”, “waste management” and “recycling” are grouped. The cluster with the biggest centrality however is the one located in the top right, having “food waste”, “consumer behavior” and “consumers” as the clustered words. The high value of 3.019 for impact might be due to the inclusion of consumers and their behaviors in this cluster.

Figure 9. Clustering by Coupling

The co-occurrence network pictured in Figure 10 shows the relationships between each word and phrase found in the authors' keywords. It is clear that authors used the term "circular economy" with "Romania", but also expanding to "recycling", "sustainable development" and even "renewable energy sources". In addition to these, "Romania" is also strongly linked with "greenhouse gas emissions", "European Union", and "economic growth". The mention of the EU might be due to the necessity of following the EU imposed guidelines regarding recycling, renewable energies, and such.

Figure 10. Co-occurrence network

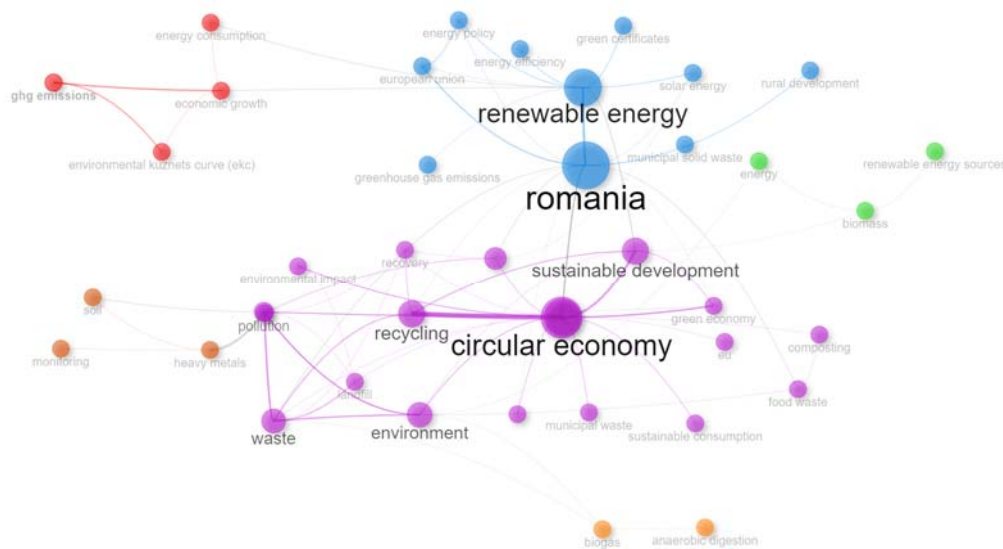
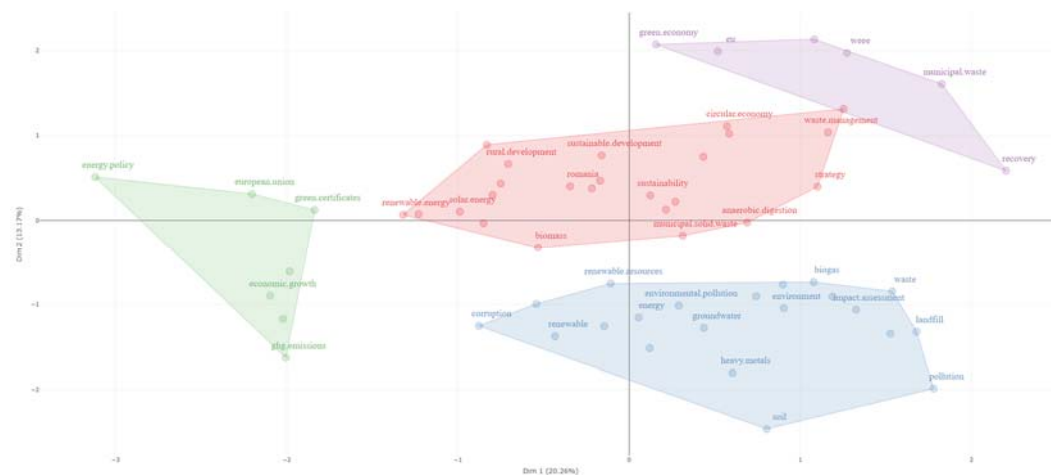


Figure 11. Factorial Analysis

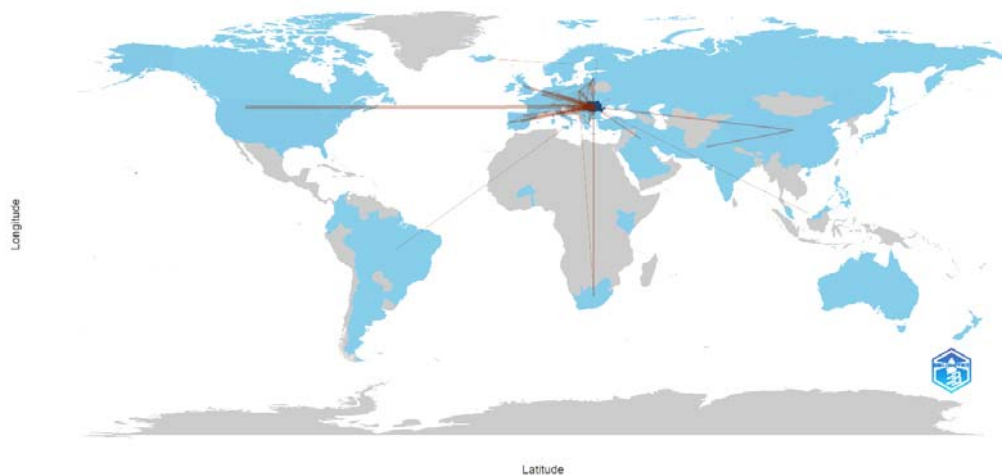


The results of a factorial analysis conducted, using the authors' keywords, are shown in Figure 11. A total of 4 clusters were considered, each cluster being representative of the words it contains. The first cluster, colored in green, contains words such as "energy

policy”, “European union”, “green certificates” and “economic growth”, tying more into the administrative side of the study. The second cluster, represented with red, is outlined with the help of words like “renewable energy”, “circular economy”, “waste management”.

In Figure 12, the collaboration between countries is depicted. Similar to Figure 8, the more articles a country has published, the darker the hue of the blue. An addition is the brown line, a thicker line signaling a stronger collaboration between the two countries it connects. Romania has the most articles published, but collaborating with countries such as Italy, Hungary, USA, France, Poland, Spain, and the southern neighbor, Bulgaria. The country with the most articles written in collaboration with Romania is Italy, with a total of 21 articles, followed by Hungary and USA with 11 articles, and then 8 articles written with assistance from France, Poland, and Spain.

Figure 12. *Countries' Collaboration World Map*



4. Conclusions

This bibliometric research on the CE in Romania highlights a significant increase in interest in this field in recent years, with an annual growth rate of scientific production of 15.86%. The results show a diversification of the themes addressed, with a focus on sustainability, waste management, and renewable energy, essential elements for the development of a CE. Additionally, the analysis highlighted the importance of international collaborations, even though their percentage remains relatively low, at around 20%.

The analyzed documents reveal a large number of references and an increasingly active involvement of Romanian academic institutions, such as the “Bucharest University of Economic Studies and the “National University of Science and Technology Politehnica Bucharest”, which play a central role in the development of knowledge in the field of CE. Additionally, the most cited authors have significantly contributed to strengthening the knowledge about the relationship between economic development and the use of renewable resources.

Nevertheless, there is still significant room for improvement regarding the expansion of international collaborations and addressing emerging topics such as technological innovations and the green transition in key industrial sectors. For the future, it is essential for Romania to continue investing in the infrastructure and policies necessary to support the CE, considering its potential impact on sustainable economic growth and the reduction of carbon emissions.

The conclusions of this study emphasize the need for a concerted effort to connect academic research with the practical implementation of the CE, so that Romania can meet the sustainable development goals set at the European and global levels.

Notes

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- (3) Data availability statement: Data are contained within paper.
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