

The turbulence of cycles

“The phenomenology of economic cycles portrays the lucrative background of human existence.”

The economic cycles only carry a rational and instrumental sense as long as they are being reduced to a behavioural problem, formulated in terms of wealth. Due to their essence, the economic cycles cannot be decoupled from the evolution of the human phenomenon within the guidelines of the human condition: work, labour, action.

Any step away from fundamental phenomenology alters the understanding of the cycles when their determinism is exclusively being associated to abstract causes, which are then hypostatized by *homo economicus* in a sort of objectification - or normalization of Platonic reveries, instead of being associated with the things which lend volume and content to the components of the human condition: the subjective reasons of the realistic man, the expectations, the choices and the projections that he has about comfort.

In practice, the phenomenology of economic cycles portrays the lucrative background of human existence. The cycles carry the consistency of behaviours which are motivated by rules, precepts, conventions, fashions and by the historical context which is dependent on nature and culture.

The cycles of the last three centuries followed the manner in which the means of subsistence were used in order to produce abundance. The sinuosity of their materialization reveals the degree to which common-sense has been exceeded, with the median line between ambition and possibility indicating where things were done properly.

The cycle portraying breakthroughs of possibilities is followed by the cycle of recalibrating ambitions, the curve of evolution being alternatively concave and convex in relation to the median. In the cycle of development the concave segment contains the active performance – where the means of wealth conform to

randamental expectations, while the convex segment contains the realignments in creativity which herald the innovation of means.

The form is similar to any investment cycles, with the exception of speculative cycles whose evolution translates into a jagged, zigzagging line.

In a complex way the cyclicity is a feature of the human condition, where work, labour and action draw curved lines in the sands of existence. The human nature is the source of the sinuosity, as the propagating reflex of the increase and decrease of the individual elements in its composition.

The cycles are patterns for the evolution of the parts, and not the whole. The evolution follows the super-cycles, which cover time scales beyond the life cycles of several generations. In global terms, the super-cycles show up in the configuration of civilizations, in the radical changes of the contents of work, labour and human action.

When the super-cycle is about to change, as it is happening now with the super-cycle of modernity, there occurs a phase of maximum turbulence as a result of the overlapping beginnings and ends of multiple cycles. Somewhat unavoidably, a Gordian knot appears in the arrangements of cohabitation.

The specific weave at the end of the super-cycle of modernity is formed from the fifth cycle of development and the third demographic cycle, which cover the final segments of the super-cycle. The last cycle of development (Kondratieff) did not contribute to the original geographic area of modernity with a technical solution to the final demographic cycle's closing problem (Straus-Howe): generational imbalance.

The models for the management of values are switching places, in a clash liminary to violent collapse, and the model of vertical dependency is being displaced by the one for horizontal dependency. The caesural movement covers the end of the over-cycle of adversity which acts as the engine of a zero-sum game between man and nature (the exclusive competition), and the birth of the over-cycle of win-win competition (cooperation/collaboration/consensualization).

The turbulence is amplified by political cycles which are structured by the eschatological ideologies at the twilight of postmodernism. We are still waiting for the manifestation of a leadership motivated by the ethos of the beginning of the new over-cycle, marking a different level in the complexity of a humanization which would be specific to the entrance into the second modernity when viewed as a sequence in the over-cycle of cooperation.

It is a phase which exacerbates the state of crisis and one which is psychologically perceived as an apocalypse. The tension of the world is at a maximum, leaning towards a violent discharge, especially after the emergence of a crisis of indebtedness. The strategy of war tends to replace the strategy of development. The emblematic term is that of exhaustion, as we are now at the ends of the over-cycle of adversity and the super-cycle of the first modernity (of the conquest of nature).

The curtain is drawn over the Pre-Global Era of Adversity and the first rays of the Global Era of Consensuality are starting to shine. The world is caught at once by the pains of unravelling and the pains of creation. It loses and it wins.

Marin Dinu

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How growth-friendly are productive public expenditures? An empirical analysis for Eastern Europe

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Abstract. *This paper investigated the effects of productive public expenditures over economic growth, using a panel-model approach, in 6 East-European countries during 1990-2013. The paper contributes to the specific literature, showing how different types of productive public expenditures influence economic growth, under an extended set of economic and socio-political control variables. The findings revealed that education, R&D and infrastructure expenditure are positively correlated with economic growth, while health expenditure seems to have a negative impact.*

Keywords: productive public expenditure, economic growth, correlation, fixed-effects, panel-model.

JEL Classification: H51, H52, H54, O40.

REL Classification: 8E, 8K, 10D.

1. Introduction

It is widely accepted that productive public expenditure, such as infrastructure, research and development, the provision of high-quality education and medical services, contributes to the rising of an economy. The Lisbon Strategy and its successor, the newly adopted Europe 2020 strategy, supportive of “smart, sustainable and inclusive growth”, acknowledge the positive potential impact of tax policy on long-term economic activity, especially given the legacy of the economic and financial crisis. This positive impact would result from the composition of public expenditure (with respect to its likely growth-friendliness), and not their size or fiscal revenues size, nor from fiscal balance.

The solution would be the restructuring of public expenditure, by increasing the share of productive expenditure, i.e. those which have a positive effect on production factors (capital and labor). Accordingly, the structure of public spending can become a useful tool in terms of influencing the level and the rate of economic growth through their impact on aggregate supply. At the core of this new tax policy strategy are public policy models based on endogenous growth, which are, in fact, an extension of the theory of endogenous growth.

Barro and Sala-i-Martin (1995) divide public expenditures into two main categories:

- i) productive expenses, which include: public services, defense, public order and national safety, education, health, housing, public services and development, environmental protection; these items are also named “growth-friendly expenditures” (European Commission, 2012).
- ii) non-productive expenses, such as: culture, recreation and religion, social protection, economic actions.

Productive public expenditures carry an impact upon the efficiency of the private sector, generating positive externalities to firms, and have a positive effect on the marginal productivity of capital and labour. Non-productive public spending have a direct benefit for households (Angelopoulos et al., 2006; Devarajan et al., 1996), affect the welfare of the consumers, but do not change the efficiency of the private sector (Barro and Sala-i-Martin, 1995).

Although empirical evidence regarding the encouraging of endogenous growth through tax policy are “mixed”, a series of studies include among productive public spending the following: public investment, R&D, education, health, defense, public order, transportation, communications and environmental protection (Afonso et al., 2005; Angelopoulos et al., 2006; Barro, 1990; Romero de Avila and Strauch, 2003).

The main objective of this study is to empirically evaluate the impact of productive public spending on economic growth for six EU-member states from Eastern Europe (relatively unexplored in this area), using a panel-model approach, for the period 1990-2013. Specifically, the study explores the relative impact of different components of public expenditure (education, health, R&D, infrastructure) on economic growth. The paper contributes to the literature in the field, showing how different types of productive public spending influence economic growth in Eastern Europe, under an extended set of economic and socio-political control variables. The main finding suggests that education, infrastructure and R&D expenditures positively affect economic growth, while health expenditures are negatively correlated with the process.

The rest of the paper is structured as follows: Section 2 presents the literature review, Section 3 highlights the methodology and data, Section 4 contains the results, while Section 5 concludes.

2. Literature review

Economic growth determinants is one of the richest areas of research in modern economics, since “economists have, in some sense, always known that growth is important” (Barro and Sala-i-Martin, 1995). A large empirical and theoretical literature promotes the idea that government spending is a productive input to firms’ production functions, and thus to economic growth. Starting with the seminal contribution of Barro (1990), who identified the existence of a positive correlation between government spending and long run economic growth, the consequences of this observation have been mainly discussed in the context of growth models.

The studies testing empirically the relationship between public expenditures and economic growth highlight different effects of public spending on economic growth, ranging from positive impact, negative impact or even insignificant correlation. The literature contains a relatively wide range of estimates (see Sturm et al., 1998), with a marginal product of public capital that is much higher than that of private capital, almost equal to it, far below and, sometimes, even negative.

An important contribution to the relevant literature belongs to Barro (1991), who based his study on a cross-section analysis including 98 developing countries, for a period spanning from 1960 to 1985. Using average annual growth rates in real GDP per capita and the ratio of real government consumption to real GDP, he finds that public consumption is negatively correlated with growth, while public investment’s impact on economic development seems insignificant. Two years later, Easterly and Rebelo (1993), in a broad cross-section of countries, with data

for the period 1970-1988, investigated the relationship between per capita growth and (sectoral) public investment, in the presence of conditional variables. Their main finding suggests that the share of public investment in transport and communication infrastructure is consistently correlated with growth.

In another empirical analysis, Ghura (1995), using pooled time-series and cross-section data for 20 years (1970-1990), in the case of 33 African countries, discovers a negative relationship between government consumption and economic growth. A similar result is obtained by Guseh (1997), in a study on the effects of government size on the rate of economic growth, using OLS estimation method and data for the period 1960-1985, available for 59 middle-income developing countries. The main result of this paper is that growth in government size has negative effects on economic growth, which greatly amplifies in non-democratic socialist systems. Knoop (1999) explores the impact of government size on economic growth in the US economy, within the framework of an endogenous growth model. Using regression analysis and time series data from 1970 to 1995, his study demonstrates that a decrease of public expenditures generates an adverse impact on economic growth and welfare. In the same manner, the results obtained by Fölster and Henrekson (2001), when conducting a panel study on a sample of rich countries over the period 1970-1995, reveal that large public expenditures affect growth negatively.

Furthermore, Devarajan et al. (1996) find evidence for 43 developing countries, for the period 1970-1990, suggesting that the share of total public expenditure has no significant effect on economic growth (the used method is OLS regression). However, the authors identify a significant composition effect of government expenditure: increases in the share of current expenditure have a significant positive impact on economic growth, while increases in the share of capital expenditure have a significant negative effect. According to the authors, these results may be due to the fact that excessive use of apparently productive expenditures in developing countries could make them unproductive. In a study for the Greek economy, Alexiou (2007), after disaggregating government spending and empirically testing of the relationship, finds a positive association between the growth in the components of government spending and GDP growth. Expanding his study for seven transition economies in the South Eastern Europe (SEE), Alexiou (2009) comes to the conclusion that four out of the five variables used in the estimation (government spending on capital formation, development assistance, private investment and trade-openness) have positive and significant effect on economic growth (the only variable found to be statistically insignificant is population).

An important category of public expenditure which has been investigated in connection with economic growth is infrastructure. Canning and Pedroni (2004), in an endogenous growth model with constant returns to aggregate capital, investigate the long run impact of infrastructure provision on per capita income in a panel of countries, over the period 1950-1992. The results suggest that, generally, infrastructure induces long run growth effects, i.e. positive shocks to infrastructure stocks raise long-run income per capita. Some studies use physical measure of infrastructure in testing its impact on economic growth (number of kilometers of paved roads, kilowatts of electricity generating capacity, and the number of telephones). Such a study belongs to Sanchez-Robles (1998), who used both infrastructure expenditure and physical units to quantify the independent variable, in a sample of 76 countries. When using infrastructure expenditure, the author finds a negative growth impact, but when she includes indicators of physical units of infrastructure, she finds they are positively and significantly correlated with growth.

Public education expenditure is another category of public spending whose connection with economic growth was investigated, since they are thought to be a key to sustained economic growth. A positive impact is empirically proved by Blankenau et al. (2007): using panel data from 23 developed countries over the period 1960-2000, the authors find a positive relationship between public education expenditures and long-run growth, but only when controlling for the government budget constraint. However, the empirical findings on the relationship between growth and public education expenditures remain mixed.

Regarding public health spending and economic growth, the studies are based on the hypothesis that health can affect economic growth through its impact on human and physical capital accumulation, assuming that healthier people are more productive (Bloom and Canning, 2000; Jack and Lewis, 2009). This assumption is confirmed by Elmi and Sadeghi (2012), after they investigate the causality and co-integration relationships between economic growth and health care expenditures in developing countries during 1990-2009. Also, Baltagi and Moscone (2010) studied the long-run economic relationship between health care expenditure and income, using a panel of 20 OECD countries during 1971-2004. Their main finding suggests that health care is a necessity rather than a luxury, with an elasticity much smaller than that estimated in other OECD studies.

In respect to R&D spending and their influence over growth, Ulku (2004) investigates the main postulations of the R&D based growth models (innovation is created in the R&D sectors and it enables sustainable economic growth). The sample contains 20 OECD and 10 non-OECD countries, for the period 1981-1997, and the results suggest a positive relationship between per capita GDP and

innovation in both OECD and non-OECD countries. This positive correlation has also been confirmed by studies using international panel data, such as Frantzen (2000) and Griffith et al. (2002).

Finally, regarding Central and East European countries, Dincă and Dincă (2013) explore the link between the structure and share of government expenditure into GDP and the real GDP per capita, for 10 countries and 11 years (2002-2012). After performing the linear regression, the authors suggest that GDP/capita is positively correlated with public order and safety expenditures, as well as with economic actions, while national defense and general public services are negatively linked. Supposedly enhancing for the long-term development of any society, health and education expenditures seem to have an insignificant impact on economic development. Last but not least, with data covering the period 1990-2011 for Romania, Braşoveanu and Braşoveanu (2007) investigate the link between public expenditures and economic growth and they reveal three main conclusions: total public expenditures are negatively correlated to economic growth, as well as unproductive spending, while productive public spending seem to be positively linked to economic growth.

3. Methodology and data

The impact of productive public expenditures on economic growth is analyzed using a set of unbalanced data, with 6 cross-sections (6 countries, i.e. Romania, Hungary, Bulgaria, Poland, Czech Republic and Slovakia) for the period 1990-2013, using a panel model approach. We use a panel model since it allows us to control for individual heterogeneity and panel data give more informative data, more variability, less collinearity among the variables, and more efficiency (Baltagi, 2008). The countries were selected taking into account two criteria: geographical criterion and common recent historic background (former communist countries). In addition, there is certain homogeneity in the group of countries selected for the study, since the Eastern Europe economies share important economic and cultural features. As well, the studied period was 1990-2013 considering availability of data.

In order to explore the relationship between productive public expenditures and economic growth, we consider economic growth as dependent variable, while as interest variables we select four types of public expenditures, viewed as productive spending in the literature.

The dependent variable is GDP at purchaser's prices (γ), expressed in current U.S. dollars, and represents the sum of gross value added by all resident producers in

the economy plus any product taxes and minus any subsidies not included in the value of the products.

The interest independent variables are:

- i) public education expenditure (λ), which measures the total public expenditure (current and capital) on education expressed as a percentage of the Gross Domestic Product (GDP) in a given year;
- ii) public health expenditure (χ), which consists of recurrent and capital spending from government (central and local) budgets, external borrowings and grants, and social health insurance funds (expressed as a percentage of GDP).
- iii) research and development expenditure (δ) are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications (expressed as a percentage of GDP).
- iv) public infrastructure expenditure (ι), measuring the total inland transport infrastructure investment (expressed as a percentage of GDP).

Since our main hypothesis considers that productive public spending influence the level of GDP, the basic function has the following form:

$$\gamma = f(\lambda, \chi, \delta, \iota), \quad (1)$$

where: γ – GDP at purchaser's prices, and $\lambda, \chi, \delta, \iota$ – the chosen productive public expenditures.

Using natural logarithm of variable γ , the basic OLS naive panel-model is as follows:

$$\ln(\gamma_{it}) = \alpha + \beta_0 \lambda_{it} + \beta_1 \chi_{it} + \beta_2 \delta_{it} + \beta_3 \iota_{it} + \varepsilon_{it} \quad (2)$$

where: α – intercept, $\beta_0, \dots, \beta_3$ – slopes of interest expenditure variables, i – country, t – time, and ε_{it} – the error term, which varies over both country, and time.

The effects of productive expenditure variables are isolated entering two types of control variables: one derived from the appropriate growth literature, and another one containing robustness variables. In this case, the extended linear model becomes:

$$\ln(\gamma_{it}) = \alpha + \beta_0 \lambda_{it} + \beta_1 \chi_{it} + \beta_2 \delta_{it} + \beta_3 \iota_{it} + \sum_{k=1}^n \beta_k X_{k,it} + \mu_i + \eta_t + \varepsilon_{it} \quad (3)$$

where: α – intercept, $\beta_0, \dots, \beta_3$ – coefficients of interest expenditure variables, β_k – coefficient of control independent variable k by n type, X – control independent variables, μ_i – stands for country fixed effects, η_t – time-specific effect that controls for unaccounted common time-varying factors, i – country, t – time, ε_{it} – the error term.

The first set of control variables is originated in the appropriate growth literature and includes: gross fixed capital formation (investments), employment, foreign direct investment, economy openness, inflation, fiscal burden and government debt. Gross fixed capital formation consists of resident producers' investments, deducting disposals, in fixed assets during a given period, as a percentage of GDP. The employment rate is calculated by dividing the number of persons aged 20 to 64 in employment by the total population of the same age group. The third control variable, net FDI, illustrates the net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors, and is divided by GDP. Economy openness is measured by the exports of goods and services (% of GDP), which represent the value of all goods and other market services provided to the rest of the world. Inflation shows the rate of price change in the economy as a whole, while fiscal burden refers to total receipts from taxes and social contributions divided by GDP. The last control variable, government debt, captures general government gross debt as percent of GDP.

The variables for robustness refer to property rights and freedom from corruption. The first variable explains the ability of individuals to accumulate private property, secured by clear laws that are fully enforced by the state (the score 100 means secure property rights, while a level of 0 suggests a weak protection of these rights). The second robustness variable, freedom from corruption, shows the intensity of corruption (the score 100 means low corruption, while a level of 0 indicates a very corrupt government).

All control variables presented above have consistent impact on economic growth, as Petrakos et al. (2007) argue. They are treated as elasticity, except the variables with no strictly positive values, such as inflation rate and net FDI. The descriptive statistics of variables and their sources are illustrated in Table 1, respectively Table 2 in Appendix.

In our panel-model approach, the model may have heterogeneity in the data. As the investigated sample is unbalanced, we test this property only in the case of cross-section fixed-effects model, because the period fixed-effects model is not appropriate for our sample (we argue that there aren't omitted variables that are the same for each entity in our sample, but vary over time) and the random effects panel-models are not consistent under unbalanced data-set. In this demarche, F-test allows us to choose between pooled model and fixed-effects model. The next section highlights the main empirical results of the explored function, performing several econometric scenarios (models 1-4), as Table 3, in Appendix, illustrates.

4. Results

The most important empirical result achieved after the statistical testing of the connection between productive public spending and economic growth, as Table 3 in Appendix reveals, is that all of the interest public expenditure variables appear significant in every scenario (only health expenditure variable is insignificant in OLS-cross-sectional fixed-effects model 4). Education, R&D and infrastructure expenditure variables are positively correlated with economic growth as dependent variable, while health expenditure variable seems to have a negative impact.

Of the control variables, only general government debt and property rights have statistical significance in each regression model, being positively related to economic growth. At the opposite pole lie economy openness, fiscal burden, inflation rate and freedom from corruption, which are significant in models (2) and (3), and negatively correlated with economic growth. Finally, gross fixed capital formation, employment rate and net FDI are statistically insignificant.

Further on, we initiate the hypothesis tests to choose between pooled model and fixed-effects model. As the sample is unbalanced and the period fixed-effects are not appropriate, only the cross-section fixed-effects are taken into account. The values of F-test and Chi-square for cross-section fixed-effects clearly reveal that the cross-section fixed-effects model is preferred to the OLS estimations. According to the cross-sectional fixed-effects model (4), three interest variables are significant (education, R&D and infrastructure spending), with positive effect on economic growth. Health expenditure variable remains negatively correlated with economic growth, but it becomes statistically insignificant. Two control variables are conclusive and have a positive impact on economic growth: public debt and property rights. As for the rest of the control variables, they have no statistical significance.

The main empirical output, for the 6 investigated countries during 1990-2013, suggests that education, R&D and infrastructure public expenditures are significant and positive correlated with economic growth, while health public spending exerts a negative influence on the dependent variable. As for the control variables, it seems that only public debt and property rights freedom have a significant and positive impact on economic growth.

5. Conclusions

The main purpose of this paper is to empirically investigate the link between productive public expenditures and economic growth, with the help of a panel dataset. Due to their capacity of increasing private capital marginal productivity, productive public spending is expected to exert a significant impact on economic growth. The main empirical result is that the influence of productive public

spending on economic growth is positive and statistically significant with regard to education, R&D and infrastructure expenditures. Our results are consistent with several other studies from the specific literature, such as Blankenau et al. (2007), Canning and Pedroni (2004) and Ulku (2004). As for public health expenditure, the negative sign could mean that in the health sector, the way of spending public money is inefficient, i.e. public investment may often be used for unproductive projects. Also, maintaining the health system in State ownership as a result of the communist legacy, together with the low rate of privatization and disruption of the planned economy's production as a result of the communism fall, have annihilated the positive effects of investment in human capital.

Since public expenditures are one of the most important policy instruments for governments, the study highlights several policy implications:

- i) public deciders must pay an increased attention to education and finance it accordingly (especially in Romania, which has the lowest percent of GDP allocated to education in the European Union), because investments in education lead to human capital accumulation which, in turn, increases the productivity of the labor force.
- ii) investing in health does not necessary mean higher health care spending; health investment should aim to improve the population's human and social capital, through improved nutrition, changing practices, better sanitation, innovations in medical technologies, and public health infrastructure.
- iii) with a small current level of R&D expenditure (around 1% of GDP or below), authorities from East-European countries should intensify the efforts in order to sustain higher levels, considering the crucial role of innovation in the process of growth.

Our overall conclusion is that productive public expenditures can be a key determinant of growth, impacting the production function of the private sector. However, the conclusions of this cross-country analysis should be enriched by additional individual country empirical studies, which should take into account country specific characteristics affecting the public spending composition and also other determinants of growth.

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References

- Afonso, A., Ebert, W., Schucknecht, L., Thöne, M. (2005). "Quality of public finances and growth", European Central Bank, *Working Paper Series*, No. 438
- Alexiou, C. (2009). "Government Spending and Economic Growth: Econometric Evidence from the South Eastern Europe (SEE)", *Journal of Economic and Social Research* 11(1), pp. 1-16
- Alexiou, C. (2007). "Unraveling the 'Mystery' Between Public Expenditure and Growth: Empirical Evidence from Greece." *International Journal of Economics* 1(1), pp. 21-31
- Angelopoulos, K., Economides, G., Kamman, P. (2006). "Tax spending policies and economic growth: theoretical predictions and evidence from the OECD", *European Journal of Political Economy*
- Aschauer, D.A. (1989). "Is Public Expenditure Productive?" *Journal of Monetary Economics*, 23, pp. 177-200
- Baltagi, B.H. (2008) *Econometric Analysis of Panel Data*, Third Edition, John Wiley & Sons, Ltd.
- Barro, R.J. (1990). "Government spending in a simple model of endogenous growth", *Journal of political Economy*, 98(1), pp. 103-117
- Barro, R.J. (1991). "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics*, 106, pp. 407-443
- Barro, R.J., Sala-i-Martin, X. (1995). *Economic growth*, New York, McGraw Hill
- Blankenau, W.F., Simpson, N.B., Tomljanovich, M. (2007). "Public Education Expenditures, Taxation, and Growth: Linking Data to Theory", *American Economic Review*, 97(2), pp. 393-397
- Bloom, D.E., Canning D. (2000). "The Health and Wealth of Nations". *Science*, 287(5456), pp. 1207-1209
- Braşoveanu, L., Braşoveanu, I. (2007) "Efecte Ale Cheltuielilor Bugetare Asupra Creşterii Economice", *Studii şi cercetări de calcul economic şi cibernetică economică*, Nr. 1
- Canning, D., Pedroni, P. (2004). *The effect of infrastructure on long run economic growth*, Harvard University
- Devarajan, S., Swaroop, V., Zou, H.F. (1996). "The composition of public expenditure and economic growth", *Journal of Monetary Economics*, 37, pp. 314-344
- Dincă, M.S., Dincă, G. (2013) "The Impact Of Government Expenditures Upon Economic Growth in Post-Communist Countries", *Scientific Annals of the „Alexandru Ioan Cuza” University of Iaşi Economic Sciences*, 60 (1), pp. 83-92
- Easterly, W., Rebelo, S. (1993). "Fiscal Policy and Economic Growth", *Journal of Monetary Economics*, 32, pp. 417-458
- Elmi, Z.M., Sadeghi, S. (2012) "Health Care Expenditures and Economic Growth in Developing Countries: Panel Co-Integration and Causality", *Middle-East Journal of Scientific Research* 12 (1), pp. 88-91
- Enache, C. (2009). "Fiscal policy and economic growth in Romania", *Annales Universitatis Apulensis Series Oeconomica*, 11(1)
- Fölster, S., Henrekson, M. (2001). "Growth Effects of Government Expenditure and Taxation in Rich Countries." *European Economic Review* 45(8), pp. 1501-1520
- Frantzen, D., (2000) "R&D, Human Capital and International Technology Spillovers: A Cross Country Analysis," *Scandinavian Journal of Economics*, 102 (1), pp. 57-75
- Ghura, D. (1995). "Macro Policies, External Forces, and Economic Growth in Sub-Saharan Africa." *Economic Development and Cultural Change* 43(4), pp. 759-778

- Griffith, R., Redding, S., Van Reenen, J. (2004) "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Countries", *The Review of Economics and Statistics*, 86(4), pp. 883-895
- Guseh, J.S. (1997) "Government Size and Economic Growth in Developing Countries: A Political-Economy Framework", *Journal of Macroeconomics* 19(1), pp. 175-192
- Jack, W., Lewis, M. (2009). *Health Investment and Economic Growth: Macroeconomic Evidence and Microeconomic Foundations*. Washington: World Bank
- Knoop, T.A. (1999). "Growth, Welfare, and the Size of Government", *Journal of Economic Inquiry* 37(1), pp. 103-119
- Petrakos, G., Arvanitidis, P., Pavleas, S. (2007) "Determinants of Economic Growth: The Experts' View", *DYNREG Working Papers*
- Romero de Avila, D., Strauch, R. (2003). "Public Finances and long-term growth in Europe: evidence from a panel data analysis", *ECB Working Paper*, 246
- Sanchez-Robles, B. (1998). "Infrastructure investment and growth: some empirical evidence", *Contemporary Economic Policy*, 16(1), pp. 98-108
- Sturm, J.E., Kuper, G.H., de Haan, J. (1998). "Modelling government investment and economic growth on a macro level: A review", *The Welfare State, Public Investment, and Growth*, pp. 61-83
- Ulku, H. (2004) "R&D, Innovation, and Economic Growth: An Empirical Analysis", *IMF Working Paper*, WP/04/185
- European Commission (2012). *The Quality of Public Expenditures in the EU*, Occasional Papers, 125

Appendix

Table 1. *Descriptive statistics*

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
GDP (US dollars)	8.93E+15	8.41E+10	5.29E+16	2.87E+10	1.34E+16	75
Public education expenditures as % of GDP	0.043321	0.0425	0.0591	0.02491	0.007504	75
Public health expenditures as % of GDP	0.049803	0.050767	0.066756	0.028508	0.008304	75
Investment in inland transport infrastructure as % of GDP	0.0138	0.012	0.032	0.004	0.006134	75
Research and development expenditure as % of GDP	0.007459	0.006336	0.016413	0.0037	0.003122	75
Gross fixed capital formation as % of GDP	0.036613	0.034	0.068	0.015	0.011468	75
Employment rate	0.650453	0.644	0.734	0.571	0.043396	75
Exports of goods and services as % of GDP	0.552129	0.589525	0.873109	0.23	0.174402	75
Net FDI as % of GDP	0.066431	0.043674	0.518958	-0.16418	0.093254	75
Inflation rate	0.09487	0.046394	1.548	-0.015816	0.200299	75
Fiscal burden as % of GDP	0.331653	0.331	0.405	0.266	0.037769	75
General government gross debt as % of GDP	0.383267	0.356	0.822	0.128	0.175413	75
Freedom from corruption	42.48	42	54	26	7.347292	75
Property rights	53.86667	50	70	30	15.99352	75

Table 2. *Source of data*

Variable	Source
GDP (US dollars)	World Bank online database (2014)
Public education expenditures as % of GDP	Eurostat online database and National Institute for Statistics (Romania, 1990-2000)
Public health expenditures as % of GDP	World Bank online database (2014)
Investment in inland transport infrastructure as % of GDP	OECD online database
Research and development expenditure as % of GDP	World Bank online database (2014)
Gross fixed capital formation as % of GDP	Eurostat online database
Employment rate	Eurostat online database
Exports of goods and services as % of GDP	World Bank online database (2014)
Net FDI as % of GDP	World Bank online database (2014)
Inflation rate	World Bank online database (2014) and National Institute for Statistics (for Romania)
Fiscal burden as % of GDP	Eurostat online database and National Institute for Statistics (Romania, 1991-1994)
General government gross debt as % of GDP	Eurostat online database
Freedom from corruption	The Heritage Foundation online data-base (2014)
Property rights	The Heritage Foundation online data-base (2014)

Table 3. Empirical results of panel regressions

Dependent variable: ln GDP (\$)				
Independent variables	Model			
	(1)	(2)	(3)	(4)
constant	110.8979*** (7.665416)	95.80597*** (5.246505)	58.98881* (1.681376)	88.80127** (2.372519)
ln public education expenditures as % of GDP	24.30527*** (6.132765)	12.80947** (2.394401)	14.94679*** (2.901003)	20.25558*** (2.701536)
ln public health expenditures as % of GDP	-12.56313*** (-3.148976)	-10.73938** (-2.154296)	-19.80925*** (-3.527553)	-6.750137 (-0.914745)
ln investment in inland transport infrastructure as % of GDP	4.559110*** (3.624106)	4.773621*** (3.518442)	5.689553*** (4.253679)	4.913260*** (3.605042)
ln R&D expenditure as % of GDP	4.462580** (2.275938)	11.63019*** (4.785331)	8.706927*** (3.075967)	8.988017** (2.179362)
ln gross fixed capital formation as % of GDP		0.880691 (0.447838)	1.553003 (0.781940)	-3.302793 (-1.357379)
ln employment rate		8.539567 (0.622549)	15.95870 (1.206055)	14.93502 (0.845289)
ln exports of goods and services as % of GDP		-8.408722*** (-4.211257)	-4.989685** (-2.268653)	6.648633 (1.567199)
net FDI as % of GDP		8.618793 (1.589264)	7.612722 (1.484671)	2.902025 (0.564565)
ln fiscal burden as % of GDP		-27.46104*** (-3.730928)	-29.52139*** (-4.224691)	-2.355777 (-0.197473)
inflation rate		-8.535826*** (-2.766205)	-8.033236*** (-2.726327)	-3.957314 (-1.081180)
ln general government gross debt as % of GDP		7.522978*** (3.882677)	6.494934*** (3.340357)	4.313663* (1.758306)
ln freedom from corruption			-7.839951** (-2.230054)	-5.277446 (-1.206538)
ln property rights			9.977434*** (2.657252)	18.43817*** (2.892385)
Type of estimation	OLS	OLS	OLS	OLS - FE:CS
		Model summary		
R squared	0.392755	0.721795	0.760799	0.805243
F-test for fixed effects				2.555866 (0.0375)
Chi-square				15.416368 (0.0087)

a. (...) denotes the t-stat;

b. FE:CS denotes cross-section fixed effects;

c. ***, ** and * denote significance at 1, 5 and 10% level of significance, respectively.

The validity of Marshall-Lerner condition in Turkey: A cointegration approach

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Abstract. *In recent years, it is discussed that the currency adjustments (devaluations) may frequently have impact on current account deficit associated with the increase in current account deficit. The impact of devaluation on balance of trade depends on the effectiveness of Marshall-Lerner condition. In this study, the validity of Marshall-Lerner condition in Turkey was investigated. According to the results of Johansen cointegration test and error correction model which were obtained by using annual data of 1980-2012 period; some findings were obtained about the validity of Marshall-Lerner condition in the long run.*

Keywords: Marshall-Lerner Condition, Current Account Deficit, Cointegration, Error Correction Model.

JEL Classification: C22 F32.

REL Classification: 8N.

1. Introduction

Export-led growth policies which are applied in Turkey after 1980 increased foreign trade volume rapidly, however this situation caused the emergence of current account deficit problem. Economic and political crises which arise from the liberalization of capital movements in 1989 led to increase in current account deficit problem. In particular, the increase in current account deficit quickened after 2001 crisis. In discussions about current account deficit which is one of the most important economic problems of Turkey in recent years, it was frequently claimed that Turkish Lira is overvalued and currency adjustments may decrease current account deficit. However the increase in export and the decrease in import after appreciation of foreign currencies depends on demand and supply elasticity of exported and imported goods (Miles, 1979).

2. The elasticity approach and Marshall-Lerner condition

Several theories were developed to explain current account balance. One of these theories is “The Elasticity Approach”. The Elasticity Approach focuses on balance of trade which is one of the main subcategories of current account balance and it assumes that relative international prices are main explanatory variable determining current account balance. This approach analyses the impact of a potential devaluation on balance of trade (Erkılıç, 2006: 17).

According to the Elasticity Approach, when a country devaluates its currency, offsetting of balance of payments depends on demand elasticity of exported and imported goods. Devaluation affects balance of payments in three ways: firstly the decrease in the amount of imported goods because of the increase in the prices of these goods; secondly increase in export because of the decrease in the prices of exported goods; and thirdly lower revenue from one exported good because of devaluation. Net results of these three impacts depend on export and import elasticity. If the sum of the export and import elasticity are bigger than 1 (one) the impact will be positive. This condition is known as Marshall-Lerner condition (Yıldırım and Özer, 2006: 332).

In studies, it was found that the elasticity of exports and imports with respect to the exchange rate is very low in short run, that is Marshall-Lerner condition cannot be fulfilled, however the elasticities are high in the long run and sum of the elasticities may be higher than 1 (one). Thus, devaluation will increase the foreign trade deficit in the short run. The reason is that devaluation makes import more

expensive and the value of export cheaper in the short run in terms of foreign currency revenues and it has less impact on the increase in export and the decrease in import. That is, economic entities need a certain time period in order to adapt themselves to new prices. However, the expected impacts of devaluation can be seen after a while and balance of trade will recover.

In Marshall-Lerner condition, for a devaluation to have a positive impact on foreign trade performance, the sum of absolute values of demand elasticity of exported and imported goods must be greater than 1 (Marshall, 1923; Lerner, 1944). In recent studies, it is asserted that the impacts of changes in foreign exchange rates on balance of trade cannot be explained with elasticity which is calculated by seeing only the changes in the prices and quantities of goods and so income effect should be added to the model.

This study is based on the export and import functions which were used in the ‘Long-Run Price Elasticities and the Marshall–Lerner Condition revisited’ study of Mohsen Bahmani-Oskooee and Farhang Niroomand in 1998 (Bahmani-Oskooee and Niroomand, 1998: 102). According to this model;

Import demand function:

$$\ln M_t = a + b \ln(PM/PD)_t + c \ln Y_t + \varepsilon_t .$$

In this function: M –import, PM – price of import, PD – domestic price level, Y – domestic income, ε – error term. Natural logarithms of all variables in the model were taken.

The increases in import price levels with respect to domestic price levels decrease import and price elasticity of import is expected to be negative ($b < 0$). According to Keynesian theory, it is expected that increase in domestic income raises import, hence income elasticity is expected to be positive ($c > 0$). However, in literature since the increase in domestic income raises import-substituting production, income elasticity will be negative.

Export demand function:

$$\ln X_t = a' + b' \ln(PX/PXW)_t + c' \ln(YW)_t + \varepsilon'_t .$$

In this function: X – export of Turkey, PX – price of export, PXW – world export price levels, YW – world income level and ε'_t – error term. Natural logarithms of all variables in the model were taken. The increases in export prices with respect to world export price levels create the expectation of a decrease in export. So b' should be smaller than 0 ($b' < 0$). When world income level increases it is

expected that the export of country will increase so c' is expected to be higher than 0 ($c' > 0$).

According to 'Marshall-Lerner Condition', the sum of price elasticity of export demand and import demand should be higher than 1. In other words, for a change in foreign exchange rates to have a positive impact on balance of trade, sum of these demand elasticities should be higher than 1.

3. Literature

Bahmani-Oskooee and Niroomand (1998) asserted that demand elasticity of export and import is inelastic in the short run and elastic in the long run by using data of 27 countries in the period of 1960-1992. For this reason, while devaluation has negative impacts on current account balance in the short run, it has positive impacts in the long run.

Baharumshah (2001) investigated the impacts of macroeconomic factors of USA, Japan, Thailand and Malaysia on balance of trade through VaR model by using data of 1980-1996 period. In conclusion, he inferred that exchange rate is an important variable affecting balance of trade in the long run.

Narayan (2004) analysed the relationship between exchange rate and balance of trade in New Zealand's economy through cointegration method by using data of 1970-2000 period and he could not find a cointegration relationship between exchange rate and balance of trade in New Zealand. However it was verified that there is J curve for balance of trade of New Zealand.

Mahmood et al. (2004) estimated elasticity of export and import prices of 6 developed countries. Based on these estimations, they showed that Marshall-Lerner Condition is partially satisfied in some periods and it is valid in fixed exchange rate regime.

Hooy and Chan (2008) made analysis through Bounds Testing Approach (ARDL) and generalized impulse response analysis by using data of January 1990-January 2008 period and they found results which support Marshall-Lerner Condition.

Jamilov (2011) investigated the validity of J curve for Azerbaijan's economy and concluded that an increase in exchange rates affects balance of trade negatively in following 12 months and after that positive impacts can be seen and J curve will be valid.

Hsiao et al. (2012) ascertained that Marshall-Lerner Condition is satisfied in trade of China with Japan, and J curve is valid in trade of China with European Union countries.

There is not an agreement about studies in which the validity of Marshall-Lerner Condition in Turkey's economy. The reason of dissidence is that different time periods, data structures (monthly, quarterly and annual) and methods are used.

Yamak and Korkmaz (2005) investigated the impacts of real exchange rate changes on balance of trade of Turkey through Granger causality test and VaR model-based impulse response analysis by using data of 1995Q1-2004Q4 period. They concluded that there is not a long-run correlation between the variables.

Şimşek and Kadılar (2005) analysed export demand model in Turkey through bounds testing approach by using data of 1970-2002 period and they concluded that Marshall-Lerner Condition is satisfied.

Peker (2008) analysed the relationship between exchange rate and balance of trade in Turkey through cointegration method by using monthly data of 1992-2006 period and they concluded that Marshall-Lerner Condition is not satisfied.

Hepaktan (2009) investigated Marshall-Lerner Condition in Turkey through cointegration method by using data of 1980-2008 period and concluded that this condition does not work accurately.

Çil Yavuz et al. (2010) investigated the validity of Marshall-Lerner Condition in Turkey through bounds testing approach by using data of 1988-2007 period and they concluded that this condition is invalid in Turkey.

Okay et al. (2012) analysed the relationship between exchange rate and balance of trade in Turkey through Johansen cointegration test and vector error correction model (VECM) by using data of 2003:M01-2010:M12 period and they concluded that Marshall-Lerner Condition is valid in Turkey.

Göçer and Elmas (2013) performed cointegration test through dynamic ordinary least square (DOLS) method and used data of 1989Q1-2012Q2 period. They concluded that Marshall-Lerner Condition is valid.

4. Method and data set

Turkey's import (M) and export (X) data, import price index (PM) and export price index (PX), Turkey's gross domestic product (GDP) and world gross domestic product (WY) data were used in order to test the elasticity approach. The period of data is 1980-2012 and annual data were used in the analysis. GDP, export and import data are taken in terms of million dollar (USD) and these data were deflated by using 2005-based related price indexes. Natural logarithms of all variables in the model were taken.

Data were collected from the web sites of Turkish Republic Central Bank electronic data delivery system, Ministry Of Development, General Directorate of Budget and Fiscal Control, and United Nations data set (UNDATA).

4.1. Stationarity tests

In literature, there are several unit root tests in order to determine stationarity of series and the most commonly used test is Augmented Dickey Fuller (ADF) test. In this study, unit root test which regards structural breakage suggested by ADF test and Zivot-Andrews were used.

Table 3. *ADF Unit Root Tests*

Variables	Levels		Diferences	
	intercept	intercept and trend	intercept	intercept and trend
lnX	-0,79	-2,67	-4,94**	-4,97**
lnM	-1,31	-3,59*	-7,65**	-7,71**
lnGSYH	0,30	-2,09	-5,96**	-6,14**
WY	-0,53	-3,00	-4,41**	-4,39**
ln(PX/PXW)	-2,80	-2,48	-6,17**	-6,51**
Ln(PM/PD)	-1,49	-2,41	-7,17**	-7,08**

** and * denote significance at 1% and 5% levels.

Table 3. *Zivot-Andrews Unit Root Tests*

Variables	Levels		Break Point
	intercept	intercept and trend	
lnX	-5,04*	-	2003
lnM	-4,23	-4,78	1990
lnGSYH	-3,58	-3,80	2004
WY	-3,51	-4,03	2006
ln(PX/PXW)	-4,73	-	2004
Ln(PM/PD)	-5,17*	-2,41	2003

** and * denote significance at 1% and 5% levels.

When unit root tests are analysed, it was seen that not all variables are stationary and these variables are stationary when taking first differences. Since the variables are first order stationary, cointegration relations between these variables were examined. Import and export demand functions of Turkey were estimated in order to test elasticity approach and determine whether Marshall-Lerner Condition is satisfied.

4.2. Results of cointegration test

Series subjecting to analysis in consequence of unit root tests are not stationary however if they are integrated at the same degree (first degree), cointegration relations between variables can be estimated and long-run relations can be defined.

4.2.1. Estimate of import demand function

Firstly, length of lag was determined through an unrestricted vector autoregression (VAR) model in order to perform Johansen cointegration test. There many criteria of determination of length of lag. AIC (Akaike Information Criterion) is one these criteria and its results are given below.

Lag	AIC
0	1.167435
1	-4.448756
2	-4.381232
3	-4.337920
4	-4.450202*

According to the result, four was chosen as the length of lag. When lag is four, it was seen that there is not autocorrelation problem and this situation was determined through the results of Breusch-Godfrey LM test.

Lag	LM-Stat.	Probability
1	10.17885	0.3362
2	6.097651	0.7301
3	5.320041	0.8056
4	9.035911	0.4340

Table 6. *Johansen's Cointegration Tests*

Number of		Trace	0.05	
Cointegration	Eigenvalue	Statistic	Critical Value	Probability
$r=0^*$	0.841520	70.16339	29.79707	0.0000
$r \leq 1^*$	0.612287	24.11015	15.49471	0.0020
$r \leq 2$	0.016775	0.422929	3.841466	0.5155

Number of		Max. Eigenvalue	0.05	
Cointegration	Eigenvalue	Statistic	Critical Value	Probability
$r=0^*$	0.841520	46.05324	21.13162	0.0000
$r \leq 1^*$	0.612287	23.68722	14.26460	0.0012
$r \leq 2$	0.016775	0.422929	3.841466	0.5155

According to the Table above, it can be seen that there is cointegration between variables and the number of cointegrated vector is at most 2. Cointegration equation is defined as;

$$\begin{aligned} \text{LnM} = & -2,174023 \text{ Ln(PM/PD)} + 1,916995 \text{ LnY} + 23,33509 \\ & (0.23837) \quad (0.06983) \\ & [9.12] \quad [27.45] \end{aligned}$$

In this equation, the values in parenthesis shows standard errors of parameters and the values in square brackets show t-statistics. According to the results of this model, price elasticity of import is negative (-2.17) as expected and it is statistically significant. Income elasticity of import is positive (1.91) as expected and it is statistically significant.

When there is a deviation in long-run relation between cointegrated variables, it was investigated through Error Correction Model whether the deviation disappears in time and long-run balance is regained. Error Correction Model estimation results which were estimated through cointegration relations are as follows:

	Coefficients	Std. Error	t-statistic	Probability
ECM(-1)	-0.644628	0.246014	-2.620292	0.0238
$\Delta(\text{LnM}(-1))$	-1.425449	0.404757	-3.521745	0.0048
$\Delta(\text{LnM}(-2))$	-1.031156	0.397060	-2.596979	0.0248
$\Delta(\text{LnM}(-3))$	-0.713130	0.462635	-1.541452	0.1515
$\Delta(\text{LnM}(-4))$	0.735262	0.354168	2.076023	0.0621
$\Delta(\text{Ln(PM/PD)}(-1))$	1.330482	0.701020	1.897924	0.0842
$\Delta(\text{Ln(PM/PD)}(-2))$	0.484697	0.549904	0.881420	0.3969
$\Delta(\text{Ln(PM/PD)}(-3))$	1.192205	0.564570	2.111705	0.0584
$\Delta(\text{Ln(PM/PD)}(-4))$	1.480563	0.571251	2.591789	0.0251
$\Delta(\text{LnY}(-1))$	0.400523	0.442226	0.905697	0.3845
$\Delta(\text{LnY}(-2))$	0.738367	0.440472	1.676309	0.1218
$\Delta(\text{LnY}(-3))$	0.176877	0.511569	0.345754	0.7360
$\Delta(\text{LnY}(-4))$	-1.920769	0.554293	-3.465259	0.0053

	Coefficients	Std. Error	t-statistic	Probability
Sabit	0.286940	0.070849	4.050051	0.0019
R ²	0.671995	Akaike info criterion		-0.798895
Adjusted R ²	0.284352	Schwarz criterion		-0.116324
F-statistic	1.733543	Hannan-Quinn criter.		-0.609579
Prob(F-statistic)	0.183717	Durbin-Watson stat		2.212090

In the model, the coefficient of error correction term is defined as $(ECM_{t-1}) -0.644$. The sign of error correction term is negative and it is statistically significant. Accordingly, 64% of deviations from long-run balance recover in a period and it will approach to long-run balance.

4.2.2. Estimation of export demand function

According to Akaike information criterion, the length of lag of export demand function was defined as 1 through unrestricted vector autoregression (VAR) model.

Lag	AIC
0	-6.232543
1	-12.55540*
2	-12.28611
3	-11.99749
4	-12.45952

When lag is 1, it was seen that there is not autocorrelation problem and this situation was determined through the results of Breusch-Godfrey LM test below.

Lag	LM-statistic	Probability
1	7.907566	0.5435
2	8.828093	0.4533
3	9.548515	0.3883
4	2.451313	0.9822

Table 6. Johansen's Cointegration Tests

Number of		Trace	0.05	
Cointegration	Eigenvalue	Statistic	Critical Value	Probability
$r=0^*$	0.510601	45.03985	35.19275	0.0032
$r \leq 1^*$	0.490283	24.31713	20.26184	0.0131
$r \leq 2$	0.151787	4.774072	9.164546	0.3091
Number of		Max. Eigenvalue	0.05	
Cointegration	Eigenvalue	Statistic	Critical Value	Probability
$r=0$	0.510601	20.72272	22.29962	0.0817
$r \leq 1^*$	0.490283	19.54306	15.89210	0.0127
$r \leq 2$	0.151787	4.774072	9.164546	0.3091

According to the Table above, it can be seen that there is cointegration between variables and the number of cointegrated vector is at most 2. Cointegration function is defined as;

$$\begin{array}{lll}
 \text{LnX} = & -0,139450 \text{ Ln(PX/WPX)} & + 3,734149 \text{ Ln(WY)} & - 55,10708 \\
 & (0,58117) & (0,16042) & (2,80986) \\
 & [-0,24] & [23,27] & [-19,61]
 \end{array}$$

Price elasticity of export is negative, however it statistically insignificant; income elasticity of export demand is positive as expected and it is statistically significant. Error correction model estimation results which are based on cointegration relations are given in the table below.

	Coefficient	Std. Error	t-statistic	Probability
ECM _{t-1}	0.180387	0.091220	1.977496	0.0591
$\Delta(\text{LnX}_{t-1})$	-0.061247	0.258264	-0.237150	0.8145
$\Delta(\text{Ln(PX/WPX)}_{t-1})$	0.041066	0.394144	0.104191	0.9178
$\Delta(\text{LnWY}(-1))$	0.783831	1.312146	0.597366	0.5556
R ²	0.089310	Akaike info criterion		-1.987665
Adjusted R ²	0.022002	Schwarz criterion		-1.799073
F-statistic	0.683229	Hannan-Quinn criter.		-1.928600
Prob(F-statistic)	0.183717	Durbin-Watson stat.		1.633645

In the model, the coefficient of error correction term is defined as (ECM_{t-1}) 0,180387. The sign of error correction term is positive and it is statistically insignificant. It shows that deviations from long-run balance which will occur in short run will diverge gradually.

5. Result and proposals

According to the estimation results of export and import demand functions of Turkey, this study in which the validity of Marshall-Lerner Condition in Turkey was analysed supports Marshall-Lerner Condition because the elasticity of export and import demands is higher than 1. However, in the short run, a statistically significant relation between the variables could not be found. Consequently, it was found that currency adjustments (devaluation) may be effective in reducing current account deficit in the long run.

References

- Bahmani-Oskooee, M., Niroomand, F. (1998). "Long-Run Price Elasticities and The Marshall-Lerner Condition" Revised, *Economics Letters*, 61(1), pp. 101-109
- Boyd, D., Caporale Guglielmo, Maria, Smith, R. (2001). "Real Exchange Rate Effects on The Balance of Trade:Cointegration And The Marshall-Lerner Condition", *International Journal Of Finance And Economics*, 6, pp.187-200
- Çil Yavuz, N., Güriş, B. Kıran, ve B. (2010). "The effect of real exchange rate on trade balance: The test of Marshall Lerner condition for Turkey", *İktisat İşletme ve Finans*, 25(287), pp. 69-90
- Erkılıç, Serdar (2006). "Türkiye’de Cari Açığın Belirleyicileri" (Uzmanlık Yeterlik Tezi), Türkiye Cumhuriyeti Merkez Bankası İstatistik Genel Müdürlüğü, Ankara
- Göçer İ., Elmas, B. (2013). "The Effects of Real Exchange Rate Changes on Turkey's Foreign Trade Performance within the Framework of the Extended Marshall-Lerner Condition: Time Series Analysis with Multiple Structural Breaks", *Journal of BRSA Banking and Financial Markets*, 7(1), pp.137-157
- Hepaktan, C.E. (2009). "The Analysis of Fractional Co-Integration related to Marshall-Lerner Condition of Turkey", *Journal of Management and Economics*, Celal Bayar University The Faculty of Economic and Administrative Sciences Journal, 16(1), pp. 39-55
- Hooy, Chee-Wooi, Chan, Tze-Haw (2008). "Examining Exchange Rates Exposure, J-Curve and the Marshall-Lerner Condition for High Frequency Trade Series between China and Malaysia", *MPRA Paper 10916*, University Library of Munich, Germany
- Johansen, S. (1988). "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control*, Vol. 12, No. 2-3, pp. 231-254
- Johansen, S., Juselius, K. (1990). "Maximum Likelihood Estimation and Inferences on Cointegration – with Application to the Demand for Money", *Oxford Bulletin of Economics and Statistics*, 52, pp. 169-210
- Lerner, A.P. (1944). *The Economics of Control: Principles of Welfare Economics*, The Macmillan Company, New York
- Mahmud, S.F., Ullah, A., Yücel, E.M. (2004). "Testing Marshall-Lerner Condition: A Non-Parametric Approach", *Applied Economics Letters*, Volume 11, Issue 4, Marshall, A. (1923), *Money, Credit and Commerce*, Macmillan, London
- Mocan, Naci, H. (1987). "Marshall-Lerner Condition, Expected Market Change and Exchange Rate Determination", *Atlantic Economic Journal*, Vol. 15(1), City University of NewYork, USA, March 1987, p. 121
- Miles, M.A. (1979). "The Effects of Devaluation on the Trade Balance and the Balance of Payment: Some New Results", *Journal of Political Economy*, 6, pp. 600-620

- Okay, E., Atabay Baytar, R. ve Sarıdoğan, E. (2012). “The effects of the exchange rate changes on the current account balance in the Turkish economy”, *İktisat İşletme ve Finans*, 27(310), pp. 79-101
- Peker, O. (2008). “Reel Döviz Kurunun Ticaret Dengesi Üzerindeki Etkileri: Türkiye Örneği”, *Atatürk University Journal of Economics and Administrative Sciences*, 22(2), pp. 33-43
- Sivri, U. ve C. Usta (2001). “Reel Döviz Kuru, İhracat ve İthalat Arasındaki İlişki”, *Uludağ Üniversitesi İ.İ.B.F. Dergisi*, 19 (4), pp. 1-9
- Şimşek, M. ve Kadılar, C. (2005). “The Cointegration Analysis of Turkey's Export Demand Function by Bounds Test”, *Doğuş University Journal*, 6 (1), pp. 144-152
- Yamak, R. ve Korkmaz, A. (2005). “Reel Döviz Kuru ve Dış Ticaret İlişkisi: Kritik Elastikiyetler (Marshall-Lerner) Şartı”, *İstanbul Üniversitesi Ekonometri ve İstatistik Dergisi*, 2, pp. 16-38
- Yıldırım, K.; Mustafa Özer (2006). “İktisat Teorisi”, Anadolu Üniversitesi Yayınları, Eskişehir

Turn Of the Month Effect and Financial Crisis: A new explanation from the Greek Stock Market (2002-2012)

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Abstract. *This study's main objective is to examine the turn of the month (TOM) effect under changing financial trends. For this reason we need to focus on a stock market which (i) does not present significant structural changes, and (ii) presents clear and long term periods of financial growth and recession. The Greek stock market during the period 2002-12 is the most appropriate. We applied a TGARCH asymmetry model which best fits to our data sample due to the leverage effect. The empirical findings suggest that: (i) there is a strong predisposition in favour of the TOM effect, (ii) the financial trend and the volatility shifts influence the TOM effect, and (iii) the TOM days do not present negative returns even during the long term recession period. Moreover, this approach may pave the way for an alternative explanation as to why the TOM effect fades or persists through time.*

Keywords: TOM effect, financial crisis, Greek stock market, investment strategy .

JEL Classification: G01, G15.

REL Classification: 11B.

1. Introduction

Sharpe (1964) and Lintner (1965) present the Asset Pricing Model (APM), while a few years later Fama (1970) presents the Efficient Market Hypothesis (EMH). These seminal papers constitute some of the most important studies in contemporary financial literature. However, scholars document some stock patterns which are widely known as “calendar effects (or anomalies)” and document unexpected or anomalous regularities in security rates of return. The calendar anomalies indicate either market inefficiencies or inadequacies in the underlying asset-pricing model (Schwert, 2003). The fact that the calendar anomalies (CA): (i) call into question the APM and the EMH, and (ii) the important practical implications for traders and investors, may be some of the reasons why there is a vast amount of literature in this specific area of study.

The CA that are most often mentioned in the international literature are: (i) the Day of the Week (DOW) effect which is the tendency for significantly different returns amongst weekdays⁽¹⁾, (ii) the Month of the Year (MOY) effect according to which there are significantly different returns depending on the month⁽²⁾, (iii) the Trading Month (or fortnight) effect (TM), which emphasizes the increased returns during the first fortnight compared to the second one and (iv) the Turn of the Month (TOM) effect according to which the returns are statistically higher on the turn of the month days rather than other days of the same month⁽³⁾.

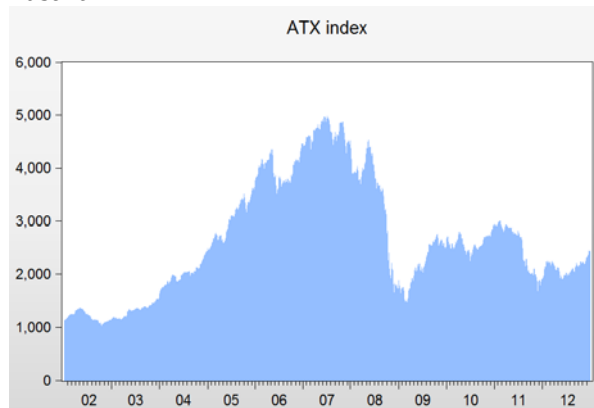
There are conflicting empirical findings regarding the calendar effects (CE) fade or persist. In particular, some scholars suggest that when CA were first documented and entered the realm of public discourse, the market responded efficiently by trading them out of existence (Agrawal and Tandon, 1994), Schwert (2003)). On the other hand there are other studies which question them due to the violations of the OLS assumptions in the returns’ time series (Connoly, 1989, Alford and Guffey, 1996).

The questions above have focused not only the financial trend, but also on the economy’s cycle, because the international literature suggests that the stock market performance is a leading indicator for economic growth/recession (Levine, 2005, Levine and Zervos, 1998 etc.). Therefore, in order to select a country which meets these requirements we examine most of the European Monetary Union’s (EMU) countries and the US economic performance during the period 2002-2012⁽⁴⁾ (Table 1). The results suggest that among all these, the country which presents the most clear and long term economic cycles is Greece. Furthermore, we examine the main stock indexes from the specific countries (Figure 1). The results also suggest that the Greek stock market (ASE GI) presents long term financial trends which are consistent with the aforementioned theories and satisfy our assumptions. Therefore, at this point we present some of the initial reasons that

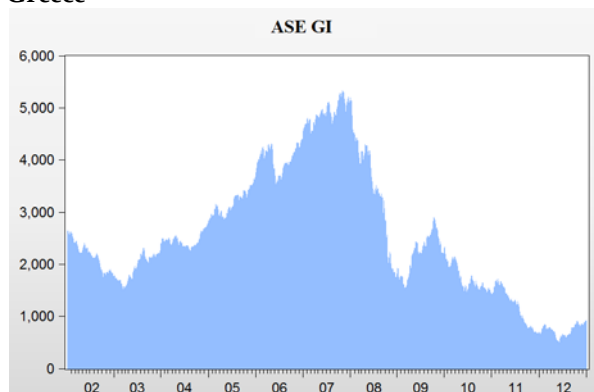
make the Greek case suitable for our study (in the next sections we analytically present our evidence).

Figure 1. *First EMU's countries (those who firstly adopted Euro as official currency) and US stock indexes performance*

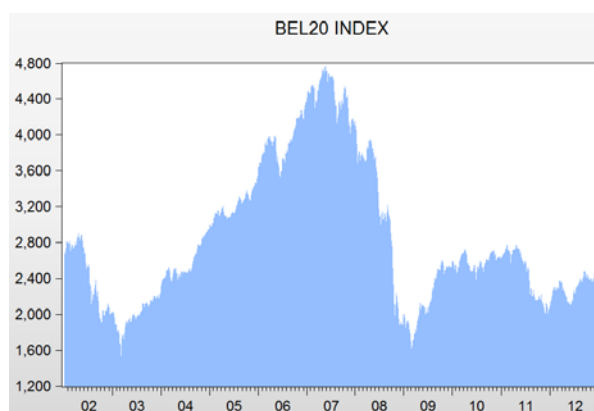
Austria

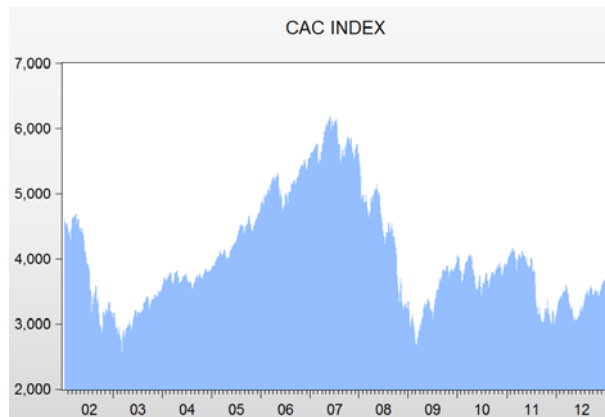
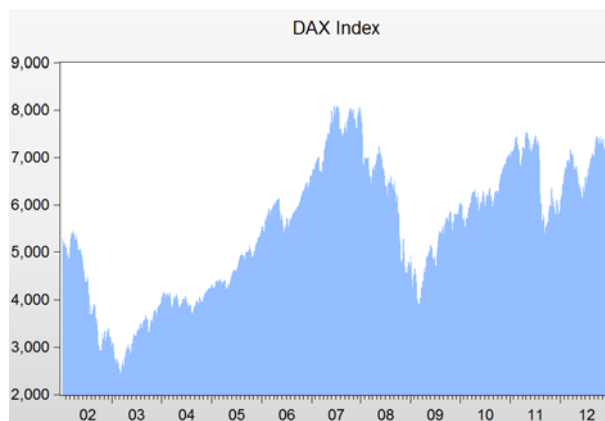
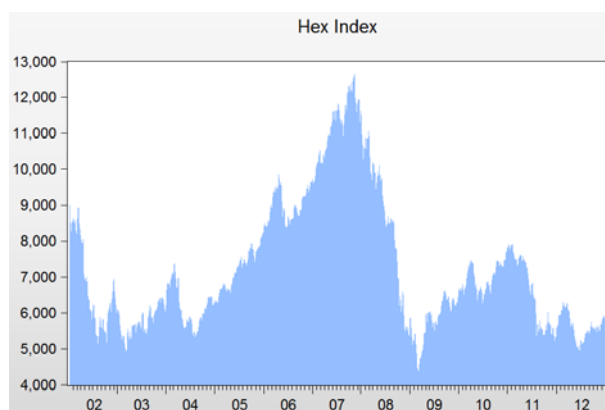


Greece

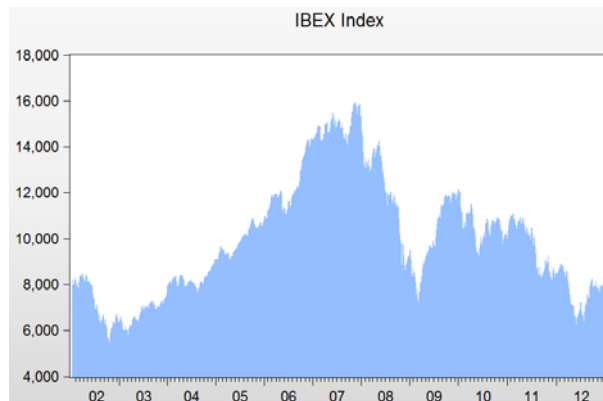


Belgium

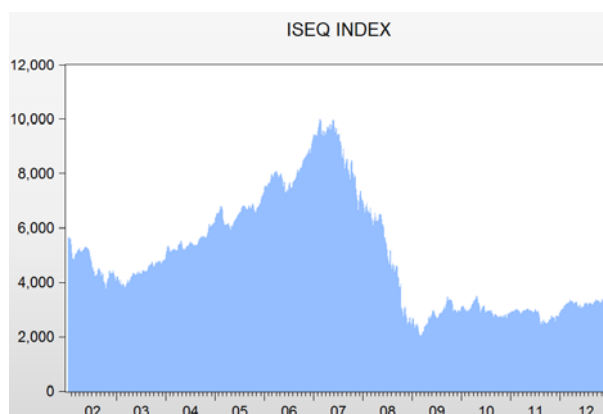


France**Germany****Finland**

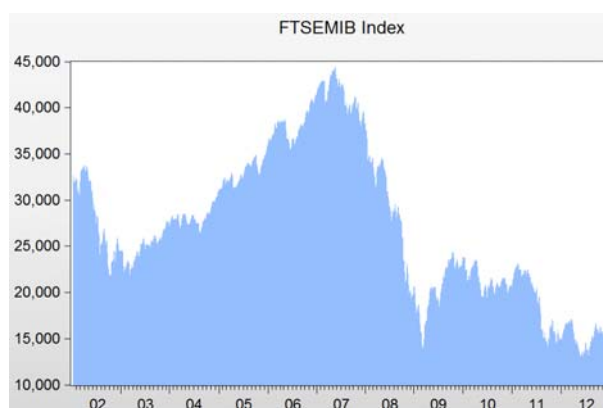
Spain

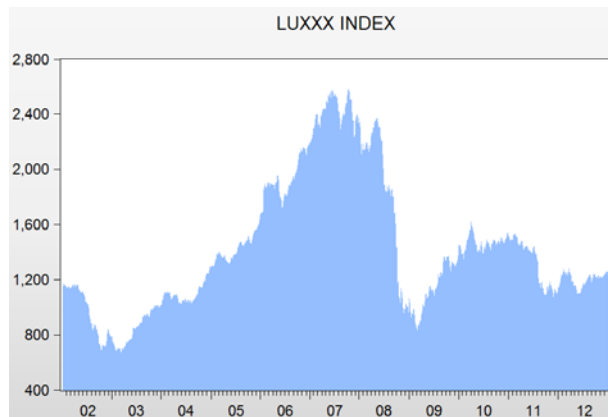
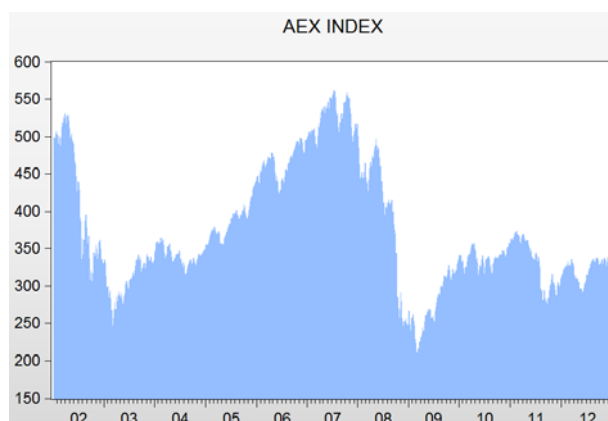
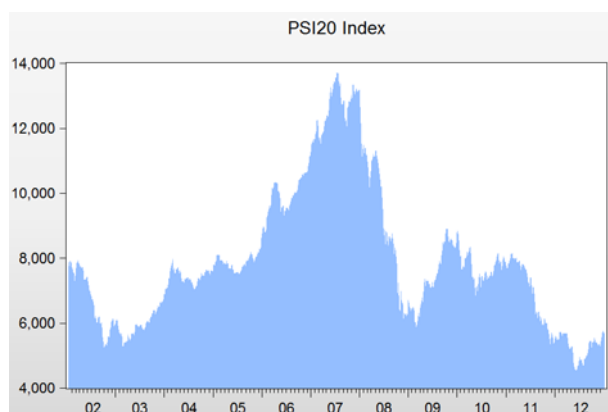


Ireland

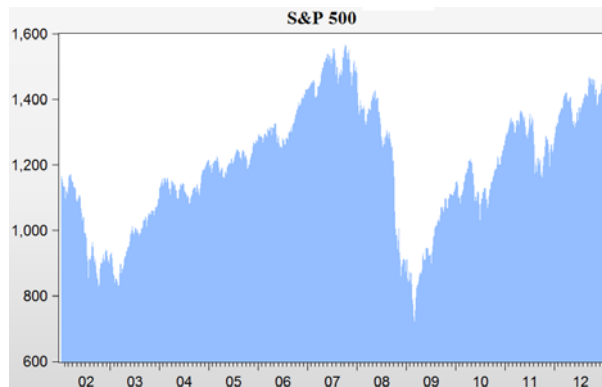


Italy



Luxemburg**Netherlands****Portugal**

USA



Source: Bloomberg.

Table 1. Gross domestic product annual percentage growth in constant prices for the 2002-2012 period in the sample countries

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Austria	1.694	0.866	2.590	2.401	3.670	3.706	1.436	-3.822	1.769	2.834	0.871
Belgium	1.359	0.807	3.274	1.752	2.666	2.883	0.985	-2.787	2.416	1.840	-0.281
Finland	1.834	2.012	4.126	2.915	4.411	5.335	0.294	-8.539	3.363	2.726	-0.827
France	0.929	0.899	2.545	1.826	2.467	2.285	-0.081	-3.147	1.725	2.027	0.014
Germany	0.030	-0.387	0.694	0.846	3.886	3.389	0.807	-5.085	3.857	3.399	0.896
Greece	3.440	5.944	4.368	2.280	5.511	3.536	-0.214	-3.136	-4.943	-7.105	-6.389
Ireland	5.417	3.730	4.200	6.080	5.505	4.970	-2.160	-6.384	-1.063	2.169	0.157
Italy	0.451	-0.047	1.731	0.931	2.199	1.683	-1.156	-5.494	1.723	0.374	-2.369
Luxembourg	4.088	1.669	4.376	5.253	4.933	6.588	-0.735	-4.073	2.891	1.656	0.336
Malta	2.434	0.716	-0.289	3.585	2.580	4.073	3.881	-2.812	3.189	1.819	1.039
Netherlands	0.076	0.336	2.237	2.046	3.394	3.921	1.804	-3.668	1.528	0.945	-1.247
Portugal	0.764	-0.911	1.560	0.775	1.448	2.365	-0.009	-2.908	1.936	-1.288	-3.238
Slovak Republic	4.583	4.775	5.058	6.655	8.346	10.494	5.751	-4.936	4.382	3.226	2.027
Slovenia	3.827	2.930	4.402	4.007	5.850	6.960	3.383	-7.943	1.258	0.709	-2.543
Spain	2.707	3.088	3.257	3.588	4.075	3.479	0.893	-3.832	-0.203	0.052	-1.643
United States	1.776	2.791	3.798	3.351	2.667	1.790	-0.291	-2.802	2.507	1.847	2.779

Source: International Monetary Fund (IMF), World Economic Outlook Database, October 2013.

Definition: Gross domestic product, constant prices.

The main objective of our study is to provide evidence for an alternative explanation on the conflicting findings in the CA literature. The Greek stock market, during the examined period (2002-2012), shows clear and long term financial trends: a growth sub period (2002-2007) and a recession sub-period (2008-2012).

As we mention above, a possible counterargument that can be put forth relates to the applied methodology. In order to avoid such counterarguments, when we examine the TOM effect we employ all the models that are usually used in these studies such as the OLS and GARCH family models. We select the TGARCH model, since it better fits our sample (in the next sections we analytically present the reasons).

In addition, the TOM literature mainly presents two equation variations (version) of the TOM effect. There is one version that focuses on the difference between the mean return of TOM and NTOM days, while the other version focuses on the returns during the TOM and the NTOM periods. In order to examine the TOM effect in detail, we present the results applying both of them.

This paper contributes to the literature by examining the TOM pattern⁽⁵⁾ in a mature market under different and long term financial and economic trends. As we present in the literature there have been documented conflicting findings regarding the TOM effect's existence. Could the financial trend (positive/negative) influence the TOM pattern? If the answer is positive the empirical findings should present different TOM patterns depending on the financial trend during each of the examined periods. Therefore, this approach may pave the way for an alternative TOM approach and an alternative explanation for the calendar anomalies' persistence or fading through the time. Finally, we would like to mention that this is the second study regarding the TOM effect for the Greek stock market, and the first study which examines the TOM effect including the pre- and the post- Greek crisis period.

The rest of this paper is organised as follows: Section 2 presents the literature review for the TOM effect, Section 3 briefly provides the market information and describes the data, Section 4 analyses the methodology and presents the empirical results, Section 5 discusses the findings and Section 6 concludes the study.

2. Literature review⁽⁶⁾

The first studies focusing on the Turn of the Month effect (TOM) examine the US stock market. In particular, Ariel (1987) first observes the TOM effect for the US market. He defines TOM as being the last trading day of the previous month and the first nine trading days of the following month. Lakonishok and Smidt (1988) provide evidence for significant TOM effects in the US market, even when the turn of the year effect is excluded. They define TOM as being the last trading day of the previous month and the first three trading days of the next month⁽⁷⁾. Ogden (1990) suggests that the TOM effect exists in the US because of the accumulation of cash at the month's end by large institutional investors.

The TOM research begins, but is not limited to the US case. The following years presented studies which examine the TOM effect using as a sample either a group of countries or each country individually. Presented in this section are selected studies from the first category in order to briefly show the TOM's international results⁽⁸⁾. Cadsby and Radner (1992) examine a sample of 10 countries, finding that the TOM effect exists in the US, Canada, the UK, Australia, Switzerland and

West Germany; there is no evidence for the TOM effect in Japan, Hong Kong, Italy and France. They documented that the TOM effect exists independently of the Turn of the Year effect. Regarding the non-existence of that calendar effect they suggest that it may be caused by the different sequence days that occur with the TOM effect⁽⁹⁾.

Kunkel et al. (2003) document that the TOM effect still exists in 16 out of the 19 sample countries, using data for the 1988-2000 period. They divide their sample into continents and suggest that the TOM exist in: European markets (Austria, Belgium, Denmark, France, Germany, the Netherlands, Switzerland, and UK), Asian countries (Japan and Singapore), America (Canada, Mexico and United States), Australia and Oceania (Australia and New Zealand) and Africa (South Africa)⁽¹⁰⁾.

Several explanations are proposed for existence of the Turn of the Month effect: (i) companies usually declare profits during the first fortnight of the month and investors may take their positions even before the announcements, (ii) the end of the month prices increase is attributed to better purchasing power resulting from salaries that are usually paid at the end of the month, (iii) the foreign investors' (institutional and individuals) behaviour, which influences the financial markets etc.

However, international literature reports a calendar effects fade after their first documentation, because investors take them into consideration and trade them away (Schwert (2003)). On the other hand, there are studies which call this theory in questions due to the violation of the OLS assumptions (Alford and Guffey (1996)).

Examining the TOM effect for the Greek case, the only study which examines and confirms the TOM effect existence, to the best of our knowledge, is Georgantopoulos et al. (2011). However, for the examined period 2000-2008 there are two significant structural and regulatory changes that may influence the TOM effect: (i) in 2001 the Greek market upgrades from the emerging to the mature markets, which is a significant financial change and (ii) in 2001 Greece enters the Eurozone, which influences the Greek economy's perspectives in general. In order to avoid similar counterarguments that may emerge: (i) we use several econometric models that are usually applied in the specific literature, and (ii) we use data from the Euro period (2002-2012) during which there are no similar changes (Greece is still an EMU member and the Greek stock market downgraded to the emerging markets in 2013).

However, as we present above and to the best of our knowledge, there is no study which examines whether the TOM is influenced by financial trends, because this may give us an explanation for the conflicting findings. For example, we assume

that the TOM effect exists in a specific stock market and the home country is in a negative trend of the economic cycle or presents severe financial crisis; is the TOM effect strong enough to make the TOM days profitable even in this case? Alternatively, during a growth or a recession period are the TOM day returns significantly higher than the returns during the non-turn of the month (NTOM) days? This study tries to answer to these questions and by this way tries to contribute to the TOM literature, by introducing an alternative explanation regarding the TOM effect's presence/fade through the time.

3. Market information and descriptive statistics

3.1. Market information

In this sub-section we would like to provide some information about the Greek economy, which is a special case and an appropriate sample for our study. It is widely known that the Greek issue has been puzzling the EU authorities in the last years. In the summer of 2007 the US begins the sub-prime mortgage crisis which quickly evolves into a full-blown crisis. In the European Monetary Union (EMU) the first crisis-recession signs begin in 2008 (Table 1). The US recession lasts for two years; however for the EMU the financial crisis follows a different pattern for the Eurozone members. The imbalances within the EMU increase and for some countries the consequences of the financial crisis are severe. The Greek economy faces the longest lasting recession and seems to be affected the most amongst the countries included in this sample⁽¹¹⁾, therefore for the Greek economy the economic cycle has the clearest sub-periods of economic growth and economic recession, among the countries we include in Table's 1 sample.

In order to examine the TOM effect in the Greek stock market we should find the indicator that best presents the Greek stock market's performance. Among several financial indices we use the ASE general index (ASEGI)⁽¹²⁾, because it adequately represents the stock market's capitalisation and the average daily trading value (Tsangarakis, 2007). Indicatively, in Table 2 we present the ratio of the ASEGI stocks capitalisation and the average trading value to the total market's respective size. So, we may assume that the chosen ratio adequately represents the Greek stock market. Moreover, the specific ratio is used in many similar ASE studies (Kenourgios and Samitas, 2008, Georgantopoulos et al., 2011 etc.). Therefore, we may assume that ASEGI is a reliable indicator for the Greek stock market's performance and we are able to present some ASEGI's information.

Table 2. *Athens Stock Exchange General Index participation to the Total Market Capitalisation and the Average Daily Trading Value*

Year	2009	2010	2011	2012
Market Capitalisation (%)	76.95%	78.60%	80.61%	85.80%
Average Daily Trading Value (%)	87.87%	92.02%	91.09%	76.50%

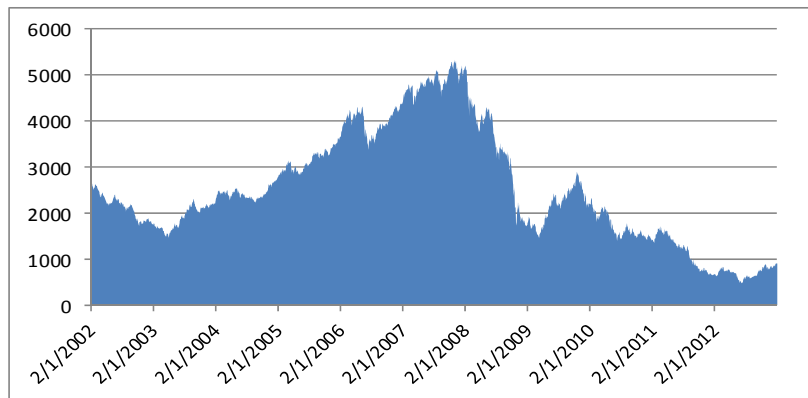
Source: www.helex.gr

The ASEGI's purpose is to be a reliable measure for the listed companies' trend. ASEGI consists of the 60 largest companies (blue chips) stock, which are listed on the main market, which is being calculated daily. It is a market capitalisation weighted-index, while there are specific criteria (e.g. increased liquidity) in order for a stock to be included in the ASE general index. The ASEGI's base year is December 31st 1980, and it is yearly reviewed in April and October⁽¹³⁾.

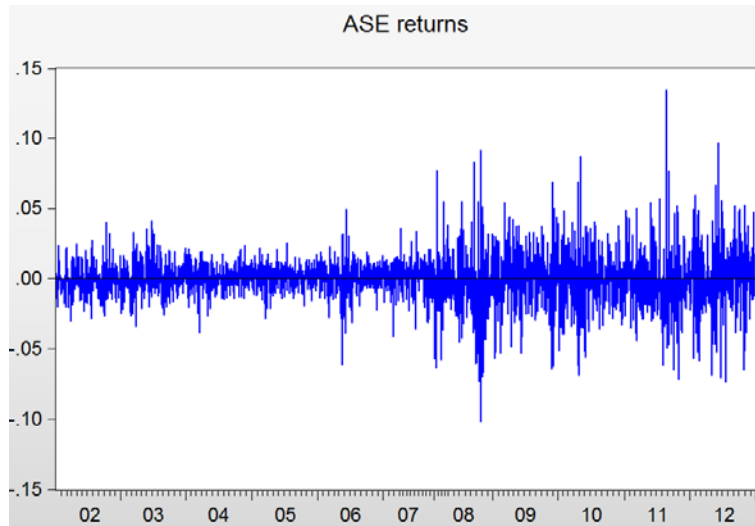
In order to graphically present the ASEGI's performance during the 2002-12 period, we collect from the Bloomberg database daily closing prices (P_t) of the ASEGI for the time span 2nd January 2002 to 31st December 2012. Furthermore, the daily returns which are used in the specific study are given by the equation $R_t = \ln(P_t/P_{t-1})$, where P_t and P_{t-1} are the current and the previous day's index prices respectively. Figure 2(a) presents the ASEGI chart, while Figure 2(b) displays the daily returns volatility for the whole period.

Figure 2. *ASE index and ASE returns chart*

(a) The ASE Index from 3rd January 2002 to 31 December 2012



(b) Returns from 3rd January 2002 to 31 December 2012



Source: Bloomberg and author's calculations.

As we have mentioned in section 1, international literature suggests that the stock market performance is a leading indicator for economic growth/recession (Levine (2005), Levine and Zervos (1998) etc.). Taking into account the financial theory and the statistics in Table 1 we may assume that the end of 2007 would be the period in which the financial trend changes, therefore the period we should divide our sample into growth and recession sub-periods. In the aforementioned theory, the Table 1 data and Figure 2 partly confirm that the Greek case may be a typical case for our study, because not only the stock index (for which we present analytical data below), but also the Greek economy in total presents long term and clear economic cycles. In particular, looking at Figure 2 we may note following: firstly, the ASEGI figure confirms our assumption that for the period 2002-2007 there is a long term growth, but from 2008 up to 2012 there is a period of long term reduction in the stock values, and secondly, the volatility figure suggests that periods of high (low) volatility are followed by periods of high (low) volatility⁽¹⁴⁾.

3.2. Descriptive statistics

Table 3 presents the ASEGI descriptive statistics, which quantitatively confirm that in our sample there is a growth sub-period during 2002-07 and a recession sub-period during 2008-12 (positive and negative mean returns, respectively). We briefly outline three main results. First, there is increased kurtosis and the Jarque-Bera test confirms that our sample does not follow the normal distribution⁽¹⁵⁾. Second, the correlation tests using the Ljung-Box (Q) statistics reject the hypothesis of first and second-order independencies, which means that the conditional mean is a function of past returns and/or past errors and the conditional variance of returns is time-dependent and heteroscedastic. Third, we

use the augmented Dickey and Fuller (1981) and the results suggest that the time series is stationary.

Table 3. Summary statistics for the ASE General Index returns in period 2002-2012

	Total Period (2/1/2002-31/12/2012)	Growth Sub-Period (2/1/2002-31/12/2007)	Recession Sub-Period (2/1/2008-31/12/2012)
Mean	-0.000474	0.000355	-0.001470
Median	3.79E-05	0.000642	-0.001225
Maximum	0.134311	0.049736	0.134311
Minimum	-0.102140	-0.061067	-0.102140
Std. Dev.	0.017633	0.010558	0.023431
Skewness	0.044502	-0.202179	0.165723
Kurtosis	7.512207	4.908667	5.084514
Jarque-Bera	2,292.241	233.7835	227.7648
Probability	0.000000	0.000000	0.000000
Q(1)*	8.1863 (0.004)*	5.7029 (0.017)**	3.0962 (0.078)***
Q(2)	13.396 (0.001)*	6.6605 (0.036)**	8.1906 (0.017)**
Q(5)	15.172 (0.010)*	8.2529 (0.143)	8.6209 (0.125)
Unit root tests for (R _t) Augmented Dickey-Fuller (ADF)	-49.15423 (0.0001)*	-36.04059 (0.0000)*	-33.26899 (0.0000)*
Days with positive returns	1,355	895	690
Percentage of positive trade sessions	50,17%	60,72%	56,23%
Days with negative returns	1,346	579	537
Percentage of negative trade sessions	49,83%	39,28%	43,77%
Observations	2,701	1,474	1,227

Notes: We exclude the turn of the year effect. *, **, *** indicate the level of statistical importance 1%, 5% and 10% respectively. The p-values are given in parentheses.

In Table 4 we provide some further descriptive statistics, which are focused in the TOM and non-Turn of the Month (NTOM) days during the sample's total period and its sub-periods. As TOM days we use the Lakonishok and Smidt (1988) definition for the TOM period (the last and the first three days of the month) and we exclude the December to January TOM days in order to exclude the turn of the year effect.

Table 4. The Trading Month Effect: Descriptive Statistics

	Total Period (2/1/2002-31/12/2012)		Growth Sub-Period (2/1/2002-31/12/2007)		Recession Sub-Period (2/1/2008-31/12/2012)	
	TOM	NTOM	TOM	NTOM	TOM	NTOM
Mean	0.001045	-0.000806	0.001178	0.000176	0.000885	-0.001985
Median	0.000419	-5.72E-05	0.001032	0.000562	-0.000395	-0.001593
Maximum	0.069058	0.134311	0.041005	0.049736	0.069058	0.134311
Minimum	-0.071679	-0.102140	-0.033930	-0.061067	-0.071679	-0.102140
Std. Dev.	0.017561	0.017635	0.011114	0.010429	0.023060	0.023491
Skewness	-0.053440	0.066127	0.077811	-0.282984	-0.046566	0.212414
Kurtosis	5.373034	7.996567	4.140111	5.087937	3.725088	5.390882
Jarque-Bera	113.7947	2307.820	14.56480	235.9399	4.898902	247.4196

	Total Period (2/1/2002-31/12/2012)		Growth Sub-Period (2/1/2002-31/12/2007)		Recession Sub-Period (2/1/2008-31/12/2012)	
	TOM	NTOM	TOM	NTOM	TOM	NTOM
Probability	0.000000	0.000000	0.000688	0.000000	0.086341	0.000000
Days with positive returns	254	1101	146	631	108	470
Percentage of days with positive returns	52.48%	49.66%	55.30%	52.15%	49.09%	46.67%
Days with negative returns	230	1116	118	579	112	537
Percentage of days with negative returns	47.52%	50.34%	44.70%	47.85%	50.91%	53.33%
Observations	484	2,217	264	1,210	220	1,007

Note: We exclude the turn of the year effect.

The mean returns during the TOM days are always positive either we examine the growth either the recession sub-period. Moreover, there are increased possibilities for positive returns sessions during the growth period (55.03%), but these possibilities are reduced during the crisis period (49.09%). On the other hand, the NTOM are highly influenced by the financial trend. In particular, during the growth period the mean returns are positive and during the recession period change to negative. Furthermore, the possibilities for positive returns session are highly influenced by the financial trend. The 52.15% session days are positive during the growth period, while this ratio falls to 46.67% when the financial trend shifts.

Finally, regarding the descriptive statistics we present a binary approach which gives us the opportunity to present in an alternative and a systematic way, when there are increased possibilities for positive (negative) returns stock sessions during each period either for TOM or for NTOM days. The Probit/Logit equation for the TOM effect is

$$Y_i = D_{1i} + D_{2i}, \quad (1)$$

where: $Y_i=1$ if there are positive returns and $Y_i=0$ otherwise. D_{1i} and D_{2i} are dummy variables which belong to the TOM and NTOM time span, respectively. If the day i belongs to the TOM days the dummy variables are $D_{1i}=1$ and $D_{2i}=0$. For the NTOM days the dummy variables values are reversed.

Table 5. *Probit/Logit Analysis for the trading month effect*

	Probit			Logit		
	Total Period (2/1/2002- 31/12/2012)	Growth Sub- Period (2/1/2002- 31/12/2007)	Recession Sub-Period (2/1/2008- 31/12/2012)	Total Period (2/1/2002- 31/12/2012)	Growth Sub- Period (2/1/2002- 31/12/2007)	Recession Sub-Period (2/1/2008- 31/12/2012)
TOM	0.062188 (0.2753)	0.133321 (0.0849)***	-0.022790 (0.7874)	0.099255 (0.2755)	0.212922 (0.0854)***	-0.036368 (0.7874)
NTOM	-0.008480 (0.7501)	0.053888 (0.1350)	-0.083485 (0.0348)**	-0.013532 (0.7501)	0.086003 (0.1351)	-0.133265 (0.0349)**

Notes: We exclude the turn of the year effect.

*, **, *** indicate the level of statistical importance 1%, 5% and 10% respectively.

The p-values are given in parentheses.

The results suggest that the TOM days present increased possibilities for positive return sessions during the growth period, while the NTOM days present increased possibilities for negative sessions during the recession period.

The descriptive statistics and the binary analysis we present above may be a first indication that financial trend influences the TOM effect, because the differences between the TOM and NTOM returns are influenced from the economic cycle. Particularly, the descriptive statistics suggest that the TOM returns are positive in both sub-periods, but during the growth years the mean return is significantly higher. On the other hand the NTOM returns are strongly influenced from the financial trend. During the growth years the mean returns are positive, but lower in comparison to the respective TOM returns. In contrast, during the recession years the NTOM mean returns are significantly negative (in absolute value higher than the TOM returns during the growth period).

The economic environment and the market's psychology may be depicted in the positive or negative return sessions. Therefore, apart from the descriptive statistics (Table 4), binary analysis enables us to present these statistics in a more systematic way (Table 5). During the growth period not only the mean returns are positive, but also the most stock sessions days are positive. Especially the TOM days during the growth period present increased possibilities for positive returns. However, during the recession period the results are almost the opposite. The most TOM days, even if they present positive mean returns, are not positive, while the NTOM days not only present negative returns, but also there are increased possibilities for negative return sessions.

From the above statistical analysis we highlight the following: (i) the TOM days present a predisposition for positive returns (even during the long term recession period the mean TOM returns are positive), (ii) the NTOM days are significantly influenced from the financial trend, (iii) the positive/negative return sessions may be an indicator for the economic climate, and (iv) this section's results enable us

to assume that in the Greek stock market there is a predisposition in favour of the TOM effect, but the financial trend influences it. In the next section we apply the methodological approaches that are used in the specific literature in order to confirm (or not) these assumptions.

4. Methodological issues and results presentation

The calendar anomalies are usually examined using either an OLS or a GARCH family model. As we mention in the introduction, a major methodological counterargument in the specific area of study is that the OLS may not be appropriate due to the violations of the OLS assumptions (Connolly (1989), Alford and Guffey (1996)). Financial econometrics theory suggests that the linear models may be inappropriate when the sample's distribution may be characterised as leptokurtic, and when there is leverage effect, which is the tendency for volatility to rise more following a large price fall than following a price rise of the same magnitude (Brooks (2008, p.380)). Moreover, as Kenourgios and Samitas (2008) suggest the error variances may not be constant over time; therefore using a GARCH family model we allow variances of errors to be time dependent to include a conditional heteroskedasticity that captures time variation of variance in stock returns.

The aforementioned features exist in our sample: (i) the distribution is leptokurtic, (ii) during the recession period the volatility raises significantly (Table 3), and (iii) periods of high (low) volatility are followed by periods of high volatility (Figure 2). Therefore, theoretically the GARCH family models may be more appropriate for our sample. We empirically confirm our assumption, because when we run a regression using the OLS approach we find an ARCH effect.

The next step of our “methodological exploration” is to find the most appropriate GARCH family model. We apply several GARCH models that usually are used in the respective literature (GARCH, EGARCH and TGARCH). Among the GARCH family models we finally choose the T-GARCH (or GJR model, named from the authors' initials Glosten, Jagannathan and Runkle (1993) model, because this model: (i) enables us to include the leverage effect in our findings, and (ii) fits better to our sample according to the Akaike and Swartz criteria.

However, the exploration does not finish here. We examine the TOM effect using two versions that are usually used in the international literature and focus on the TOM-NTOM returns relationship from two slightly different views. In this way we try to completely examine the TOM effect.

4.1.1. First version of the TOM effect: Methodological issues

The first TOM effect version focuses on the difference between the mean return of TOM and NTOM days. The mean equation result this case is the following

$$R_t = a + b \cdot \text{TOM}_D + c \cdot R_{t-1} + \varepsilon_t \quad (2a),$$

where $R_t = \ln(P_t/P_{t-1})$, TOM_D is a dummy variable taking the value 1 for the TOM days (otherwise takes the value zero), and ε_t is an iid $\sim (0, \sigma^2)$ error term. The a term indicates the mean daily return for the NTOM day, the b term measures the difference between the mean TOM and the mean NTOM return. R_{t-1} is the previous day's return, which enables us to resolve the autocorrelation issues and to include the non-synchronous trading effect (different trader types) in our analysis. In order to examine which is the crisis influence into the total period's mean equation we include the crisis dummy variable, which takes the value 0 for the pre-crisis period (2002-07) and the value 1 for the post-crisis period. Therefore, only when the total period is examined the equation is the following:

$$R_t = a + b \cdot \text{TOM}_D + c \cdot R_{t-1} + \text{crisis} + \varepsilon_t \quad (2b).$$

The conditional variance for the total period is given by the equation (3)

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 + \beta_1 \sigma_{t-1}^2 + \gamma_1 u_{t-1}^2 I_{t-1} + \delta \text{crisis}_t, \quad (3)$$

where u_{t-1}^2 and u_{t-2}^2 are the ARCH terms, which captures the volatility during the previous period (order 1 and 2 respectively), and σ_{t-1}^2 is the GARCH term, which indicates that the value of the variance depends on the past value of the variance itself. The difference between a simple GARCH and the T-GARCH model is the dummy variable I_{t-1} which takes the value 1, if $u_{t-1} < 0$, and zero otherwise. The crisis dummy variable indicates how the crisis influences on the volatility (this variable is included only when the total period is examined). Positive δ coefficient means that crisis increases the volatility (and vice versa). In this case positive returns will have impact α_1 , and negative returns will have impact $\alpha_1 + \gamma$. If $\gamma > 0$ we conclude that there is asymmetry and that a negative return tends to increase subsequent volatility much more than a positive return of the same magnitude.

For the total and the growth period we use a TGARCH (2,1) model in order to eliminate the ARCH effect. Therefore, the conditional variance for the first period is given by the equation

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 + \beta_1 \sigma_{t-1}^2 + \gamma_1 u_{t-1}^2 I_{t-1}, \quad (4)$$

while in the second period the variance equation is a simple TGARCH (1,1) model

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta \sigma_{t-1}^2 + \gamma_1 u_{t-1}^2 I_{t-1}, \quad (5)$$

4.1.2. First version of the TOM effect: Empirical results' presentation

The findings are presented in Table 6. The mean return's results suggest the following. In the Greek stock market there is a long term tendency in favour the TOM effect. The TOM term (coefficient b) is always positive either we examine the whole period or each sub-period individually. However, the strength of the TOM is influenced by the financial trend. In particular, during the growth period the TOM effect is not statistically significant, probably because the TOM and the NTOM returns are both positive. In this case, the returns' difference is not statistically significant. In contrast, when the recession years come the NTOM returns are negative and the TOM returns are positive. This contrast in the returns may be the reason for the increased significance that the b term represents. Therefore, we may assume that in the Greek stock market a TOM effect predisposition may exists, which is stronger during the crisis due to the opposite results that TOM and NTOM days present.

The previous day's returns coefficients (x) are positive and statistically significant during the total and the growth (or pre-crisis) periods. This means that previous days' returns influence the current returns and this may be due to non-synchronous trading (different trader types), which is likely to characterize the less developed markets. However, these results are not empirically confirmed during the recession (or post crisis) period. Finally, as it is expected the crisis reduces the returns (crisis coefficient is negative and statistically significant).

According to the variance equation, the results suggest the following: (i) the crisis increases the ASE volatility (δ coefficient is positive and statistically significant), (ii) the leverage holds in the Greek stock market (γ is positive and statistically significant), which means that bad news has larger effects on the volatility of the series than good news, therefore the asymmetry models are more appropriate, and (iii) the sum of the coefficients in the volatility equation, which is less than 1, suggests stationary and not explosive variance.

Table 6. *The turn of the month effect: first version's empirical findings*

Mean Equation			
	Total Period (2/1/2002-31/12/2012)	Growth (or Pre-Crisis) Period (2/1/2002-31/12/2007)	Recession (or Post-Crisis) Period (2/1/2008-31/12/2012)
Constant	0.000232 (0.3983)	0.000190 (0.4877)	-0.001717 (0.0105)**
TOM	0.001281 (0.0219)**	0.000759 (0.1806)	0.003079 (0.0563)***
Return _{t-1}	0.055935 (0.0044)*	0.087914 (0.0002)*	0.027976 (0.3450)
Crisis	-0.001721 (0.0064)*		

Mean Equation			
	Total Period (2/1/2002-31/12/2012)	Growth (or Pre-Crisis) Period (2/1/2002-31/12/2007)	Recession (or Post-Crisis) Period (2/1/2008-31/12/2012)
Volatility Equation			
Constant	6.83E-06 (0.0000)*	7.58E-06 (0.0000)*	3.26E-05 (0.0000)*
α_1	-0.002316 (0.7805)	-0.066008 (0.0000)*	0.039433 (0.0054)*
α_2	0.051848 (0.0001)*	0.100931 (0.0000)*	
γ	0.105504 (0.0000)*	0.130941 (0.0000)*	0.095563 (0.0003)*
β	0.832068 (0.0000)*	0.827474 (0.0000)*	0.853617 (0.0000)*
δ	3.05E-05 (0.0000)*		

Notes: *, **, *** indicate the level of statistical importance 1%, 5% and 10% respectively.

The p-values are given in parentheses.

4.2.1. Second version of the TOM effect: Methodological issues

Equation 6 is the second version of the TOM model. This approach focuses on the returns' during the TOM and the NTOM periods

$$R_t = a \cdot \text{TOM}_D + b \cdot \text{NTOM}_D + c \cdot R_{t-1} + \varepsilon_t, \quad (6a)$$

where TOM_D dummy takes the value 1 if the corresponding day is a TOM day and zero otherwise. The NTOM_D is exactly the opposite from the TOM_D , therefore we do not use an intercept in order to avoid the dummy variable trap. Similar to the previous case, when the total period is examined we include the crisis variable and the equation is

$$R_t = a \cdot \text{TOM}_D + b \cdot \text{NTOM}_D + c \cdot R_{t-1} + \text{crisis} + \varepsilon_t. \quad (6b)$$

The conditional variance equations are the same as in the previous version.

4.2.2. Second version of the TOM effect: Empirical results' presentation

Table 7 presents the results and confirms our previously mentioned assumptions (in version 1). The returns during the TOM period are constantly positive, but only during the growth period are statistically significant. The positive NTOM returns during the growth period does the difference between TOM and NTOM mean returns lower. On the other hand, during the recession period the TOM returns are positive, but statistically not significant, while the NTOM returns present increased negative significance (almost 1%). For this reason the difference between TOM and NTOM returns during the recession period is statistically significant.

The results according to the crisis variable, the previous day's returns and the variance equation are similar to the results we previously present; therefore it is not necessary to repeat them.

Table 7. *The turn of the month effect: second version's empirical findings*

Mean Equation			
	Total Period (2/1/2002-31/12/2012)	Growth (or Pre-Crisis) Period (2/1/2002-31/12/2007)	Recession (or Post-Crisis) Period (2/1/2008-31/12/2012)
TOM	0.001514 (0.0030)*	0.000952 (0.0687)***	0.001361 (0.3618)
NTOM	0.000232 (0.3983)	0.000200 (0.4675)	-0.001717 (0.0105)**
Return _{t-1}	0.055937 (0.0044)*	0.086568 (0.0003)*	0.027972 (0.3450)
Crisis	-0.001721 (0.0064)*		
Volatility Equation			
Constant	6.83E-06 (0.0000)*	7.65E-06 (0.0000)*	3.26E-05 (0.0000)*
α_1	-0.002315 (0.7806)	-0.066446 (0.0000)*	0.039431 (0.0054)*
α_2	0.051848 (0.0001)*	0.102269 (0.0000)*	
γ	0.105504 (0.0000)*	0.130593 (0.0000)*	0.095552 (0.0003)*
β	0.832067 (0.0000)*	0.826583 (0.0000)*	0.853624 (0.0000)*
δ	3.05E-05 (0.0000)*		

Notes: *, **, *** indicate the level of statistical importance 1%, 5% and 10% respectively.

The p-values are given in parentheses

4.3. Econometric validity

Finally, Table 8 presents the autocorrelation and ARCH effect tests in order to complete our models' econometric analysis and to confirm their validity. We report the Ljung-Box Q statistics for the normalized residuals and Engle's (1982) ARCH-LM test at 1-, 10-, and 15-day lags⁽¹⁶⁾. None of these coefficients are statistically significant. Therefore, we cannot reject the null hypothesis that the residuals are not autocorrelated and there is no significant ARCH effect⁽¹⁷⁾.

Table 8. *Autocorrelation and ARCH-LM tests*

	Total Period (2/1/2002-31/12/2012)	Growth (or Pre-Crisis) Period (2/1/2002-31/12/2007)	Recession (or Post-Crisis) Period (2/1/2008-31/12/2012)
Wald	4.584 (0.0103)**	1.800 (0.1658)	3.782 (0.0230)**
Q(1)	1.0760 (0.300)	0.0661 (0.797)	0.8396 (0.359)
Q(10)	8.7716 (0.554)	5.5944 (0.848)	9.7088 (0.466)
Q(15)	19.116 (0.209)	8.3280 (0.910)	18.491 (0.238)
ARCH(1)	0.236899 (0.6265)	0.019926 (0.8878)	1.482062 (0.2237)
ARCH(10)	0.627266 (0.7917)	0.651222 (0.7703)	0.969877 (0.4679)
ARCH(15)	0.711635 (0.7750)	0.640537 (0.8430)	0.834564 (0.6392)

Note: We present Q statistic for the autocorrelation test and the F-statistics of the ARCH- LM test. The p-values are given in parentheses.

5. Discussion

In this study we try to present detailed examination of the TOM effect in the Greek stock market taking as sample the period 2002-2012, because during this period there are no significant economic or financial reforms (e.g. Euro adoption, market upgrade etc.), which may influence the results (Alexakis and Xanthakis, 1995, Kenourgios and Samitas, 2008). During the sample's period the ASE presents long term financial trends, which enables us to examine the TOM effect in a period of long term growth and in a period of long term recession (Table 1 and Figure 2). The descriptive statistics suggest that the TOM days' returns are positive (even during the recession period), but the financial trend influences the NTOM days' returns (Table 4). Moreover, the TOM days present increased possibilities for positive sessions during the growth period and resist during the recession period (Table 5). Using a binary approach we are able to quantitatively present and confirm the economic climate in each period.

Apart from the descriptive statistics, we examine the TOM effect by employing the most appropriate methodology from those that are usually used in the respective literature. Furthermore, we examine the TOM effect using the two versions that are mainly presented in the international literature and complement each other (Tables 6 and 7).

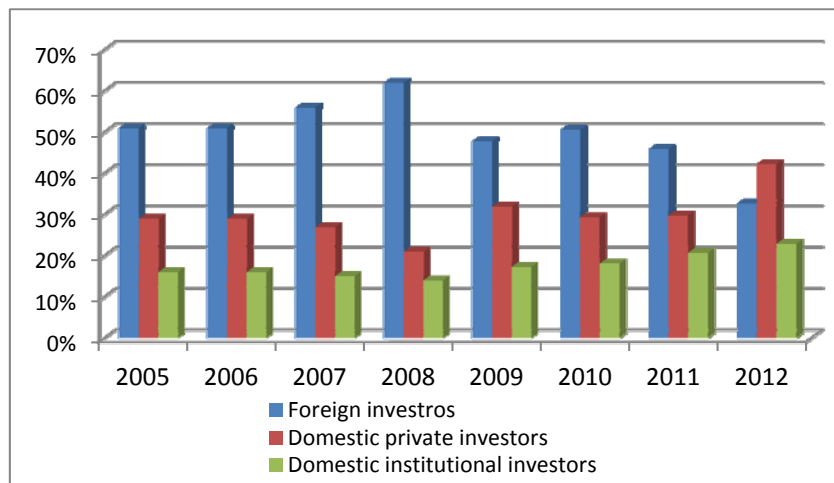
The first version focuses on the returns' difference between TOM and NTOM days. In this case the empirical findings suggest that there is a long term

predisposition in favour of the TOM effect (TOM is positive and statistically significant during the total period), however the TOM existence is highly influenced by the financial trend. In particular, TOM days are positive, but statistically significant only during the recession period. So we may assume that during the TOM days there is a tendency for increased returns relative to the NTOM days, but only during the recession period this difference is statistically significant. Therefore, if somebody should invest in the Greek stock market (e.g. the manager of a Greek mutual fund) in order to achieve significantly increased returns (s)he should buy when the returns are relatively lower (NTOM days) and sell during the increased returns days (TOM).

The second version focuses on the returns during the TOM and the NTOM days. There is a long term predisposition in favour of the positive TOM days (see the TOM coef. when the total period is examined, Table 6), but the returns are significantly positive only during the growth period. Therefore, similar to the previously mentioned results an individual investor has increased possibilities for increased profits if (s)he buys stocks during the NTOM days and sells them during the TOM days, when there is a growth period. On the other hand, during the recession period a short sales strategy during the NTOM days using futures it could be profitable (or such a strategy could hedge the recession's influence on a Greek mutual fund)⁽¹⁸⁾.

The aforementioned versions are complementary to each other. Both of them suggest that there is a long term predisposition in favour of the TOM effect and that the financial trend influences the TOM effect. Particularly, during the growth period the TOM days present significantly positive returns, the NTOM days are also positive due to the positive financial environment, therefore the returns' difference between TOM and NTOM days is not significant. In contrast, the negative financial and economic environment turn the NTOM returns to be significantly negative, but the TOM days still present positive returns (even if there are not statistically significant). The TOM days' resistance during this long term recession period and this makes the TOM-NTOM returns' difference significant.

Moreover, the results suggest that (i) the crisis reduces returns and increases the volatility, (ii) there are volatility asymmetries and the leverage effect is present, regardless of the financial trend, (iii) generally, there is a predisposition for positive returns during the TOM days, and (iv) the previous day's returns influence the current returns, and as Vasileiou (2014) suggests this may be due to probably due to the changes in the participation ratios of domestic private investors, foreign investors and domestic institutional investors (Figure 3).

Figure 3. *Investors' Participation in ASE (% of total turnover)*

Source: www.helex.gr

6. Conclusions

This article's objective is to examine whether the calendar anomalies are influenced by the financial trend. The empirical findings suggest that the recent financial crisis influences not only the stock market's returns and volatility, but also the TOM effect. In other words, the economic crisis and the changing financial trend influence not only the ASE returns, but also its anomalies.

The conflicting results, according to the existence of the TOM effect in the Greek stock market during periods of growth and recession, confirm our assumption that the fading or persistence of the calendar anomalies may be dependent on the financial trend. Therefore, future calendar effects studies, which examine the specific relationship, may help establish whether calendar anomalies are influenced by financial trends and thus pave the way for a new explanation for the fading of calendar anomalies over time⁽¹⁹⁾.

Moreover, if the calendar anomalies existence suggests that the market is inefficient, since investment results could be predicted from the historical returns, the findings for the Greek stock market suggest that it is inefficient. If we examine the total period, the results suggest that the TOM effect exists, while the results regarding the sub-period depend on the version of the TOM we apply. In any case there is a clear predisposition for positive returns during the TOM days⁽²⁰⁾. Further studies which use a similar approach may be useful for examining whether the economic environment and financial trends influence the markets' efficiency. Practically, the results may be useful for investors and professionals who deal with the Greek stock market and take into account the TOM effect in their investment strategy.

A very significant result (as far as the Greek case is concerned) is that there is a predisposition in favour of the calendar effects, but a strategy based on this effect may be profitable during the growth period and no-profitable during the recession period. The reasoning, which was the primary assumption of our study, is quite simple: if we know that a country will face long term recession would it be a profitable investment strategy during the TOM days? The results confirm our assumption that increased profitability are presented on TOM days only during the growth period and that in general the TOM effect is influenced by the financial trends.

If these results are confirmed in a group of countries, future research may focus on whether the TOM fade or persistence may be a leading indicator for a change in the financial trend (e.g. if the TOM returns turn to be positive and statistically significant (2nd version) this may be an indicator for an upward financial trend). Finally, a notable find is that the TOM days are positive even during severe financial crisis. This may be the objective of new research which examines the TOM in a group of countries and if the results are confirmed a detailed examination for the reasons why this effect exists may be further developed (e.g. institutional or/and foreign investors funds create the conditions for the TOM effect).

Notes

- (1) In most of the cases is mentioned as Monday or turn of the week effect; higher returns on Fridays and lower returns on Mondays.
- (2) Most frequently it is examined the January effect which is the tendency for increased returns during the January.
- (3) Through the years scholars document more CAs such as the week of the year, May to October, the time of the month etc., but the aforementioned CAs are the most popular.
- (4) We examine the EMU's stock markets during the years after the Euro era (2002), because significant economic reforms that may influence the financial market's performance and anomalies. Alexakis and Xanthakis (1995) and Kenourgios and Samitas (2008) present that the day of the week calendar effect is influenced when significant structural reforms take place. We may assume that some significant regulatory and economic reforms, such as the Euro adoption or a market upgrade or downgrade, may violate the *ceteris paribus* principle. If we include in this sample other EMU countries which adopted the Euro during the next years, their time span would be significantly reduced in a level which could make it inappropriate for a similar study.
- (5) Vasileiou and Samitas (2014) and Vasileiou (2013) present that the financial trend changes influence the month and the trading month, and the day of the week patterns, respectively.
- (6) There is vast calendar anomalies literature (for the DOW, MOY, TM etc.), but our study focuses on the TOM effect, therefore we present only the specific literature review.
- (7) In our study, as in most studies, we use this definition for the TOM effect.
- (8) There is a vast literature which examines if the TOM exists. Most studies main contribution to the international literature is the TOM effect documentation for the sample they examine. In order to save space we choose to present only some of them from which we use some features in our study.

- ⁽⁹⁾ Characteristically, Ziemba (1989) shows that for the Japanese case, the TOM effect runs over the last five and first two trading days of the month.
- ⁽¹⁰⁾ The other three sample's countries are: Brazil, Hong-Kong and Malaysia).
- ⁽¹¹⁾ Many times, since the Greek entrance to the European Stability Mechanism, the term "Grexit" often mentions, because some analysts and EU authorities believe that Greece cannot stand to the EMU environment, and indicates the severity of the Greek financial crisis.
- ⁽¹²⁾ We use the ASE which the historical name. The current name (since 2002) is Athens Exchange (ATHEX), however both acronyms (ASE, ATHEX) are widely known and indicate the Greek Stock market.
- ⁽¹³⁾ More information from the section "Indicators" on ASE website: http://www.ase.gr/default_en.asp.
- ⁽¹⁴⁾ We mention this information at this point because, as we present below, it is very crucial for our analysis.
- ⁽¹⁵⁾ The leptokurtosis of these three distributions is a sign that linear models may not be appropriate for the specific time series. The descriptive statistics we present are derived from time series which follow the Lakonishok and Smidt (1988) definition for the TOM period (the last and the first three days of the month) and we exclude the December to January TOM days in order to exclude the turn of the year effect. Similar results present the raw time series (data available upon request).
- ⁽¹⁶⁾ We randomly present some of the values we check, in order to save space. More results are available upon request.
- ⁽¹⁷⁾ The final results do not change whether we use equation 2 or the equation 6 for the mean return. Therefore, we present the first version's tests, but not the second one in order to save space.
- ⁽¹⁸⁾ The Greek stock market does not have future contracts on the AGI, but there are other indexes, with present increased correlation with the AGI. e.g. the returns on AGI and the FTSE/ASE-20 present 0.9866 correlation. However, we present the AGI because better represents the Greek stock market (Table 1).
- ⁽¹⁹⁾ If a study examines the TOM effect during the growth period and another study examines the TOM effect during the recession period the results are conflict.
- ⁽²⁰⁾ We present a briefly analysis for the TOM effect during the sub-periods if we use the first version of the TOM equation: during the growth period the stock market is efficient, but during the crisis period there are inefficiency signs.

References

- Agrawal A. and Tandon K. (1994). "Anomalies or illusions? Evidence from the stock markets in eighteen countries", *Journal of International Money and Finance*, Vol. 13, Issue 1, pp. 83-106
- Alford, A. and Guffey, D (1996). "A re-examination of international seasonalities", *Journal of Financial Economics*, Vol. 5, issue 1, pp. 1-17
- Ariel, R.A. (1987). "A monthly effect in stock returns", *Journal of Financial Economics*, Vol. 18, no. 1, pp. 161-174
- Brooks, C., (2008). *Introductory econometrics for finance*, Cambridge University Press, Cambridge
- Cadsby, C.B. and Ratner, M. (1992). "Turn-of-month and pre-holiday effects on stock returns: some international evidence", *Journal of Banking and Finance*, Vol. 16, No. 3, pp. 497-509
- Connolly, R. (1989). "An examination of the robustness of the weekend effect", *Journal of Financial and Quantitative Analysis*, Vol. 24, issue 2, pp. 133-169

- Dickey, D.A., Fuller, W.A. (1981). "Likelihood ratio statistics for autoregressive time series with a unit root", *Econometrica*, Vol. 49, No. 4, pp. 1057-1072
- Engle, R. (1982) "Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflation", *Econometrica*, Vol. 50, pp. 987-1006
- Gaunersdorfer, A., Hommes, C.H. (2000). "A nonlinear structural model for volatility clustering CeNDEF", *Working Paper* 00-02, University of Amsterdam
- Georgantopoulos, A., Kenourgios, D., Tsamis, A., (2011). "Calendar Anomalies in Emerging Balkan Equity Markets", *International Economics and Finance Journal*, Vol. 6, No. 1, pp. 67-82
- Glosten, L.R., Jagannathan, R., Runkle, D.E. (1993). "On the Relation Between the Expected Value and the Volatility of the Nominal Excess Return on Stocks", *The Journal of Finance*, Vol. 48, pp. 1779-1801
- Kenourgios, D., Samitas, A. (2008). "The Day of the Week Effect Patterns on Stock Market Return and Volatility: Evidence for the Athens Stock Exchange", *International Research Journal of Finance and Economics*, Vol. 15, pp.78-89
- Kunkel, R., Compton, W., Beyer, S. (2003). "The turn-of-the-month effect still lives: the international evidence", *International Review of Financial Analysis*, Vol. 12, Issue 2, pp. 207-221
- Lakonishok, J., Smidt, S. (1988). "Are Seasonal Anomalies Real? A Ninety-Year Perspective", *The Review of Financial Studies*, Vol. 1, No. 4, pp. 403-425
- Levine, R. (2005). *Finance and growth: Theory and evidence*. In Aghion, Philippe, Durlauf, Steven (Eds.), *Handbook of Economic Growth*, North-Holland, Amsterdam, pp. 865-934
- Levine, R., Zervos, S. (1998). "Stock markets, banks and economic growth", *The American Economic Review*, Vol. 88, No. 3, pp. 537-558
- Lintner, J. (1965). "Security Prices, Risk, and Maximal Gains From Diversification", *Journal of Finance*, Vol. 20, No. 4, pp. 587-615
- Ogden, J. (1990). "Turn-of-Month Evaluations of Liquid Profits and Stock Returns: A Common Explanation for the Monthly and January Effects", *The Journal of Finance*, Vol. 45, No. 4, pp. 1259-1272
- Schwert, G.W., (2003). "Anomalies and Market Efficiency" In: G. Constantinides et al. (Eds.), *Handbook of the Economics of Finance*, Chapter 17, North Holland: Amsterdam
- Sharpe, W.F. (1964). "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk", *Journal of Finance*, Vol. 19, pp. 425-442
- Tsangarakis, N.V. (2007). "The day-of-the-week effect in the Athens stock exchange (ASE)", *Applied Financial Economics*, Vol. 17, no. 17, p.p. 1447-54
- Vasileiou, E., Samitas, A. (2014). "Does the Financial Crisis Influence the Month and the Trading Month Effects? Evidence from the Athens Stock Exchange", *Working paper* <http://dx.doi.org/10.2139/ssrn.2345450>
- Vasileiou, E. (2014). "Is Technical Analysis Profitable Even for an Amateur Investor? Evidence from the Greek Stock Market (2002-12)", forthcoming in (Copur, Z., Ed.), *Behavioral Finance and Investment Strategies: Decision Making in the Financial Industry*, IGI Global Publishers
- Vasileiou, E. (2013). "Long Live Day of the Week Patterns and the Financial Trends' Role. Evidence from the Greek Stock Market during the Euro Era (2002-12)", *Working paper* series <http://dx.doi.org/10.2139/ssrn.2338430>
- Ziemba, W. (1989). "Japanese security market regularities: Monthly, turn-of-the-month and year, holiday and golden week effects", *Japan and the World Economy*, Vol. 3, Issue 2, pp. 119-146

Econometric model used in the capital market analysis

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Abstract. *In the frame of this article, by applying the linear regression model, we proceed to the analysis of the existing dependence between the value recorded by the Bucharest Exchange Trading index (meaning the overall evolution of the capital market in Romania) and that of the stock exchange capitalization. The application of this econometric model provides to the capita investors a series of necessary information meant to fix their behaviour during the forthcoming periods.*

Keywords: regression model, capitalization, BET index, statistical tests, the least squares method.

JEL Classification: G10, G14, C58.
REL Classification: 11B.

1. Introduction

The financial markets and, mainly, the stock exchange markets, are complex structures where a very large number of economic entities are acting wishing, first and foremost, to get a profit as high as possible. In this respect, the modern financial markets are distinguishing themselves by a very conspicuous dynamics of the investment activity and – particularly – as far as the portfolio investments are concerned. In this context, it is required that statistical-mathematical models are formulated, as support for modelling the main processes occurring on these markets as well as to allow a easier management of all the activities involved by the investment activity. A significant aspect when analysing the performances of the capital market is given by the establishment of the existing correlations between the various indicators and/or indices this one.

2. Literature review

The first econometric models which could be applied on the financial markets, generally speaking and, particularly, on the capital market, have been conceived during the second half of the XX century. This is the period when starting from the existing theoretical models, the first models with strict application in the financial and capital investment domains have been conceived and implemented. This kind of econometric models can be found out in the works of certain well-known specialists in the field, such as: A. Goldberg (*Econometric theory* – 1964), H. Theil (*Principles of econometrics* – 1971), L. Klein (*A textbook of econometrics* – 1974) etc.

By the years 1990 and the beginning of the years 2000, the econometric models meant to the financial and banking analysis reached a new stage of development which allowed them to be matched with the new requirements of the capital market. In this respect, to note the efforts paid by researchers such T. Milles (*The econometric modelling of financial time series* – 1993), E. Berndt (*The practice of econometrics: classic and contemporary* – 1991), W. Green (*Econometric analysis* – 2000), F. Diebold (*Elements of forecasting* – 2002) or C. Dougherty (*Introduction to econometrics* – 2007), He, Changli; Silvennoinen, Annatiina; Terasvirta, Timo (*Parameterizing Unconditional Skewness in Models for Financial Time Series* – 2008).

The econometric model of regression and the actual possibilities to use it for economic analysis kept on being permanently analysed during the previous century, a series of reference works for this domain to be mentioned such as those signed by Franklin Graybill (*An introduction to linear statistical models* – 1961),

Peter Sprent (*Models in regression and related topics* – 1969), David Belsley, Edwin Kuh și Roy Welsh (*Regression diagnostics* – 1977), Damodar Gujarati (*Basic econometrics* – 2005) or Gregory Chow (*Econometrics* – 1983).

3. The simple regression model

From a theoretical point of view, the simple regression model is defined through a mathematical relation built up on the basis of the economic theory which assumes that the economic phenomenon, as an effect, is the outcome of the cumulated action of two categories of factors (Dougherty, 2008):

- a main, determinant factor;
- all the other factors which can be considered as not essential, of casual or constant action, invariable of the economic effect phenomenon.

Consequently, by way of abstracting, these ones are not taken into account for the aimed analysis, their effect being concentrated in the residual variable.

From a mathematical point of view, the simple regression model implies a direct relation between two variables, of which one is considered as a factorial one (causal or explicative) while the second one, is a resulting one. Such an econometric model can be transcribed, in a mathematical form, as follows (Andrei, Bourbonnais, 2008):

$$Y = f(X) + \varepsilon.$$

Out of the category of the uni-factorial regression models the largest utilization in the economic analyses goes to the linear model. In the case of this model, the relation between the resulting (Y) and the factorial variable (X) can be synthesized through a function of the form (Voineagu, Țițan, 2007):

$$y_i = b + a \cdot x_i + \varepsilon_i$$

where:

y_i – the resulting characteristic (explained);

x_i – the factorial characteristic (explicative, causal);

ε_i – the residual variable.

In the situation that the linear dependence is found again as a result of making transformations on the two variables, we shall say that the regression model is a linear one as against its parameters.

For instance, the model $Y = b + a \ln X$ is non-linear as against the factorial variable but it is a linear model as against the two parameters. On the contrary, the regression model $Y = b + \ln aX$ is linear as against the factorial variable, but it is not linear as against the two parameters a și b , but as against b and $\ln a$.

From a theoretical point of view, it must be mentioned that there are various uni-factorial non-linear models, which are linearized through transformations applied to the variables of the regression model. This category of non-linear models transformed into linear models can include the following (Guijarati, 2005)

- $y_i = a \cdot x_i^b$ turns into a linear model by logarithmic procedure applied to the two terms of the equality above:

$$\log y_i = \log a + b \cdot \log x_i$$

On the basis of this transformation, we get as result a linear model as against the variables $\log y_i$ and $\log x_i$.

- *The exponential model or the log model* defined by the relation:

$$y_i = a + b^x$$

it is linearized by logarithmic procedure, resulting the linear model:

$$\log y_i = \log a + x_i \cdot \log b$$

A series of non-linear models cannot be written in the form of linear models by applying certain elementary transformations. In other situations, there are different techniques of estimations which are applied in order to estimate the parameters. As they cannot be linearized through elementary transformations, the estimation of the parameters is made through numerical methods (Anghelache, Anghelache, 2009).

In order to get correctly estimates results out of applying the linear regression model it is necessary to define a set of standard hypotheses for the model out of the general population. These hypotheses are formulated as follows (Anghelache, 2013):

- I_1 : the data series are not affected by measurement errors;
- I_2 : the residual variable has a zero mean;
- I_3 : the dispersion of the residual variable is invariant in time, meaning that it gets the homoscedasticity property;
- I_4 : the residuum are not self-correlated;
- I_5 : the factorial (explicative) variable is not correlated with the residual variable;
- I_6 : the model's errors are normally distributed according to a co-distribution of a zero mean and a dispersion σ^2 ($\varepsilon_t \rightarrow N(0, \sigma_t^2)$).

In order to test these hypotheses the statistical tests are applied.

The estimation of the linear regression model is made on the basis of the data series for the two characteristics. From the mathematical point of view, these series are represented by the column vectors of the variables x_i and y_i :

When defining the linear regression, the above mentioned hypotheses are taken into consideration. Considering the relation $y_i = a * b^x_i$ it is to notice that the estimated value of the resulting variable, of the estimators of the model parameters and their properties depend on the characteristics of the independent variable and the properties of the residual variable (Anghelache et al., 2010).

In order to estimate the parameters of the linear model of regression, we can use the least squares method. In this case, the values of the resulting characteristic are estimated by using the relation:

$$\hat{y}_i = \hat{b} + \hat{a}x_i$$

where $\hat{a}$ and $\hat{b}$ are the estimators of the parameters of the regression line.

The real values of the resulting characteristic are equal to the estimation we get with the help of the regression model, corrected with the residual error, namely:

$$y_i = \hat{y}_i + e_i$$

The estimation of the parameters is based on the condition that the sum of the squares of the differences between the real value and the estimated one through the regression model is a minimum one (Anghelache, 2013):

$$F(\hat{a}, \hat{b}) = \min \sum_{i=1}^n (y_i - \hat{y}_i)^2 = \min \sum_{i=1}^n (y_i - \hat{a} - \hat{b} \cdot x_i)^2$$

$$\min_{\hat{a}, \hat{b}} \phi(\hat{a}, \hat{b}) = \min_{\hat{a}, \hat{b}} \sum_i e_i^2 = \min_{\hat{a}, \hat{b}} \sum_i (y_i - \hat{b} - \hat{a}x_i)^2.$$

The optimum conditions lead to the following system of equations:

$$\begin{cases} \frac{\partial(\hat{a}, \hat{b})}{\partial(\hat{b})} = -\sum_i 2(y_i - \hat{b} - \hat{a}x_i) = 0 \\ \frac{\partial(\hat{a}, \hat{b})}{\partial(\hat{a})} = -2\sum_i (y_i - \hat{b} - \hat{a}x_i) \cdot x_i = 0 \end{cases}$$

In order to establish the two estimators the linear system of equations is solved:

$$\begin{cases} n\hat{b} + \hat{a}\left(\sum_i x_i\right) = \sum_i y_i \\ \left(\sum_i x_i\right) \cdot \hat{b} + \hat{a}\left(\sum_i x_i^2\right) = \sum_i y_i x_i \end{cases}.$$

The computing relations of the two, $\hat{a}$ and $\hat{b}$, are coming out of the settlement of the linear system of equations:

$$\hat{a} = \frac{\begin{vmatrix} n & \sum y_t \\ \sum x_t & \sum (x_t \cdot y_t) \end{vmatrix}}{\begin{vmatrix} n & \sum x_t \\ \sum x_t & \sum x_t^2 \end{vmatrix}}$$

The coefficient of the regression line slope is obtained out of the relation (Anghelache, 2013):

$$\hat{a} = \frac{\sum_{i=1}^n x_i y_i - n\bar{x}\bar{y}}{\sum_{i=1}^n x_i^2 - n\bar{x}^2} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^n (x_i - \bar{x})^2}.$$

$$w_i = \frac{x_i - \bar{x}}{\sum_{i=1}^n (x_i - \bar{x})^2}.$$

The formula for calculating the estimator of the loose term of the regression line is set up by solving the equations system or by considering the fact that the regression line is passing through the centre of the points cloud, namely:

$$\hat{b} = \bar{y}_t - \hat{\beta} \cdot \bar{x}_t$$

$$\hat{b} + \hat{a}\bar{x} = \bar{y}$$

The method of the least squares holds certain drawbacks as to its utilization in estimating the parameters of the linear regression model, as follows:

- It does not provide acceptable outcomes if the formulated hypotheses are not satisfied:
- If noting by $\hat{a}^n, \hat{b}^n$ the estimators set up on the basis of the series $(x_i, y_i), i = \overline{1, n}$ and by $\hat{a}^{n+1}, \hat{b}^{n+1}$ those evaluated through the values series $(x_i, y_i), i = \overline{1, n+1}$, it is resulting that between the two pairs of estimators there is not a simple relation of recurrence:
- The estimators are affected in case that the data series is showing major changes, in the form of breaks of level.

In order to facilitate the utilization of the regression models for economic and financial analyses, specific statistical tests have been created which afterwards

have been included in specialized informatics packages. For instance, the Eviews programme which allows getting econometric models of quality with a minimum effort from the side of the user of such a software solution (Andrei, 2008).

4. The application of the regression model on the capital market in Romania

In order to take advantage of the submitted theoretical aspects, we used the regression econometric model meant to evaluate the relation between the value recorded by the BET index and the value of the stock exchange capitalization.

The analysis of the Bucharest Stock Exchange can be achieved through the support of a complex system of indices. Among them, a significant role as to generate a true image on the performances of the major stock exchange institution from Romania is played by the BET index (*Bucharest Exchange Trading*) (Anghel, 2008). The BET index has been launched on September 19th, 1997 and represents the reference index of the capital market in our country. BET is a prices index weighted by the free-float capitalization (free-float of a company included in the structure of the BET index represents the number of shares issued in circulation which are available for transactions to the public), which is reflecting the overall tendency of the equities issued by the first ten companies, classified depending on their liquidity (Anghelache, 2009). Thus, the prices recorded during every session of transactions are reported at the corresponding prices recorded during the transactions session of reference, by applying the following calculation relation in this respect (Bucharest Stock Exchange – BET index manual):

$$BET_T = BET_{T-1} \cdot \frac{\sum_{i=1}^N p_{i,T} \cdot q_{i,T} \cdot Ff_i \cdot R_i \cdot c_{i,T}}{\sum_{i=1}^N p_{i,T-1} \cdot q_{i,T} \cdot Ff_i \cdot R_i \cdot c_{i,T-1}}$$

where:

BET_T – value of BET index at the current moment, T;

BET_{T-1} – value of BET index at the previous moment, T-1;

$p_{i,T}$ – price corresponding to the equities of the company „i” by the current moment T;

$p_{i,T-1}$ – closing price corresponding to the equities of the company „i” by the moment T-1;

$q_{i,T}$ – number of equities by the current moment T;

Ff_i – free float factor corresponding to the company „i” from the index being calculated with two digits, bearing one of the following values: {0,1; 0,2; 0,3; 0,4; 0,5; 0,6; 0,7; 0,8; 0,9; 1};

R_i – representation factor at maximum 20% of the weight of the components of the index cost, corresponding to the equities of the company „i”; it is calculates with three digits and belongs to (0,1];

$c_{i,T}$ – correction factor of the price corresponding to the equities of the company; „i” at the moment T, in the days of operational revision; it is calculated with six digits;

$c_{i,T-1}$ – correction factor of the price corresponding to the equities of the company; „i” at the moment T-1, in the days of operational revision; it is calculated with six digits;

N – number of companies included in the index.

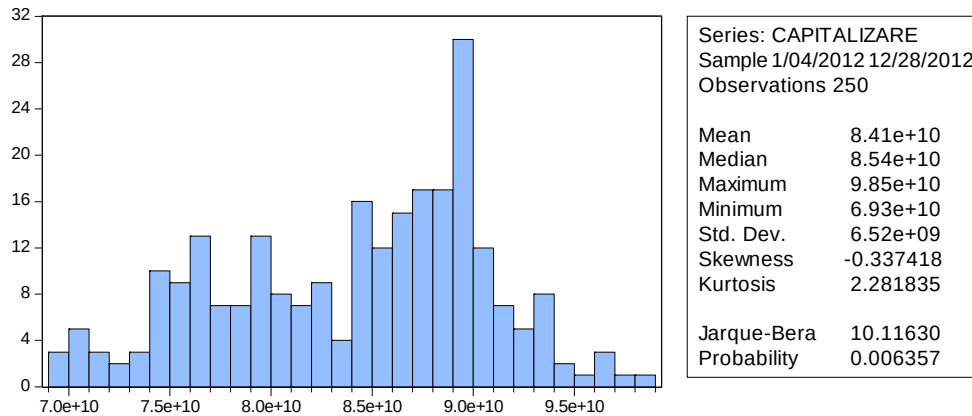
One of the factors of significant influence on the value of the BET index is given by the stock exchange capitalization. This one represents an indicator of one stock exchange potential reflecting the market value of the listed companies, which can be established as a sum of the products between the number of shares issued by each of the listed companies and the corresponding market price (Anghel, 2013).

In order to analyse the existing relation between the values recorded by the Bucharest Exchange Trading index and the stock exchange capitalization value, both statistical-mathematical models and, mainly, regression econometric models can be used. In this respect, we submitted to the analysis a series of data (daily frequency) concerning the BET index value and the stock exchange capitalization for the year 2012. (366 calendar days/ 250 actual transacting sessions – the data being used are daily surveys over a time horizon between January 1st 2012 and December 31st 2012, respectively 250 surveys, excepting week-end days and legal holidays).

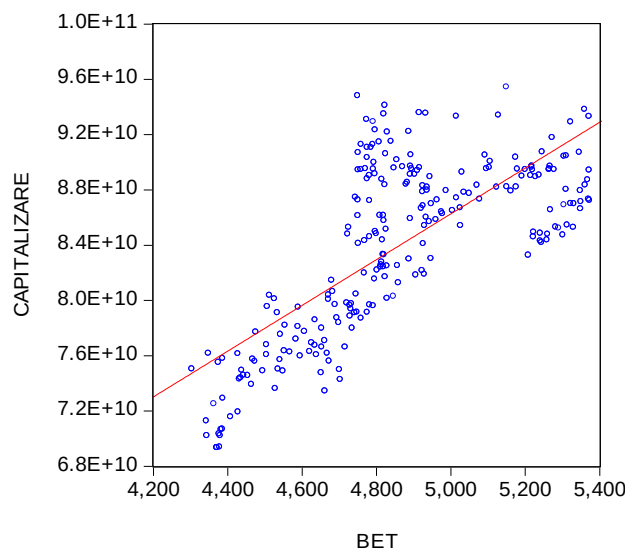
As a first stage of the analysis of the considered series of data, we used the informatics package Eviews in order to generate a series of statistical tests typical for each one of the two indicators taken into account: the BET index value and the stock exchange capitalization value.

The statistical tests applied to the series of data referring to the BET index evolution during the analysed period evidenced the fact that average value of this index counts for 4,857.236 lei. Meantime, it is to notice that the distribution of this series of data do not correspond exactly to the normal distribution, a situation which, however, should be not considered as very grave as it is typical to most of the data series in the financial domain.

In the case of the analysis of the series of data referring to the evolution of the stock exchange capitalization, it is to state out that this indicator is recording an average value of 84,146.510 million lei, the distribution of the recorded values being also different from the normal distribution.



In order to set up the type of regression model to be utilized for establishing the dependence between the BET index value and the value of the stock exchange capitalization, the two series of data have been represented as a points graph on which the regression line has been also plotted.



Out of the analysis of the above graph, we state out that there is connection of linear type between the two variables. This dependence can be synthetically showed up by means of an econometric model typical for the simple linear regression, namely:

$$\text{BET} = \alpha + \beta * \text{CAPITALIZATIO} + \varepsilon$$

where:

BET – BET index value (the dependent variable);

CAP – value of Bucharest Stock Exchange capitalization (the independent variable);

α , β – the parameters of the linear regression model;
 ε – the residual value of the regression model.

Based on the previous mentioned elements, with the help of the informatics package, the parameters of the previously submitted regression model have been estimated, through the method of the least squares.

Dependent Variable: BET
 Method: Least Squares
 Date: 11/20/13 Time: 18:51
 Sample (adjusted): 1/04/2012 12/18/2012
 Included observations: 245 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2141.023	162.4726	13.17775	0.0000
CAPITALIZARE	3.24E-08	1.93E-09	16.75345	0.0000
R-squared	0.535975	Mean dependent var		4855.378
Adjusted R-squared	0.534065	S.D. dependent var		278.6151
S.E. of regression	190.1811	Akaike info criterion		13.34196
Sum squared resid	8789032.	Schwarz criterion		13.37054
Log likelihood	-1632.390	Hannan-Quinn criter.		13.35347
F-statistic	280.6781	Durbin-Watson stat		1.982817
Prob(F-statistic)	0.000000			

Estimation Command:

=====

LS BET C CAPITALIZARE

Estimation Equation:

=====

BET = C(1) + C(2)*CAPITALIZARE

Substituted Coefficients:

=====

BET = 2141.02316511 + 3.23613403506e-08*CAPITALIZARE

Based on the previously submitted data, the values of the two parameters of the regression model, α and β , are set up as follows:

$$\alpha = 2141,123$$

$$\beta = 3,24 \cdot 10^{-8}$$

The regression model defining the relation between the BET index and the value of the stock exchange capitalization is transcribed as follows:

$$\text{BET} = 2141,123 + 0,0000000324 \cdot \text{CAPITALIZARE}$$

The value being recorded by Prob (0.0000) evidences the fact that the variable is significant from statistical point of view. The connection between the BET index value and that of the stock exchange capitalization is a direct one which can be explained as follows: by an increase of 1% of the capitalization value, the BET index value is recording an increase 0.00000324% only. Both R-squared (R^2) and the Adjusted R-squared (R^2 adjusted) show the extent to which the dependent variable is explained by the independent variable. The recorded values are comprised between 0 and 1. The difference between the two coefficients consists of the fact that Adjusted R-squared is presenting, from statistical point of view, a more significant result since it is sanctioning the inclusion of independent variable of a low relevance for explaining the dependent variable. In the situation here submitted, the value recorded by R-squared shows that in a proportion of 53.59% of the BET index value is explained by the value of the capitalization, the difference up to 100% representing the influence of other factors not included into the present mode (a rather low influence). A comparison made between the model set up for the values recorded by the two indicators during the year 2012 and those for the years 2010, respectively 2007 (which made the object of previous analyses) evidenced the fact that the significance of the stock exchange capitalization for setting up the BET index value diminished significantly. This situation can be explained by going deeply into the effects of the economic and financial crisis which led to the occurrence of rapid and difficult to anticipate alterations of the factors which are influencing the activity of the main companies quoted on the capital market from our country and, implicitly, the evolution of the major specific indicators of the Bucharest Stock Exchange. The connection between the BET index value and that of the stock exchange capitalization can be explained as follows: for the increase of 1% of the capitalization value, the BET index value is recording an increase of 0.00000324% only.

The validity of the analysed regression model can be studied by means of the tests implemented in the informatics package EvIEWS. Thus, based on the values of the test R-squared and of the test F-statistic (which value of 280.6781 is exceeding the reference level of the tables) we can state out that the model describing the relation between the stock exchange capitalization and the value of the main stock exchange index of the Romanian capital market is a correct one.

5. Conclusions

The simple linear regression model submitted above is confirming, on the basis of the real data recorded on the Romanian capital market, the allegations from the specialized literature according to which this type of econometric model can be successfully utilized in order to define and systemize in a mathematical form the

existing relations between the various financial indicators specific to the stock exchange system. The regression models allow the identification of certain functional dependences between the various components of the capital market, which provides the real possibility to forecast the phenomena submitted to the analysis over a large established time horizon. The simple linear regression model can be utilized with good results in other analyses concerning the evolution of the financial market.

References

- Andrei, T., Bourbonnais, R. (2008). *Econometrics*, Economica Publishing House, Bucharest
- Andrei, T., Stancu, S., Iacob, A.I. (2008). *Introduction in Econometrics using Eviews*, Economica Publishing House, Bucharest
- Anghel, M.G. (2008). "Using the Regression Model in the Analysis of the Capital Market", *Romanian Statistical Review*, Supplement „Romania in the Process of European Integration”, issue 12
- Anghel, M.G. (2013). *Models for the Management and Analysis of Portfolios*, Economica Publishing House, Bucharest
- Anghelache C. (2013). *Elements of Theoretical Econometrics*, Artifex Publishing House, Bucharest
- Anghelache C., Anghelache G.V. (2009). *Utilization of the econometric models in the analysis of the assets rates*, Metalurgia International Vol. XIV, Special Issue 9, F.M.R. Scientific
- Anghelache, C., Marin, D. and Barbu, C.M. (2010). *Estimation of the regression functions transformation*, Metalurgia International, Vol. XV, issue. 1
- Anghelache, G.V. (2009). *Capital Market in an European Context*, Economica Publishing House, Bucharest
- Dougherty, C. (2008). *Introduction to econometrics. Fourth edition*, Oxford University Press
- Guijarati, D. (2005). *Basic Econometrics*, The McGraw-Hill Companies
- Voineagu, V., Țițan, E. (2007), *Theory and Practice in Econometrics*, Meteor Press Publishing House, Bucharest
- Wooldrige, J. (2006). *Introductory econometrics. A modern approach*, 2nd edition, MIT Press
- www.bvb.ro (Bucharest Stock Exchange)

Economic order, catallactics and entrepreneurship

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Abstract. *The economic efficiency of entrepreneurship was analyzed by theories on economic growth, production and human order. In order to achieve economic development the entrepreneur must constantly make new combinations or innovative processes that represent optimal responses to a globalized society's demand, which is constantly changing.*

The main craftsmen of entrepreneurship theories are representatives of the Austrian school of economics that conducted a systematic analysis of Misesian rationalism versus Hayek's spontaneous order. The economic issue is based on knowledge and rational allocation of resources as individuals are not always rational and calculated, since they lack a common appreciation of the heterogeneous results generated by alternative processes in the economy. Friedrich von Hayek introduces in his analysis the concepts of catallaxy and catallactic game, the latter being a wealth creating game that leads to an increase in the flow of goods and opportunities for all participants to meet their needs, the result being essentially determined by a mixture of skill and chance.

Keywords: economic order, catallactics, interference, consumers, entrepreneurship.

JEL Classification: B26, D84, E32.

REL Classification: 1I, 8H, 14D.

Introduction

Contemporary society, which is marked by the fluctuating evolution of economic phenomena and by uncertainty, determines entrepreneurs to seek solutions to anticipate future market patterns, different ways to use resources and to determine profits or loss.

Economic order is a state in which multiple types of elements are linked together so that, knowing several parts of the temporal or spatial query we can formulate the correct hypotheses regarding market evolution. The Austrian School of economics has analyzed the role of entrepreneurs in society, their decision-making under uncertainty and risk, and especially their capacity to anticipate their actions based on the importance of self-knowledge and information on economic activity. Entrepreneur's preference involves making decisions by determining the best alternative which can lead to significant and attainable rewards.

Economic order, entrepreneurship and economic development

In human society, the concept of order is assimilated to the entirety of regulations of the organizational superstructure of the national economy and of economic activities, as well as all the institutions which regulate the administration, taxation and economic configuration.

Walter Eucken, representative of the individual-inductive German historical school, considered the economic order as a whole segment of material and spiritual life, in a time and space, starting from ideal types. Therefore, the actual order of the national economy is characterized by the ratio of use of such ideal economic systems.

The concept of economic order must solve three problems that exist in any society: the functionality of the economy, the achievement of the fundamental social and political objectives and the efficiency of all economic activities.

The most important issue is the answer to the question on how to coordinate the economic activity of a multitude of agents, so that the specialized economic process which is based on the division of labor and is institutionally conducted in separate time and space can be as effective as possible?

At the level of the national economy the decisions based on the urgency of needs and their coverage belong to applicants, consumers of goods and services, as a means of production. In the limits of available income the applicants decide freely, according to their needs, on the quantitative and qualitative structures.

Important prerequisites for economic functionality are not only pricing and consumption and production freedom but also freedom of profession and freedom of competition. Effective economic coordination is based on the decisions of economic agents with equal rights in the market.

The social quality of economic order is crucially dependant on how the problem of income and wealth distribution is resolved, on economic power and on the issue of social costs. Consumers' ability to influence production depends on their endowment with purchasing power (available income). Differences between available revenues - incomes from work, from capitalization of assets or from entrepreneurial activity on one hand, and the ownership of factors of production, unevenly divided between individuals on the other hand - and the needs which differ from the production factors, i.e. various supply-demand relationships in the market for production factors. Low budget revenues, which can not cover the needs of life, are one of the reasons why initial private goods, such as: personal safety, education, health, became collective goods. Thus, equity demands the correction of such differences between income extremes and resolving the concentration of wealth issue.

There is belief that the order can be created only through forces outside the system, of an exogenous nature, concept that can not be applied to a balance achieved from the inside, of an endogenous nature. Exogenous order, created deliberately, is described by Friedrich von Hayek as an artificial construction or a strict social field that is assimilated with an organization, and the natural order is a spontaneous order.

The rules of a spontaneous order must be independent of the purpose and be the same, if not necessarily for all members, at least on categories. The general rules underlying spontaneous order tend to an abstract order; however the ones inside organizations serve specific purposes.

Spontaneous order stems from the fact that its components comply with certain rules of behavior, but not every regularly in the components behavior ensures the overall order. Some of the rules governing individual behavior can make it impossible for an overall order to exist.

Can order in society be established on the basis of universal rules? According to the second law of thermodynamics, and also the entropy law, the tendency of gas molecules to move at a constant speed in a straight line produces a condition that has been termed "a perfect disorder". Similarly, in society, perfectly regular behaviors of individuals can cause chaos. Society itself can exist only if there has been a change in the rules, through a selection process, which causes the individual to behave in such a way that social life can be possible. In the social

order, certain circumstances in which every individual reacts are known only by him. Individual responses in certain situations will result in a comprehensive order only if individuals comply with some rules so an order can manifest itself. Such an order will always be an adaptation to the myriad of circumstances known to all members.

"The catallactic game" (Hayek 1976, pp. 108-109), according to Friedrich von Hayek is a welfare creating game; it leads to an increase in the flow of goods and opportunities for all participants so as to satisfy their needs in accordance with certain rules, skill, power or luck.

It is a game which creates welfare because it provides information to enable each player to meet needs that are not directly known and whose existence could not be learnt using their own means, so that the satisfaction of many more needs can be possible. In the market order, each one is determined by its own gain, to satisfy needs that remain invisible to him so individuals take advantage of certain unknown circumstances that allow them to meet these needs with a cost as low possible, a cost that is expressed in the goods that could have been produced instead. When only a few know of a new event, the crowd of speculators will not take it into account, so the prices will change. In this process current prices are indicators of what is to be done in the present. These direct the manufacturer's efforts, the result of his efforts will be different from his expectations and revenues are determined. Chance can not be separated from market functionality and the amount of information reflected in prices is entirely the product of competition.

More important than the information regarding needs that can be satisfied and for whom there an attractive price is information related to the needs. Each product can be obtained through different combinations of inputs and those that imply the smallest sacrifice expressed in other goods that could have been produced with the same resources, will be indicated by the relative prices of inputs. Through their effort to obtain results as cheaply as possible, manufacturers will make total production in catallactic be as high as possible. The prices for which they can buy various factors on the market are the same because they produce the same marginal result. Thus, the entrepreneurs will be determined to adjust the relative amounts of any pair of factors so that they can have the same contribution to their income, as they are marginal substitutes. If this what it is generally wanted and marginal rates of substitution between any two factors are the same in all their uses, it can be said that the market reaches the catallactic horizon of possibilities where there is the largest amount of specific combinations of goods possible under the circumstances. The contribution of each factor of production to the overall result is determined by the instrumental needs of the only process known

that can ensure a stable approach to this horizon, the material equivalent of any contributions being as high as possible. Therefore, the contribution of each player in the catallactic game is determined partly by understanding, partly by chance, the part will be allocated through this game of chance and skill being truly maximal.

According to Friedrich von Hayek, the rule of correct behavior serves to the agreement of the different purposes of numerous individuals. The interference in national economies can exist only if there is a process that works on the basis of principles and the components respect certain rules. The goal of interference is always to generate a certain result that differs from that which would have been produced if the mechanism had been left to pursue its inherent driving forces. Any act of interference creates a privilege guaranteeing benefits achieved to the detriment of others, in a way that can not be justified by principles that may have general application. A spontaneous order requires, as a limitation of the coercion to apply the general rules of correct behavior, that this coercion is applicable equally to all.

The Austrian School of economic thought assigns an important role in its research to entrepreneurship, which is synonymous with human actions to adjust the present, the future being determined by them. The entrepreneurial function requires the discovery of business opportunities for profit, based on individual skills of forecasting and analysis and on the information acquired. However, this function concerns human actions under uncertainty. In the economy, individuals try to avoid losses and maximize their welfare, in order to improve the quality of life. If the purpose of their actions was contrary, this would create disorder.

Entrepreneurs must produce information and the existence of institutional freedom must lead it in meeting social and economic goals and interests. Human action in terms of entrepreneurship is specific and unrepeatable being determined by the level of knowledge and information acquired at some point, directly related to the competitive environment. Any act entrepreneurial discovers, coordinates and eliminates social inconsistencies. The entrepreneurial process of social coordination continues because the elementary social act consists of the creation and transmission of information. The entrepreneurial function must be correlated to the need to anticipate the future configuration of the context of the action. Entrepreneurial actions that are based on expectations contribute to a viable market as consumers choose goods according to preferences, supply conditions of consumer goods and production. Opportunities for profit, like price differences, are capitalized by entrepreneurs and entrepreneurial loss is due to wrong anticipations of producers and the overpricing of inputs.

Conclusions

According to the Austrian School of economic thought competitive markets are a social construct, consciously created by human action. Sustainable economic activity implies the existence of incentives for the processes of investment, production and savings, and its effect is equivalent to having a positive sum game. The increase in earnings for some entrepreneurs, while the general economic conditions are worsening, has the effect of gradually reducing revenues' capacity to transform due to the fact that speculation are taking place of real economic growth processes

References

- Garrison Roger W. (2010), "Austrian macroeconomics: a diagrammatical exposition", The Ludwig von Mises Institute, Alabama
- Hayek Friedrich A. von (2008), "Price and Production and Other Works", The Ludwig von Mises Institute, Alabama
- Hayek Friedrich A. von (1976), "Full employment at any price?", Institute of Economic Affairs, London
- Hayek Friedrich A von (2009), "The use of knowledge in Society, in Individualism and Economic Order", The Ludwig von Mises Institute, Alabama
- Hayek Friedrich A. von (1973), "Law, Legislation, and Liberty", The University of Chicago Press, Chicago, Vol. 2
- Lampert H. (1994), "Economic and Social Order", Al.I. Cuza University Press, Iași
- Soto Jesus Huerta (2011), "The Austrian School. The market and entrepreneurial creativity", Al.I. Cuza University Press, Iași

Public-private partnership in the context of regional development – a solution for renewable energy projects?

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Abstract. *The public-private partnership (PPP) is the latest trend and it represents a real concern for both the authorities and investors. It is believed that the public-private partnership is a concrete solution for regional development that the European countries want to promote lately.*

Romania wants to expand in this system of regional development and this research aims to emphasize the connection between the concept of sustainable regional development and green energy at level of public authorities, private companies and individuals who compose the society.

This study aims to show that Romania is a country with great potential for development in renewable energy and, at the same time, attractive for creating the PPPs. In this research, it shall be pointed out that Romania is a favorable environment for creating the PPPs in green energy domain and this can be a starting point for identifying specific projects in the context of sustainable regional development.

Given that the authorities and private sector companies will work together to accelerate the development of renewable energy projects, regional development phenomenon can operate normally facilitating investments in this area.

Keywords: Public-private Partnership; Renewable Energy; Sustainable Development; Regional Development; Investment.

JEL Classification: F18, O13.

REL Classification: 16H, 18G.

Introduction

Although countries in the world go through a difficult economic period, opportunities can be created to foster growth for both public authorities and private companies. Renewable energy is a solution in this regard proposing various actors to use renewable energy in an intelligent way to bring gains for all the involved parts.

In terms of public authorities, if they would take into account urban and educational institutions, we could observe that there are high costs for their operation and discounts are necessary to cut expenses. In this case, the use of renewable energy is a solution, as the costs for unconventional sources is smaller. The problem occurs in this area because of the initial costs that a customer has when installing a system using renewable energy. The public authority needs a considerable investment to cover expenses and budgets are not a solution in this matter. Thus, representatives of public authorities are obliged to seek solutions to solve these problems, and the hardest part to solve is represented by the financial domain.

A solution to these issues is represented by public-private partnerships that can bring funding for such investments, but if such an association is taken into account, there should be presented both the advantages and disadvantages for all the parties involved. Globally, both public environmental components, as well as those of the private sector want and support the development of renewable energies. Our society is using now conventional sources of energy that are exhaustible and affect the environment. A solution proposed in recent years is to reduce the use of energy from conventional sources and emphasizing the use of renewable energy sources and also balancing the costs between the two forms. Considering the continuous economic crisis, the fact that energy policy and strategies need to be correlated with economic growth should be taken into account. There are three ways that ensure the success of using renewable energy sources, namely:

1. Concern of existing fuel reserves;
2. Protecting the environment;
3. Government support through financial incentives and adequate programs.

As the use of renewable energy are introduced in all the environments, the sustainable development shall be ensured. This matter can have positive effects on regional development provided if it finds sources of funding to ensure investment in projects aimed to develop renewable energy sources. The positive aspects that would result from the combination of regional development and green energy sources integrate as a result for the public policy of a state that wants to create jobs, reduce unemployment, promote activities with low environmental impact, support wellbeing of its citizens.

This research is studying public-private partnership in Romania as a solution to regional development. This article highlights the link between regional sustainable development, green energy and their effects on public, private environment and on citizens. This paper also presents development potential of renewable energy in Romania and investment opportunities in unconventional energy.

1. The analysis of the connection between the concepts of sustainable regional development and renewable energy under law aspects

In order to analyze whether a link between the concepts regional sustainable development and renewable energy is or can be created, one has to follow their definition and highlighting their characteristics. In the following, an analysis of the two concepts related to public environment under the aspects of public policy will be presented.

Regional sustainable development can be defined as a concept that is based on promoting economic activity, attracting investment, reducing unemployment, population welfare promoting, reducing environmental impacts. For Romania, this concept has assumed the appearance of regional development through the establishment of eight regions: North East, South East, South Muntenia, South West, North West, Centre, Bucharest-Ilfov.

After their appearance together with the term regional development there was introduced the concept of sustainable, which represents *„all forms and methods of socio-economic development whose foundation was to ensure balance between the socio-economic and natural potential within each development region”* (<http://www.mmediu.ro/beta/domenii/dezvoltare-durabila/concepte-si-principii-de-dezvoltare-durabila/>). The basis for this definition is pointed out in the Brundtland Report according to which *„sustainable development is the development that follows the needs of the present without compromising the ability of future generations to meet their own needs”* (The Brundtland Report, 1987). These definitions were applied as they sound without customizing their object in the regions using the concept of regional sustainable development.

In order to create the regional sustainable development at the level of public authorities, the regional development policy was created and it contains *„all the measures planned and promoted by local and central public administration authorities, in partnership with various stakeholders (private, public, voluntary) in order to ensure economic growth, dynamic and sustainable, through the effective use of local and regional potential in order to improve living conditions”* (<http://www.mdrt.ro/en/dezvoltare-regionala/politica-de-dezvoltare-regionala>).

The main areas of interest for regional development policy in Romania are:

1. Development of SMEs;
2. Attracting investments;
3. Environmental Quality;
4. Labor Market;
5. Technology Transfer;
6. Development of infrastructure;
7. Health, education, education, research, culture;
8. Rural Development (<http://www.mdrt.ro/en/dezvoltare-regionala/politica-de-dezvoltare-regionala>).

Sustainable regional development policy works in three main directions which want to develop the areas mentioned above:

1. To reduce regional imbalance favoring remodernization and stimulating development and disadvantaged areas; preventing new imbalances;
2. To fulfill the integration criteria of European Union structures and assure access to financial assistance instruments for member countries (structural and cohesion funds, other funds);
3. To create a correlation with government sectoral development policies, to stimulate interregional, international and domestic cooperation, which contribute to economic development and which is in accordance with the law and international agreements concluded by Romania (<http://www.mdrt.ro/en/dezvoltare-regionala/politica-de-dezvoltare-regionala>).

Table 1. Principles of sustainable regional development policies

Principles	Methods of implementing
1. Decentralization	Decisions are taken at the central level and they are applied to each region.
2. Partnership	It aims to create partnerships between the public, private, individuals involved in a particular field.
3. Planning	It creates specific programs and projects to achieve the indicators assumed by the main objectives.
4. Cofinancing	It is focused on providing financial contributions of the partners involved in the implementation of specific programs.

Source: processing the information provided by the online address <http://www.mdrt.ro/en/dezvoltare-regionala/politica-de-dezvoltare-regionala>, accessed on 3rd of October 2013.

Given these aspects of sustainable regional development, the renewable energy shall be analyzed pointing the same structure as for the concept previous presented.

Therefore, **renewable energy** is „the energy from natural processes that are repeated constantly. In its various forms, it comes directly or indirectly from the sun or from heat generated in the earth's crust” (Reports from International Energy Agency, <http://www.iea.org/>). This includes many forms such as: wind energy, solar energy, biomass, geothermal, biofuels, hydrogen obtained from unconventional sources, hydraulic, tidal, osmotic potential energy.

The energy policy plays an important role for EU institutions and Member States, and it always has been a priority for the community due to the scale and particular issues. So far, we can observe as a common feature of energy policy, that all the states have involved in this sector as a normal operating pattern. The energy domain is a controversial area by the fact that any state depends on it and it can have a great influence towards national economies. Regardless of the nature of energy set, this is a sensitive issue which concerns the governments very much. Basically, we can state a pattern, in the relationship between public authorities, energy agencies operators and consumers of energy, that consists of the government control on this segment that influences all stakeholders, especially consumers.

The measures that are intended to be adopted through 2020 Strategy aim the trend that this area will be focused on. There are five directions to be followed, such as:

1. Energy saving;
2. Free circulation of energy;
3. Security of supply and fair prices;
4. Technological innovations;
5. International agreements on energy (http://europa.eu/pol/ener/index_ro.htm).

Renewable energy has become a goal for the European Union member states. It is considered that the renewable energy represents the future as it seeks to reduce the use of conventional sources of energy and to promote the use and production of energy from unconventional sources. The issue of safe energy was born from this idea and has generated a major controversy in recent years together with the establishment of national targets for renewable energy production.

The issue of renewable energy has had fluctuations on the European agenda because over time, the Member States were not able to break away from conventional energy and preferred to exploit it further. Currently, the focus is on sustainable development as a global goal that supports environmental protection for the future welfare of mankind. However, not all Member States succeeded to adopt the set out measures in directives due to financial reasons. A plan of measures to encourage renewable energy production must include: fiscal decisions, investment in research, state aids, loans, specific programs.

At the national level, the strategy for promoting the use of renewable contains the following objectives:

1. The inclusion of renewable energy in the national energy system structure;
2. Reducing barriers to the use of renewable energy;
3. Promoting private sector investment;
4. Facilitating access to foreign investment on renewable energy market;
5. Ensuring the independence of the internal energy;
6. Security of energy supplies for isolated communities;

7. Creating conditions for Romania's participation on the European market of green certificates for renewable energy (http://www.minind.ro/pnaer/pnaer_29%20iunie_2010_final_alx.pdf).

In addition to finance energy programs, it is necessary to identify fiscal measures to support the development of unconventional domain which is considered to be a trend for our country and that is characterized by a high potential in terms of renewable energy. These measures consist of tax exemptions or tax refunds, creating a single VAT rate for certain types of non-conventional energy, tax relief on investments in renewable area and special taxes to encourage investment in areas of renewable energy.

We can conclude that the two concepts are strongly connected and they can affect both the public and private sectors. Moreover, the way the two concepts are supported in the legislation, shows that they have common interests and goals to accomplish in order to create a stable economic environment.

Regarding the issue of regional sustainable development, the strategic objectives are aimed for increasing energy efficiency, promoting energy production based on renewable resources, promoting the production of electricity and heat cogeneration plants, especially in high-efficiency cogeneration plants, supporting research development and dissemination of research results, reducing the negative impact of the energy sector on the environment and the rational and efficient use of primary energy resources, pointing out the close relationship with public authorities.

Concerning the competitiveness in the private sector, the main objectives consisted of the development of competitive markets for electricity, natural gas, oil, uranium, green certificates, emission allowances for greenhouse gas and energy services, liberalization of energy transit and ensuring equal and continuous access of market participants to transmission, distribution and international interconnections, further restructuring and privatization in the electricity, heat and gas, further restructuring of the coal, in order to increase profitability and access capital market.

2. Romania's potential in renewable energy field

Diminishing the negative effects of energy process production on climate requires concrete and efficient actions. In this context, Romania must act consistently to support and to align with European actions that promote the Lisbon objectives.

In order to limit the global temperature increase that is expected, the emission of greenhouse gases, Romania will act specifically on energy efficiency and renewable sources of energy.

Actions to promote energy efficiency and renewable energy will contribute to the reduction of negative environmental impact and also increasing food security, reducing the dependence on energy imports of Romania.

Potential national energy savings, reducing energy losses is estimated at 27-35% of primary energy (industry 20 to 25%, buildings 40-50%, transport 35-40%). On an annual consumption of primary energy resources of about 36 million toe/year, the potential savings is about 10 million toe/year, respectively savings of around 3 billion/year (Resolution no. 1069/2007 approving the Romanian Energy Strategy for 2007-2020). To support the production of electricity from renewable energy sources, from 2005 it was established a mechanism to be promoted, based on green certificates by purchasing certified providers mandatory quotas in proportion to the volume of electricity sold to consumers.

Measures envisaged to promote renewable energy sources are:

- Increasing recovery, in terms of economic efficiency, renewable energy resources to produce electricity and heat through facilities in the investment stage including facilitating access to the grid;
- Improving green certificates market in order to attract private capital investments in renewable sources;
- Promoting mechanisms to support renewable energy resources in the production of heat and hot water;
- The use of structural funds.

The most suitable renewable resources (depending on operating costs and the amount of resources) and the technologies used to produce electricity are hydroelectric, including small hydropower, wind turbines and CHP plants using biomass and heat production that are biomass and solar.

In rural areas there is a great diversity of forms of renewable energy that can be used to supply power to these areas or urban areas:

- Biomass fuel is the main area that is mostly used for space and water heating and cooking. Biomass covers about 7% of primary energy demand and 50% of Romania's renewable resource potential.
- Geothermal energy that can be used for space and water, because of the location, the main potential for use in rural areas – housing, greenhouses, aquaculture, milk pasteurization – the locations at distances up to 35 km from the place of extraction;
- Solar energy, especially hot water, resulting in a reduction in the consumption of fossil fuels used to heat water;
- Micro-hydro can be a basic option for supplying rural areas that are not connected to the electricity network;
- Wind generators can also cover the electricity needs of rural areas that are difficult to access without electricity.

In accordance with the Strategy for the renewable energy investment, the need in the period 2006-2015 is estimated at 1.8 billion Euros (<http://www.enero.ro/doc/STRATEGIA%20ENERGETICA%20A%20ROMANIEI%20PENTRU%20PERIOADA%202007-2020.pdf>). Renewable energy sources in Romania are

considered to have high potential, but at this use it imposes barriers related to technology and innovation.

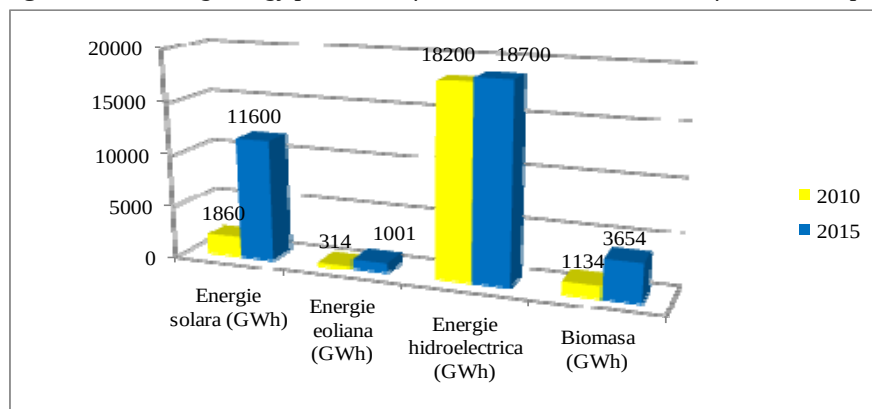
Table 2. *Applicability and potential of national renewable energy sources*

Applicability	Renewable energy source	Annual energy potential	Economic equivalent (thousands tep)
Produces heat	Solar thermal energy	60x10 ⁶ GJ	1433
Produces electricity	Solar photovoltaic energy	1200 GWh	103,2
Produces electricity	Wind energy	23000 GWh	1978
Produces electricity	Hydro energy	40000 GWh	3440
Produces heat	Biomass and Biogas	318x10 ⁶ GJ	7597
Produces heat	Geothermal energy	7x10 ⁶ GJ	167

Source: Data from the National Action Plan for Renewable Energy available at the online address <http://www.minind.ro/energie/pnaer.pdf>, accessed on 16th of October 2013.

Linked to the production of energy from renewable sources, targets for our country have been modified according to the results obtained in these areas. In terms of weights initially settled as 30% of energy to be from renewable sources in 2010 and 30,4% for 2015. These targets have been changed, reaching a value of 33% for 2010, 35% for 2015 and 38% for 2020, which shows that Romania has made significant progress in this regard and adopted a responsible strategy for development of this area.

Figure 1. *Estimating energy production from unconventional sources for 2015 compared to 2010 data*



Source: Author's own contribution according to the National Action Plan on Renewable Energy data, available at the online address <http://www.minind.ro/energie/pnaer.pdf>, accessed on 15th of November 2013.

It can be seen a significant increase especially at the solar energy chapter, followed by biomass, wind and hydropower, this increase is correlated with the legislation and national efforts to develop energy related to the renewable energy chapter. Romania has a high potential in renewable energy, which provides a point of attraction for investors. There are many challenges for both sections, from the public authorities, who want renewable energy development in developing regions, as well

as from the private sector by investors seeking to maximize profits in relation to compliance with the laws of Romania conditions and investment objectives.

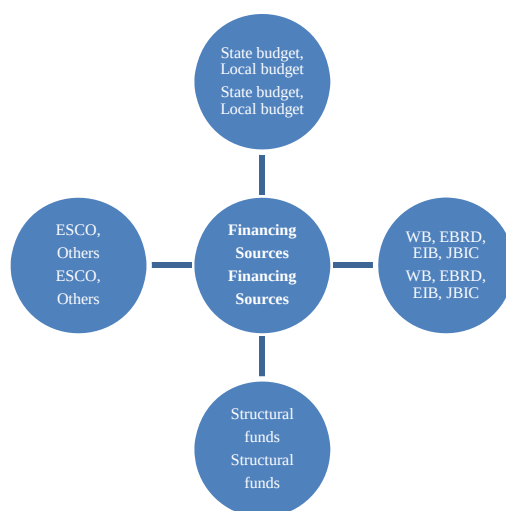
3. Romania – adequate environment of Public-Private Partnership

Romania is based on the development of renewable energy projects and efforts to integrate them better and to support and attract investments in this area. Financial mechanisms to support energy efficiency measures mentioned are relatively limited in Romania, which has a negative impact on their promotion. To be successful, the implementation of the measures provided for these areas need financial support materialized in subsidies, tax cuts, aid to private companies engaged in the implementation of these plans and loans on favorable terms from banks. Financial aid will be proposed to support this sector that will be given by law, in compliance with laws on state aid.

Currently, investment financing aimed mainly increasing energy efficiency can be achieved:

- From the state budget and local budgets;
- Based on a performance contract entered into with third parties;
- Based on a performance contract concluded with an energy service company (ESCO);
- Bank loans obtained from external funding bodies (WB, EBRD, EIB, JBIC) or commercial banks;
- Co-financing from structural funds.

Figure 2. Sources of funding investments to increase energy efficiency



Source: Author's own contribution according to the data from the online address <http://www.mdrt.ro/en/dezvoltare-regionala/politica-de-dezvoltare-regionala>, accessed on 18th of October 2013.

In terms of renewable energy projects, they have to take into account the actors from the public or private area, citizens of a region, or country and the assurance of a success from such a project that involves a certain implementation and creating a link between these actors for their operation in relation to the national legal system.

Government has a key role in this situation, because by this organism are awarded funds for investments in renewable energy. Basically the government, along with local authorities, network operators, environmental authorities are involved in this system, because they provide the administrative management of renewable energy projects.

Basically, for each region of Romania, the authorities have their own responsibility regarding the local situation of an area that may hinder or facilitate the investments in green energy, but they are also coordinated by the central authorities. In Romania, the bureaucratic system is a serious problem that discourages investors from the very first contact with the authorities.

A practical example of a renewable energy project is the list of documents and notices required to obtain a financing or a loan for such an investment, as it follows: acts issued by the local public authority, certificate of urbanism, building permits, opinion approving construction sites, documents eliberated from the environmental system, documents issued by the grid operator will be connected to the recipient; documents issued by the National Authority for Energy Regulation; special authorization for the purposes of producing more than 1 MW, licensed manufacturer for the purposes of producing more than 1 MW etc.

Given the necessary documents in the first phase, it is more effective to promote public-private partnerships, in order to facilitate the obtaining of documents and communication energy efficiency on these projects and minimize bureaucracy. Public-private partnerships are supported at European level and identify the following strengths related to: reducing costs for public sector infrastructure, fast delivery, high efficiency, stability and sustainability, responsibility assumed, private management, risk elimination, improved quality of services (Hodge and Greve, 2007, pp. 545-558).

To summarize, the steps that can be adapted to implement renewable energy projects in areas of national development by creating public-private partnerships are: encouraging research and innovation, supporting local initiatives, promotion of renewable energy and attracting investors in this field (Directive 2009/28/CE of the European Parliament and of the Council from 23 April 2009 on the promotion of energy from renewable sources and amending and subsequently repealing Directives 2001/77/CE and 2003/30/CE).

Conclusions

Of the above-stated, it can be concluded that the two concepts, sustainable regional development and renewable energy are intertwined and affect both the public and private sectors. Moreover, how the two concepts are supported in the legislation shows that the two concepts have common interests and goals to accomplish the creation of a stable economic environment.

Romania is an attractive country in terms of the multitude of renewable energy sources in its possession. To attract investments in this area is needed further work related to the institutional framework for conducting such activities. It is also necessary to find concrete solutions for accessing European funds for the development of non-conventional energy sources and encourage energy producers.

There are many challenges for both sections of the public authorities who want renewable energy development in developing regions, as well as the private sector by investors seeking to maximize profits in relation to compliance with the laws of Romania conditions and also on investment objectives.

In order to achieve investments in this area, eliminating any risk that may further exacerbate the economic crisis we are facing now should be considered. Encouraging investments in renewable energy sources is considered to be a solution that will generate economical growth.

Public-private partnerships are supported at European level and consist of a series of advantages both for the public and the private sector, such as reducing public sector costs, fast delivery infrastructure, high efficiency, stability and sustainability assumed responsibility, private management, elimination risk, more improved quality of services.

Given the foregoing, it can be concluded that Romania is an environment for creating PPP's in green energy field and it has the ability and resources to attract these types of partnerships.

References

- Hodge, G.A., Greve, C. (2007). "Public-Private Partnerships: An International Performance Review", *Public Administration Review*, 67 (3)
- The Brundtland Report (1987). "Our Common Future" www.unep.org, accessed on 5th November, 2013
- <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF>, accessed on 1st November, 2013
- http://europa.eu/pol/ener/index_ro.htm accessed on November 5th, 2013

- <http://lege5.ro/en/Gratuit/geydkmrsgq/hotararea-nr-1069-2007-privind-aprobarea-strategiei-energetice-a-romaniei-pentru-perioada-2007-2020/7>, accessed on 27th October, 2013
- <http://www.enero.ro/doc/STRATEGIA%20ENERGETICA%20A%20ROMANIEI%20PENTRU%20PERIOADA%202007-2020.pdf>, accessed on November 15th 2013
- <http://www.iea.org/> accessed on 17th October, 2013
- <http://www.mdr.ro/en/dezvoltare-regionala/politica-de-dezvoltare-regionala>, accessed on October 6th 2013
- http://www.minind.ro/pnaer/pnaer_29%20iunie_2010_final_alx.pdf, accessed on October 12th 2013
- <http://www.mmediu.ro/beta/domenii/dezvoltare-durabila/concepte-si-principii-de-dezvoltare-durabila/>, accessed on October 4th 2013

Mixed strategy Nash Equilibrium and Quantal Response Equilibrium. An experimental comparison using RPS games⁽¹⁾

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Abstract. *In this paper I test the hypothesis according to which the Quantal Response Equilibrium (QRE) solution concept significantly outperforms the Mixed Strategy Nash Equilibrium (MSNE) in experimental situations. The testing ground for the hypothesis is an experiment with variations of the RPS game applied in June 2013 to students from various universities in Bucharest. The results of the experiment show that the QRE solution does not perform substantially better than the Nash Equilibrium for two of the three games studied and that it does represent a slight improvement in only one of the games. This result lies in stark contrast to the bulk of the literature developed thusfar on the QRE solution*

Keywords: experiment, Mixed Strategy Nash Equilibrium, Quantal Response Equilibrium, strategies, solution concept.

JEL Classification: C72, C73, C79, C91, D83.

REL Classification: 7L, 9J, 9Z.

1. Introduction

The solution introduced in (1950) by John Nash, i.e. the Nash Equilibrium, is without a doubt the most used solution concept in game theory⁽³⁾. A vast strand of the meta-theoretical literature in this field has been focused solely on producing refinements to the Nash Equilibrium solution for the past 60 years. But still, the Nash Equilibrium solution has often come under heavy criticism for often being inadequate when it comes to predicting observed human behavior. The Quantal Response Equilibrium⁽⁴⁾, proposed by McKelvey and Palfrey (1995) seeks to address this concern by providing an alternate solution concept, one which is not a refinement of the Nash Equilibrium but rather a statistical counterpart. In a nutshell, the QRE replaces the best response utility functions of individuals, used in classical game theory, with quantal response functions that attach a wide array of probabilities to playing pure strategies according to an error parameter⁽⁵⁾.

The purpose of this paper is to experimentally test the presumed superiority of the Quantal Response Equilibrium over the Mixed Strategy Nash Equilibrium⁽⁶⁾ in 3×3 games, and, more specifically for several variations of the RPS game. The paper is structured as follows: in the second section I present an outline of the Quantal Response Equilibrium in which I detail some of its general characteristics and the logit QRE operationalization which has been commonplace in the economic literature. In the third section I describe the RPS game in its original form. I then describe the experimental design and present the general results obtained which are relevant to my paper, i.e. the mixed strategies used by players in each of the three games played. In the fourth section I analyze the predictive capacity of the Mixed Strategy Nash Equilibrium solution for each of these games. In the fifth section I perform an identical task for the QRE solution and compare it with the Nash Equilibrium. In the last part I present the conclusions and limitations of the paper.

2. Theoretical background: the MSNE and QRE solutions

The Nash Equilibrium solution is characteristic of a profile which has the property that no player has any reason to unilaterally change his strategy. In other words, a Nash Equilibrium is the best response of each player to the strategy used by the other player. Formally, if we have two players i and j with agendas $S_i = \{s_1, s_2\}, S_j = \{s_3, s_4\}$, $\{s_1, s_3\}$ is a Nash Equilibrium *iff* $u_i(s_1, s_3) \geq u_i(s_2, s_3)$ and at the same time $u_j(s_1, s_3) \geq u_j(s_1, s_4)$. Since a game can have more than a single Nash equilibrium⁽⁷⁾, its usage is not able to guarantee that we will obtain a single profile as a result (and consequently make definite predictions). Still, the Nash Equilibrium solution is “without doubt the single game theoretic solution concept

that is most frequently applied in economics” (Aumann, 2000, p. 67). The Mixed Strategy Nash Equilibrium (MSNE) is an extension of the concept of Nash Equilibrium from pure strategies to mixed strategies. A mixed strategy is a combination of pure strategies, in which players assign probabilities to choosing each alternative within a round. Formally, we can represent a mixed strategy⁽⁸⁾ as $\sigma_i(s_i)$ with the agenda being represented by the set of probability distributions defined on S_i , namely $\Delta_i = \Delta(S_i)$ (McCarty, Meirowitz, 2007, p. 90). The MSNE solution therefore characterizes the profile of mixed strategies where each player provides the best response to the mixed strategy used by the other player⁽⁹⁾.

The main reason for the introduction of the Quantal Response Equilibrium⁽¹⁰⁾ in the mainstream solution set of game theory is the widespread failure of classical solution concepts, and in particular the Mixed Strategy Nash Equilibrium, to accurately predict human behavior in empirical and experimental situations, especially in games where the classical solutions yield somewhat counterintuitive results, predicting that the game will end with low-payoff outcomes for all players. There are various examples which support this finding. One of them is the centipede game, studied by McKelvey and Palfrey (1992). In the general form of this game, two players compete in an n -round game, with the number of rounds being common knowledge between the players. On every round of the game one of the players has the option to either take the money (t), in which case the game ends, or pass (p), in which case the game continues. During every round in which a player passes, the payoff is multiplied by a number k , with the highest payoff corresponding to the player who chooses an alternative. For instance, in McKelvey and Palfrey’s experiment, the game typically lasted for 4 rounds⁽¹¹⁾, with the standard payoffs being (0.4, 0.1) in the first round, where player 1 had to make the choice, (0.2, 0.8) in the second one, where player 2 had to make the choice, (1.6, 0.4) in the third round where it was once again player 1’s turn to make the choice, and (0.8, 3.2) in the fourth round when the roles were once again reversed. Although it was clear that both players received higher payoffs if the game lasts longer, the Nash Equilibrium solution predicts that the first player will choose to take the money in the first round. The experimental results proved to thoroughly refute this hypothesis however, with only 7% of the 4-round games and 1% of the 6-round games ending on the first round.

Another such example is the ultimatum game, introduced by Guth et al. (1982), in the case of which Binmore et al. (1995) experimentally show that the subgame perfect Nash Equilibrium fails to correctly predict the vast majority of player strategies. Still another frequently encountered example, described at length by McKelvey and Palfrey (1995) and used by Goeree et al. (2005) to explain the concept of Regular QRE is that of the matching pennies game, in its original and

modified versions, as introduced by Ochs (1995). The author considers three versions of the matching pennies game with two players. In the first one the payoffs are identical between the players, with the first one gaining +1 (and the second one obtaining 0) if the strategies selected coincide and the second one obtaining +1 (with the first one obtaining 0) if the profile resulted is composed of distinct strategies. The two modified versions of the game yield +9 (in the first version) and +4 (in the second one) instead of +1 for the profile in which both player 1 and player 2 choose s_1 , with all the other payoffs (included 0 for the second player in this profile) remaining unchanged. As Ochs (1995, p.205) explains, although the MSNE prediction in this case would yield different probabilities of playing pure strategies for player 2, in the case of player 1 he would have to play each strategy with the same 0.5 probability since that ensures that his opponent is indifferent amongst his/her alternatives. The results obtained by Ochs, on an experimental sample consisting of 48 subjects for all three sessions (1995, p.208), thoroughly disproved the hypothesis that player 1 would play according to the predictions of the MSNE in the second and third game, with the choice of s_1 in both games significantly exceeding 0.5⁽¹²⁾.

Thus, the unravelling of these examples and others which similarly showed that the MSNE or other classical solution concepts are poor predictors of actual human behavior, represented the context in which the QRE solution arises as a powerful contender in game theory during the 1990s.

QRE is based on the idea that “players are ‘better responders’ rather than best responders” (Goeree et al., 2005, p. 364). The solution concept is introduced for normal-form games⁽¹³⁾ by McKelvey and Palfrey (1995) who sought to replace “the perfectly rational expectations equilibrium embodied in Nash Equilibrium with an imperfect, or noisy, rational expectations equilibrium” (McKelvey, Palfrey, 1995, p. 7). Thus, the QRE can be defined as “an extension of standard random utility models of discrete (‘quantal’) choice to strategic settings, or as a generalization of Nash Equilibrium that allows noisy optimizing behavior while maintaining the internal consistency of rational expectations” (Haile et al., 2008, p.180).

The basic idea behind the QRE⁽¹⁴⁾ is to define an equilibrium solution while allowing individuals to play the game in a sub-optimal fashion, due to the fact that they are characterized by various cognitive constraints and limitations. Thus, bounded rationality⁽¹⁵⁾, as the core element which underlies the QRE⁽¹⁶⁾, is then used to replace the best response functions of individuals which characterizes a Nash Equilibrium solution with a *statistical reaction function* (McKelvey, Palfrey, 1995, p. 10) or *quantal response function* (Goeree et al., 2005, p. 351).

One interesting aspect of the QRE solution is that in of itself it only specifies the procedure for generating predictions regarding strategy choices but it does not specify any exact mathematical tool employed in this regard. The most frequent way to operationalize it is to use the *Logit QRE*, which uses the following

response functions: $P_{ij} = \frac{e^{\lambda \pi_{ij}}}{\sum_{k=1}^{J_i} e^{\lambda \pi_{ik}}}$, where P_{ij} is the quantal response function of

player i which corresponds to strategy j , λ is an error parameter and π_{ij} is the expected payoff obtained by player i when playing strategy j ⁽¹⁷⁾.

As we can see from their Logit expression above, quantal response functions vary according to an error parameter λ , which can take values from 0, where the choices made are completely random, or as McKelvey and Palfrey phrase it, “actions consist of all error” (1995, p.11) to $+\infty$, where no error exists and the choices made overlap or asymptotically approach the Nash Equilibrium solution. The intersection of each of these functions generate the Quantal Response Equilibrium, which is a fixed point⁽¹⁸⁾.

3. The RPS game

“Rock-Paper-Scissors”⁽¹⁹⁾ is a game well known to individuals due to its frequent usage in common day situations to solve minor disputes between parties where no one is perceived to be more entitled to a disputed good than the other^{(20), (21)}. In its standard form, the game is played between two players, let us call them p_1 and p_2 . Each player has three available strategies on the agenda: Rock (r), Paper (p) and Scissors (s), thus $S_i = \{r, p, s\}$. Since both players have the same agenda, there are $S_i \times S_j$ profiles possible, namely $\{(r, r), (r, p), (r, s), (p, r), (p, p), (p, s), (s, r), (s, p), (s, s)\}$. The payoffs for each player are determined by the following pattern: a) Rock crushes Scissors, i.e. $r > s$, b) Scissors cuts Paper, i.e. $s > p$, c) Paper covers Rock, i.e. $p > r$ and d) in case an alternative is played against its twin the game ends in a draw.

The general game is depicted in its strategic form in Figure 1. In its standard form, for each win the players gain +1, for each loss -1 and for each draw 0. Thus, for player 1 we have $u_1(r, s) = u_1(p, r) = u_1(s, p) = +1$, $u_1(r, r) = u_1(p, p) = u_1(s, s) = 0$ and $u_1(r, p) = u_1(p, s) = u_1(s, r) = -1$. Since the game is symmetrical player 2 has an identical payoff scheme. The first thing we notice is that there is no Pure Strategy Nash Equilibrium since in every profile at least one player has the

incentive to unilaterally change his strategy. To see this let us take for instance the profile (r, p) . Player 2 gains +1 while Player 1 receives a payoff of -1. Naturally, Player 1 has an incentive to unilaterally change his strategy to s . In the resulting profile, i.e. (s, p) Player 2 now has an incentive to change his strategy to r . But the resulting profile, (s, r) is now once again sub-optimal for Player 1 who changes his strategy to p and so forth. In the case that players reach a tie the reasoning is similar. Suppose the profile resulting from their choices is $u_1(p, p)$. Both players receive 0 and they would like to receive +1. Therefore both of them would be stimulated to unilaterally adopt the strategy s in the following round. But this would result in a tie once again which would lead both players to adopt strategy p in the subsequent round and so forth⁽²²⁾.

Figure 1. RPS strategic-form game

$p_1 \backslash p_2$	Rock (r)	Paper (p)	Scissors (s)
Rock (r)	$u_2(r, r)$ $u_1(r, r)$	$u_2(r, p)$ $u_1(r, p)$	$u_2(r, s)$ $u_1(r, s)$
Paper (p)	$u_2(p, r)$ $u_1(p, r)$	$u_2(p, p)$ $u_1(p, p)$	$u_2(p, s)$ $u_1(p, s)$
Scissors (s)	$u_2(s, r)$ $u_1(s, r)$	$u_2(s, p)$ $u_1(s, p)$	$u_2(s, s)$ $u_1(s, s)$

Source: Author.

Although there are no pure strategies Nash equilibria, each two-player zero-sum game has at least one equilibria in mixed strategies, which in this case is the profile generated by strategies $\sigma_1(s_1) = \sigma_2(s_2) = \frac{1}{3}r + \frac{1}{3}p + \frac{1}{3}s$. The main idea is

“to ‘mix’ the possible ways of playing with certain probabilities” so that “he can protect himself against loss” (von Neumann, Morgenstern, 1944, p.144) since the other player becomes indifferent amongst his own alternatives (the mix of strategies is built in such a way in which the expected payoff of the opponent is equivalent for all alternatives and equal to 0). The proof of this solution for the standard RPS game is straightforward and I will not detail it here, since the mathematical procedure is also described in Section 4 for the modified versions⁽²³⁾.

4. The experiment

4.1. Experimental design

The experiment consisted of three repeated Rock-Paper-Scissors games, with a modified payoff structure for each game. There were 22 participants in total (all of them responded to a call for participants), with 17 of them studying at the National School of Political and Administrative Studies (10 of them enrolled at that time in Political Science programs at a BA level, 2 of them studying International Relations at a BA level, 3 of them studying Project Evaluation at an MA level, 2 of them studying Government and Society at an MA level and one studying Project Management at an MA level), 3 studying Law either at the University of Bucharest or Nicolae Titulescu University (2 at a BA level and one at an MA level), 1 studying Political Sciences at the University of Bucharest (BA level) and 1 studying Applied Electronics at the Polytechnic University of Bucharest (BA level). Each pair of players (except one) was formed between players who were not previously acquainted in order to mitigate any potential side-effects caused by the establishment of prior social relations between the participants⁽²⁴⁾.

The three games played by the participants are described in detail in Section 5 of this paper. At the beginning of the experiment, each pair played one round of the regular RPS game in order to determine which one of them would be Player 1 and Player 2⁽²⁵⁾. The first game which was played for 24 rounds between the players was an RPS game (subsequently called RPS-1; see Figure 2) where strategy p yielded a higher payoff (+2) than the other two (which yielded +1) when used as a winning strategy. The game was symmetric, in the sense that the payoff structure satisfied the anonymity property. The second game (subsequently called RPS-2; see Figure 4), which was also played for 24 rounds was identical to RPS-1 except for the fact that strategy p yielded a much higher payoff (+8) than before. The other payoffs remained constant. The third game, which was played only for 21 rounds was an RPS game (subsequently called RPS-3; see Figure 6) where winning with strategy r yielded a higher payoff for player 1 (+2 instead of the regular +1) and winning with strategy s yielded a higher payoff for player 2 (+2 instead of the regular +1). All other payoffs were kept the same. The number of rounds for each game was not communicated to the participants and was varied in order to mitigate any potential end-game effects.

In order to create the conditions for instrumentally rational behavior directed towards winning the game, the players were remunerated according to their performance, with the winner of each game receiving the sum of 6 lei for a victory, with the sum being divided equally between both players in case of ties. If one player won all three games a 2 lei bonus was added to his total payoff, in

order to stimulate him to adopt a competitive attitude throughout the entirety of the game, thus a player could win at most 20 lei. If the player did not win any games or lost two games and drew the other he received a 5 lei sum for participation. The length of each game was of approximately 10 minutes. The intention was to balance the length so that players would have time to make calculations between rounds but still keep each game as short as possible, so that the monetary incentives would not be overturned by temporal costs associated with participation to the experiment.

At the beginning of the experiment, each player was handed a sheet of paper with the Instructions for Participants alongside the payoff tables for each game and the Experiment form. The rules, the payoff structures and other logistical details were also explained verbally by the operator of the experiment prior to each of the three games. After the explanations were concluded, the players were given a few minutes in order to reflect on the array of strategies available. Regarding the mechanism of play, participants were required to play physically, i.e. by a show of hands depicting each alternative^{(26), (27)}, showing their choices simultaneously after the elapse of the countdown kept by the operator of the experiment. After the choices were revealed each player had to write the initial of his own choice of the respective round on the Experiment form and then consult the payoff table in order to see what the payoff corresponding to the respective profile was. Especially since all of the three games played had only mixed strategy equilibria, the players were allowed to call for a suspension of the game between rounds in order to evaluate the history of the game^{(28), (29)}.

After the experiment was conducted, the participants received a questionnaire⁽³⁰⁾ via e-mail in which they were asked to describe their strategies for each game and especially if the strategies employed were built rather on the history of the game, on the history of the previous round or on a pre-determined probabilistic pattern. The participants were also asked to describe their previous level of knowledge regarding game theoretical concepts such as Nash Equilibrium, Mixed Strategy Nash Equilibrium and Quantal Response Equilibrium and, if familiar, if they intended to play strategies leading to these sort of solutions.

4.2. An overview of the results

From the perspective of this study, the main element of interest generated by the experiment was the combination of pure strategies used by the players during each game, namely the proportion with which each strategy was played. These results are summarized in Table 1.

Each cell of the table represents the probability with which a player played a specific strategy during a game. The double line divides the Player 1-type and the Player 2-type of participants in the experiment. Although the sample size was

relatively small, I contend that the results can be validly used to construct a preliminary image of the issues discussed in the following sections.

Table 1. Percentages of pure strategies played in the three RPS games

Players	Game 1			Game 2			Game 3		
	<i>r</i>	<i>p</i>	<i>s</i>	<i>r</i>	<i>p</i>	<i>s</i>	<i>r</i>	<i>p</i>	<i>s</i>
1	0.25	0.08	0.66	0	0.16	0.83	0.66	0	0.33
2	0.29	0.42	0.29	0.37	0.37	0.25	0.42	0.38	0.19
3	0.33	0.45	0.2	0.25	0.45	0.29	0.23	0.52	0.23
4	0.33	0.41	0.25	0.25	0.04	0.7	0.14	0.19	0.66
5	0.12	0.62	0.25	0.2	0.45	0.33	0.42	0	0.57
6	0.08	0.54	0.37	0.12	0.58	0.29	0.42	0.28	0.28
7	0.29	0.33	0.37	0.45	0.16	0.37	0.47	0.04	0.47
8	0.25	0.33	0.41	0.33	0.16	0.5	0.28	0.33	0.38
9	0.25	0.37	0.37	0.12	0.5	0.37	0.71	0	0.28
10	0.16	0.54	0.29	0.04	0.45	0.5	0.38	0	0.61
11	0.37	0.41	0.2	0.41	0.12	0.45	0.47	0	0.52
12	0.16	0.62	0.2	0.12	0.62	0.25	0.19	0.57	0.23
13	0.29	0.29	0.37	0.41	0.45	0.12	0.28	0.52	0.19
14	0.2	0.16	0.62	0.12	0.25	0.62	0.23	0.23	0.52
15	0.25	0.41	0.33	0.08	0.62	0.29	0.04	0.66	0.28
16	0.41	0.33	0.25	0.25	0.29	0.45	0.28	0.28	0.42
17	0.37	0.08	0.54	0.16	0.33	0.5	0.23	0.33	0.42
18	0.2	0.37	0.41	0	0.79	0.2	0.28	0.52	0.19
19	0.25	0.37	0.37	0.29	0.41	0.29	0.28	0.23	0.47
20	0.29	0.25	0.45	0.33	0.16	0.5	0.28	0.23	0.47
21	0.2	0.37	0.41	0.12	0.66	0.2	0.09	0.38	0.52
22	0.29	0.33	0.37	0.33	0.37	0.29	0.33	0.33	0.33

Source: Author.

5. Mixed Strategy Nash Equilibrium performance in predicting strategy choices

5.1. MSNE predictive power in RPS-1

The first game played by the participants in the experiment, termed RPS-1 was a symmetrical RPS game with the strategy p yielding a higher payoff than r or s when winning, i.e. +2 instead of +1. By analogy, losing with r against p yielded a negative payoff of -2 instead of -1. The game is depicted in Figure 2. The game has a unique Mixed Strategy Nash Equilibrium, which will be computed subsequently. Let us consider that $u_i(s_i)$ represents the expected utility gained by i when playing strategy s_i and that $\sigma_i(s_i)$ is the mixed strategy played by player i .

Let us further consider that $u_i(s_i) = \sum u_i(s_i, s_j)P(s_j)$, where $u_i(s_i, s_j)$ represents the utility gained by player i when gaining the payoff of the profile (s_i, s_j) and $P(s_j)$ represents the probability that player j will play strategy s_j . Thus, for any known system of payoffs we can solve for $P(s_j)$ in the Mixed Strategy Nash Equilibrium by solving the system of equations generated by the three expected payoffs of i .

Figure 2. RPS-1 game

$P_1 \backslash P_2$	Rock (r)	Paper (p)	Scissors (s)
Rock (r)	0	+2	-1
Paper (p)	-2	0	+1
Scissors (s)	+1	-1	0

Source: Author.

In RPS-1, let us first solve for the probability parameters of Player 2. Notice that since the sum of all probabilities must be equal the following equivalency holds: $P_2(s) = 1 - P_2(r) - P_2(p)$. Since the game is symmetrical, the exact mixed strategy is prescribed for Player 1 as well in the MSNE. Thus for Player 1 we have the following system of equations:

$$u_1(r) = u(r, r)P_2(r) + u(r, p)P_2(p) + u(r, s)(1 - P_2(r) - P_2(p)) \quad (1.1)$$

$$u_1(p) = u(p, r)P_2(r) + u(p, p)P_2(p) + u(p, s)(1 - P_2(r) - P_2(p)) \quad (2.1)$$

$$u_1(s) = u(s, r)P_2(r) + u(s, p)P_2(p) + u(s, s)(1 - P_2(r) - P_2(p)) \quad (3.1)$$

From (1.1), (2.1) and (3.1) we further obtain:

$$u_1(r) = -2P_2(p) + 1 - P_2(r) - P_2(p) = 1 - P_2(r) - 3P_2(p) \quad (1.2)$$

$$u_1(p) = 2P_2(r) - 1 + P_2(r) + P_2(p) = -1 + 3P_2(r) + P_2(p) \quad (2.2)$$

$$u_1(s) = -P_2(r) + P_2(p) \quad (3.2)$$

But by definition of MSNE we have $u_1(r) = u_1(p) = u_1(s)$, therefore we can replace (3.2) in (1.2) and (2.2) Thus we have:

$$1 - P_2(r) - 3P_2(p) = -P_2(r) + P_2(p) \Rightarrow 1 - P_2(r) - 3P_2(p) + P_2(r) - P_2(p) = 0 \quad (1.3)$$

$$-1 + 3P_2(r) + P_2(p) = -P_2(r) + P_2(p) \Rightarrow -1 + 3P_2(r) + P_2(p) + P_2(r) - P_2(p) = 0 \quad (2.3)$$

From (1.3) we then obtain $1 - 4P_2(p) = 0 \Rightarrow P_2(p) = \frac{1}{4} = 0.25$. Also, for (2.3) we

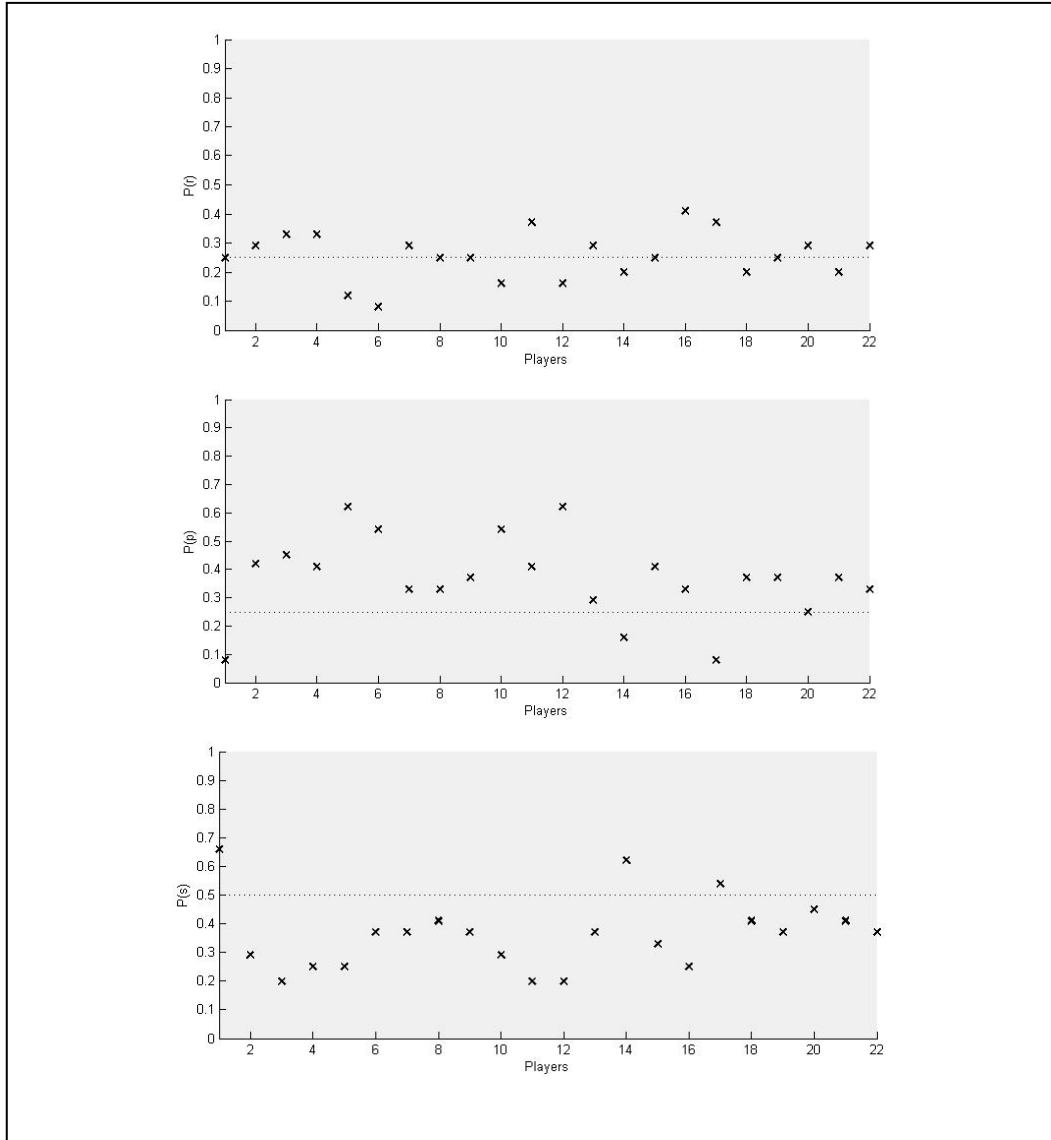
have $-1 + 4P_2(r) = 0 \Rightarrow P_2(r) = \frac{1}{4} = 0.25$. Further, since we know that

$P_2(s) = 1 - P_2(r) - P_2(p)$, we have $P_2(s) = 1 - 0.25 - 0.25 = 0.5$. The Mixed Strategy Nash Equilibrium for RPS-1 is therefore achieved when $\sigma_1(s_i) = \sigma_2(s_i) = \{0.25r, 0.25p, 0.5s\}$.

The MSNE is not immediately intuitive. As we can see, the strategy which yields the highest payoff (p) is not the strategy which should be played most often and in fact it is on par with what appears to be the worst possible strategy since losing with r yields a negative payoff of -2 while winning with r yields a positive payoff of only 1. The MSNE strategy therefore seeks to exploit the temptation of the opponent to frequently use the higher paying strategy, while in the meantime ensuring that the negative payoff associated with a defeat is not significantly large.

In Figure 3 the experimental results are plotted against the MSNE for RPS-1. The first plot corresponds to $P(r)$, the second one to $P(p)$ and the third one to $P(s)$. The dotted lines represent the percentage prescribed by MSNE, with the $\times$'s representing the percentages of each strategy as played in the experiments. By looking at the plots it is easy to see that the Nash Equilibrium predictions perform very poorly. Although in some of the cases $P(r)$ is indeed played as prescribed by the MSNE, i.e. with 0.25 probability, the predictions for $P(p)$ and $P(s)$ fall way outside of their intended targets. Indeed, the bulk of participants fell prey to the temptation to use $P(p)$ more often than prescribed due to its higher payoff (approximately 81% of players), with $P(s)$ being under-used by 86% of players. All in all, none of the participants played the NE mixed strategy.

Further, considering that due to the relatively small number of rounds combined with a lack of knowledge regarding the position of the final turn, it would have been possible for participants to mix the strategies so as to converge towards the Nash Equilibrium but their failure to do so was caused by the end of the game, let us assume that some small margin of disturbance in the percentages required for a mixed strategy to generate a Nash Equilibrium is allowed. With a 0.05 vicinity (which corresponds to an error of ± 1 in the number of strategies played), we only find one participant who plays consistently with the MSNE.

Figure 3. MSNE and experimental results in RPS-1

Source: Author.

5.2. MSNE predictive power in RPS-2

The second game played by the participants in the experiment, termed RPS-2 was a symmetrical RPS game with the strategy p yielding an even higher payoff than in RPS-1, i.e. +8 instead of +2. By analogy, losing with r against p yielded a negative payoff of -8 instead of -2. The game is depicted in Figure 4.

Figure 4. *RPS-2 game*

$p_1 \backslash p_2$	Rock (r)	Paper (p)	Scissors (s)
Rock (r)	0	+8	-1
Paper (p)	-8	0	+1
Scissors (s)	+1	-1	0

Source: Author.

In order to compute the MSNE we will proceed in an identical manner as in section 5.1. The game is once again symmetrical, therefore solving the probability parameters for Player 2 will automatically yield the parameters for player one. Once again we consider that $P_2(s) = 1 - P_2(r) - P_2(p)$. We obtain:

$$u_1(r) = u(r, r)P_2(r) + u(r, p)P_2(p) + u(r, s)(1 - P_2(r) - P_2(p)) \quad (4.1)$$

$$u_1(p) = u(p, r)P_2(r) + u(p, p)P_2(p) + u(p, s)(1 - P_2(r) - P_2(p)) \quad (5.1)$$

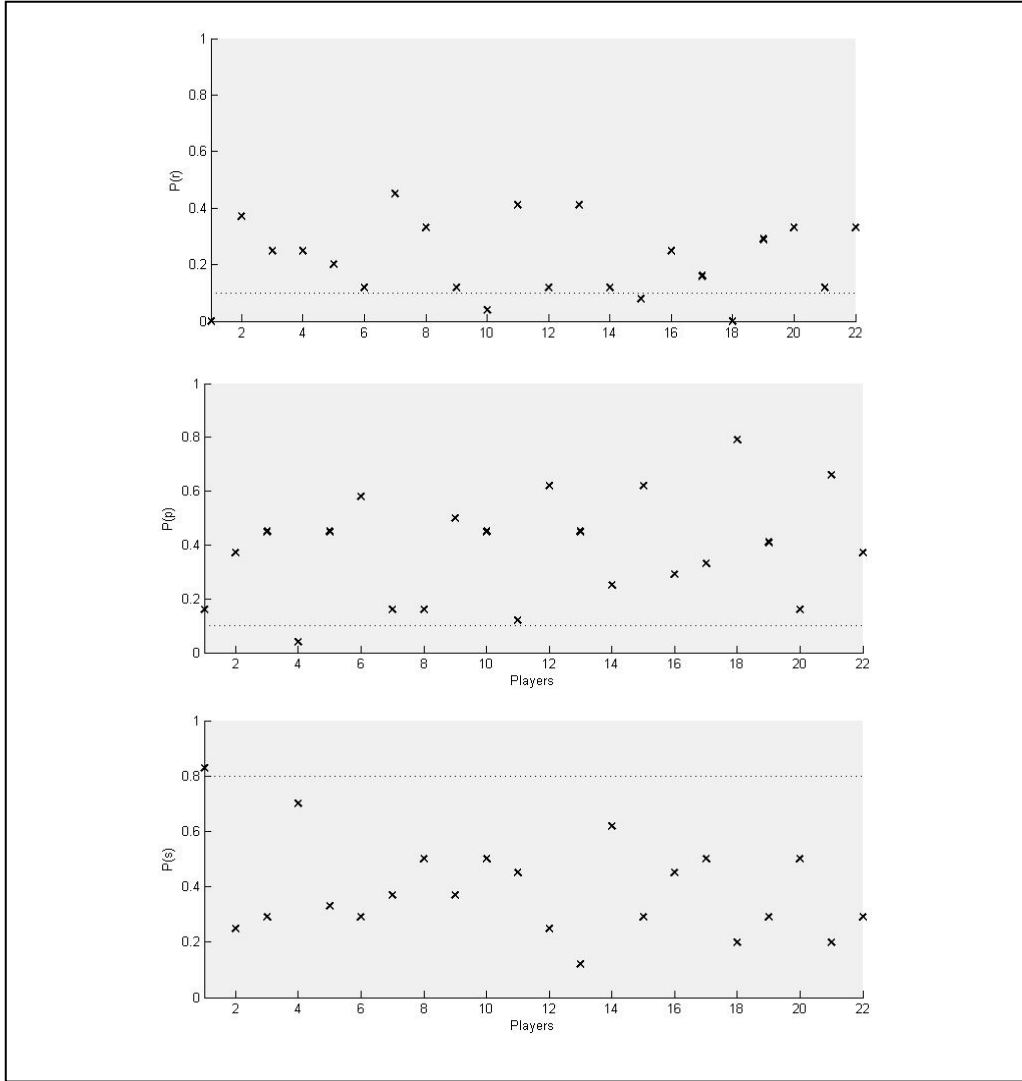
$$u_1(s) = u(s, r)P_2(r) + u(s, p)P_2(p) + u(s, s)(1 - P_2(r) - P_2(p)) \quad (6.1)$$

From (4.1), (5.1) and (6.1) we further obtain:

$$u_1(r) = -8P_2(p) + 1 - P_2(r) - P_2(p) = 1 - P_2(r) - 9P_2(p) \quad (4.2)$$

$$u_1(p) = 8P_2(r) - 1 + P_2(r) + P_2(p) = -1 + 9P_2(r) + P_2(p) \quad (5.2)$$

$$u_1(s) = -P_2(r) + P_2(p) \quad (6.2)$$

Figure 5. MSNE and experimental results in RPS-2

Source: Author.

But by definition of MSNE we have $u_1(r) = u_1(p) = u_1(s)$, therefore we can replace (6.2) in (4.2) and (5.2) Thus we have:

$$1 - P_2(r) - 9P_2(p) = -P_2(r) + P_2(p) \Rightarrow 1 - P_2(r) - 9P_2(p) + P_2(r) - P_2(p) = 0 \quad (4.3)$$

$$-1 + 9P_2(r) + P_2(p) = -P_2(r) + P_2(p) \Rightarrow -1 + 9P_2(r) + P_2(p) + P_2(r) - P_2(p) = 0 \quad (5.3)$$

From (4.3) we then obtain $1 - 10P_2(p) = 0 \Rightarrow P_2(p) = \frac{1}{10} = 0.1$. Also, for (5.3) we have $-1 + 10P_2(r) = 0 \Rightarrow P_2(r) = \frac{1}{10} = 0.1$. Further, since we know that $P_2(s) = 1 - P_2(r) - P_2(p)$, we have $P_2(s) = 1 - 0.1 - 0.1 = 0.8$. The Mixed Strategy Nash Equilibrium for RPS-2 is therefore achieved when $\sigma_1(s_i) = \sigma_2(s_i) = \{0.1r, 0.1p, 0.8s\}$.

The MSNE is once again somewhat counterintuitive at first sight, since the strategy which is projected to be played no less than 80% of time in equilibrium is once again not the one yielding the higher payoff, but the one which is able to defeat it. Observing the pattern, we can therefore arrive at a very interesting, and perhaps paradoxical result, namely that as a strategy becomes *prima facie* more attractive in an RPS game, it is rational for individuals to avoid using it. The relation between the payoff (not *expected payoff*) of a strategy and the probability assigned to its usage in symmetrical RPS games with a single strategy modified from the standard game is one of inverse proportionality. The MSNE is compared with the experimental results in Figure 5. Once again, we notice that there are a few mixed strategies which assign to $P(r)$ the probability prescribed by the MSNE (although half of them still depart with more than 10% from it).

The predictions for the other two strategies however are decidedly inconsistent with individual behavior. Only 6 of the 22 players are in a 0.1 vicinity of the prescribed $P(p)$ and the situation for $P(s)$ is the worst of all with 21 out of 22 players underplaying this strategy. There are only 2 strategies out of 22 (0.09) which are in a 0.1 vicinity to the MSNE prediction for s , with players assigning probabilities as low as 0.2 (two cases) or even 0.12 (one case) to s when its prescribed probability according to the MSNE is 0.8.

5.3. MSNE predictive power in RPS-3

The third game played by the participants in the experiment, termed RPS-3 was an asymmetrical RPS game with the strategy r yielding a payoff of +2 only for Player 1 when winning and strategy s yielding a payoff of +2 only for Player 2 when winning. All the other payoffs are symmetrical between the players and equal to +1. The game is depicted in Figure 6.

We will once again proceed with finding the Nash Equilibrium, however, since the game is asymmetric from the perspective of payoffs, $\sigma_1(s_i) \neq \sigma_2(s_i)$, we will need to identify the solution for each of the players. I will start with player 2.

I begin once again with the standard system of equations:

$$u_1(r) = u(r, r)P_2(r) + u(r, p)P_2(p) + u(r, s)(1 - P_2(r) - P_2(p)) \quad (7.1)$$

$$u_1(p) = u(p, r)P_2(r) + u(p, p)P_2(p) + u(p, s)(1 - P_2(r) - P_2(p)) \quad (8.1)$$

$$u_1(s) = u(s, r)P_2(r) + u(s, p)P_2(p) + u(s, s)(1 - P_2(r) - P_2(p)) \quad (9.1)$$

Figure 6. RPS-3 game

$P_1 \backslash P_2$	Rock (r)	Paper (p)	Scissors (s)
Rock (r)	0	+1	-2
Paper (p)	-1	0	+2
Scissors (s)	+1	-1	0

Source: Author.

From (7.1), (8.1) and (9.1) we further obtain:

$$u_1(r) = -P_2(p) + 2 - 2P_2(r) - 2P_2(p) = 2 - 2P_2(r) - 3P_2(p) \quad (7.2)$$

$$u_1(p) = P_2(r) - 2 + 2P_2(r) + 2P_2(p) = -2 + 3P_2(r) + 2P_2(p) \quad (8.2)$$

$$u_1(s) = -P_2(r) + P_2(p) \quad (9.2)$$

But by definition of MSNE we have $u_1(r) = u_1(p) = u_1(s)$, therefore we can replace (9.2) in (7.2) and (8.2) Thus we have:

$$2 - 2P_2(r) - 3P_2(p) = -P_2(r) + P_2(p) \Rightarrow 2 - 2P_2(r) - 3P_2(p) + P_2(r) - P_2(p) = 0 \quad (7.3)$$

$$-2 + 3P_2(r) + 2P_2(p) = -P_2(r) + P_2(p) \Rightarrow -2 + 3P_2(r) + 2P_2(p) + P_2(r) - P_2(p) = 0 \quad (8.3)$$

From (7.3) we then obtain $2 - P_2(r) - 4P_2(p) = 0 \Rightarrow P_2(r) = 2 - 4P_2(p)$. By substituting $P_2(r)$ in (8.3) we obtain $-2 + 4(2 - 4P_2(p)) + P_2(p) = 0 \Rightarrow -2 + 8 - 16P_2(p) + P_2(p) = 0$ which results in $6 - 15P_2(p) = 0 \Rightarrow P_2(p) = \frac{6}{15} = 0.4$. Thus, $P_2(r) = 2 - 4 \cdot 0.4 = 0.4$. Finally, since $P_2(s) = 1 - P_2(r) - P_2(p) \Rightarrow P_2(s) = 1 - 0.4 - 0.4 = 0.2$.

Solving for player 1, we have the following system of utility payoffs:

$$u_2(r) = u(r, r)P_1(r) + u(r, p)P_1(p) + u(r, s)(1 - P_1(r) - P_1(p)) \quad (10.1)$$

$$u_2(p) = u(p, r)P_1(r) + u(p, p)P_1(p) + u(p, s)(1 - P_1(r) - P_1(p)) \quad (11.1)$$

$$u_2(s) = u(s, r)P_1(r) + u(s, p)P_1(p) + u(s, s)(1 - P_1(r) - P_1(p)) \quad (12.1)$$

From (10.1), (11.1) and (12.1) we further obtain:

$$u_2(r) = -P_2(p) + 1 - P_2(r) - P_2(p) = 1 - P_2(r) - 2P_2(p) \quad (10.2)$$

$$u_2(p) = P_2(r) - 1 + P_2(r) + P_2(p) = -1 + 2P_2(r) + P_2(p) \quad (11.2)$$

$$u_2(s) = -2P_2(r) + 2P_2(p) \quad (12.2)$$

But by definition of MSNE we have $u_2(r) = u_2(p) = u_2(s)$, therefore we can replace (12.2) in (10.2) and (11.2). We then have:

$$-1 + 2P_2(r) + P_2(p) = -2P_2(r) + 2P_2(p) \Rightarrow 1 - P_2(r) - 2P_2(p) + 2P_2(r) - 2P_2(p) = 0 \quad (10.3)$$

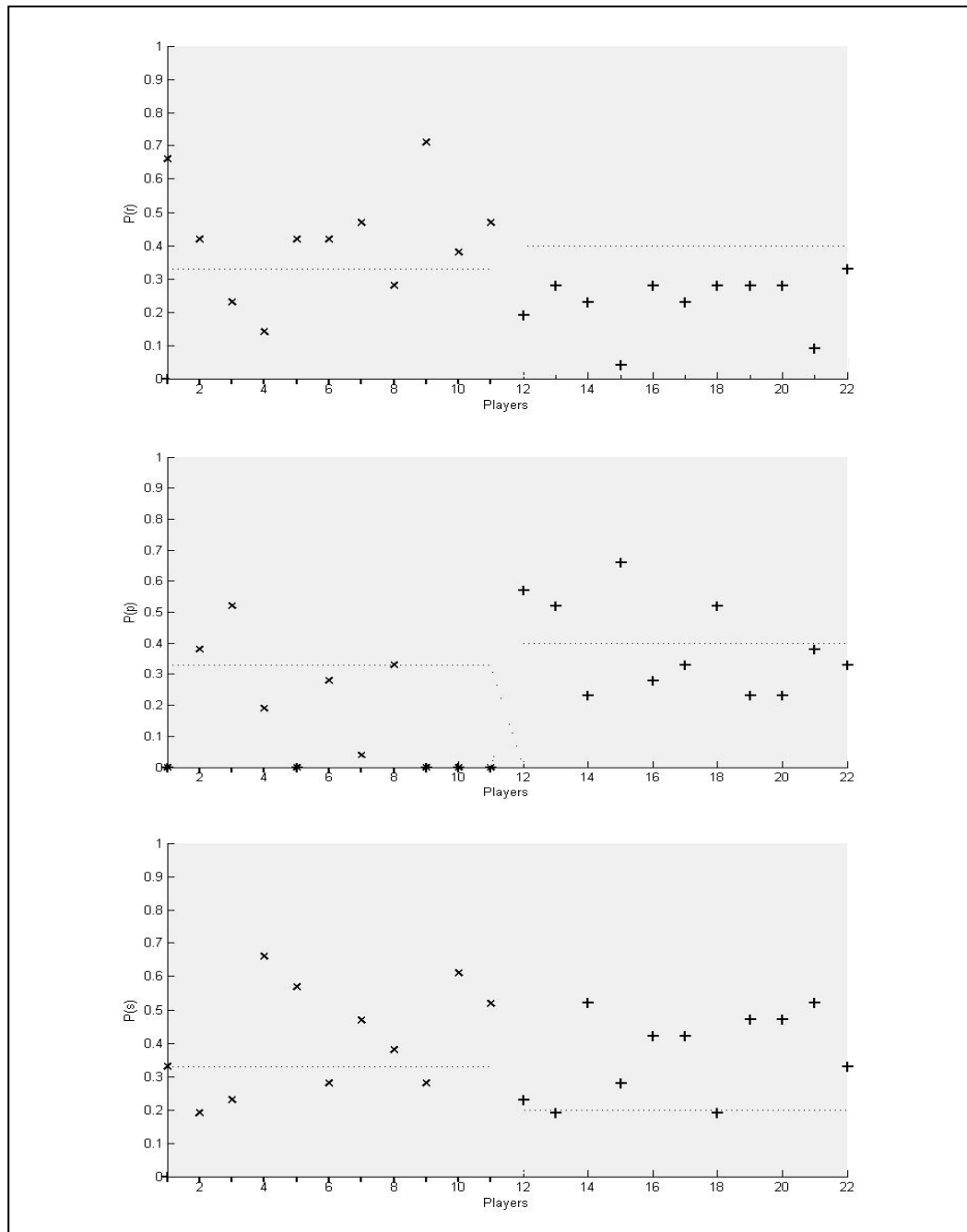
$$-1 + 2P_2(r) + P_2(p) = -2P_2(r) + 2P_2(p) \Rightarrow -1 + 2P_2(r) + P_2(p) + 2P_2(r) - 2P_2(p) = 0 \quad (11.3)$$

Thus we have $1 + P_2(r) - 4P_2(p) = 0$ (10.4) and $-1 + 4P_2(r) - P_2(p) = 0$ (11.4). We can then calculate that $P_2(r) = 4P_2(p) - 1$ and substitute this into (11.4). We have

$$-1 + 4(4P_2(p) - 1) - P_2(p) = 0 \Rightarrow -1 + 16P_2(p) - 4 - P_2(p) = 0 \Rightarrow$$

$$\Rightarrow -5 + 15P_2(p) = 0 \Rightarrow P_2(p) = \frac{5}{15} = 0.33.$$

$$\text{Since } P_2(r) = 4P_2(p) - 1 \Rightarrow P_2(r) = 4 \cdot \frac{1}{3} - 1 = \frac{1}{3} = 0.33 \text{ and } P_2(s) = 1 - \frac{1}{3} - \frac{1}{3} = \frac{1}{3}.$$

Figure 7. MSNE and experimental results in RPS-3**Source:** Author.

The MSNE of RPS-3 is therefore the mixed strategy profile where $\sigma_1(s_i) = \{0.33r, 0.33p, 0.33s\}$ and $\sigma_2(s_i) = \{0.4r, 0.4p, 0.2s\}$. Both equilibria are interesting to analyze. In the case of player 2, the strategy which yields the highest payoff is now the strategy which should be played less than each of the other two strategies. In the case of the first player, although he also has a unique strategy which yields a higher payoff than the other two when winning, the MSNE prescribes that he should play all pure strategies with equal probability. There is an intuition underlying the MSNE strategies which is exceptionally well captured by the mathematical apparatus. Although at first instance it may appear that the game is symmetrical in the sense that although the players do not have the same payoff matrix, exactly one strategy yields a higher (and identical between players) payoff for each of them, the fact that player 1 has r as a more attractive strategy and player 2 has s in the same position changes the game dynamic since the strategy which benefits player 1 the most is also the one winning against the strategy which benefits player 2 the most, but the inverse relation is *not* true. Therefore, in anticipation of player 1 choosing r with a high frequency, the optimal mixed strategy for player 2 is to play s with a lower frequency than the other alternatives.

The MSNE is compared with the experimental results in Figure 7. Each plot is divided into two halves, with the first half being represented by participants who were Player 1 during the experiment (and the corresponding Nash equilibria for Player 1) and with the second half being represented by participants who were Player 2 (and the corresponding Nash equilibria for Player 2). In this case the $\times$'s represent Player 1 and the $+$'s Player 2. The results of RPS-3 are consistent with the results from the previous two games and support the idea that the MSNE is not an adequate predictor of individual choices in repeated games of RPS.

In the case of Player 1's no less than 5 out of the 11 (almost half) played only a 2-strategy mix, avoiding to play $P(p)$, although any strategy which does not mixes all 3 strategies is clearly exploitable by an opponent who notices this fact. Further, while in the case of Player 1, one of them plays MSNE within a 0.05 vicinity of each probability prescription, in the case of Player 2, none of the 11 participants manage to do this.

5.4. Section conclusions

In this section I questioned if the strategies adopted by individuals in RPS-type of games is consistent with the Mixed Strategy Nash Equilibrium. The evidence found from the experimental study clearly show that individuals do not play RPS in accordance with the MSNE (see Table 2 below). The claim is relevant for both scientific realist and instrumentalist perspectives. Regarding the first one I would bring the following argument: although most participants studied Political Science

and more than half of the participants who filled out the post-experiment questionnaire mentioned that they had prior knowledge regarding the concept of Nash Equilibrium, when asked if they had attempted to play in accordance with the MSNE for any of the games none of them replied affirmatively. Although the sample size was relatively small and the results should be treated with caution, I have not managed to find any evidence supporting the idea that individuals intentionally seek to play in accordance with the MSNE solution in RPS games. Regarding the instrumentalist perspective I have found no evidence that individuals play the MSNE “as if” they had calculated it, with 0 out of 66 strategies being the ones prescribed by the solution concept.

Table 2. *Percentage of mixed strategies played as prescribed by the MSNE*

	MSNE	MSNE (~ 0.05)
RPS-1	0	4%
RPS-2	0	0
RPS-3 - Player 1	0	9%
RPS-3 - Player 2	0	0
Total	0	3%

*RPS-1, RPS-2: 22 strategies; RPS-3 – Player 1, RPS-3 – Player 2: 11 strategies; Total: 66 strategies.

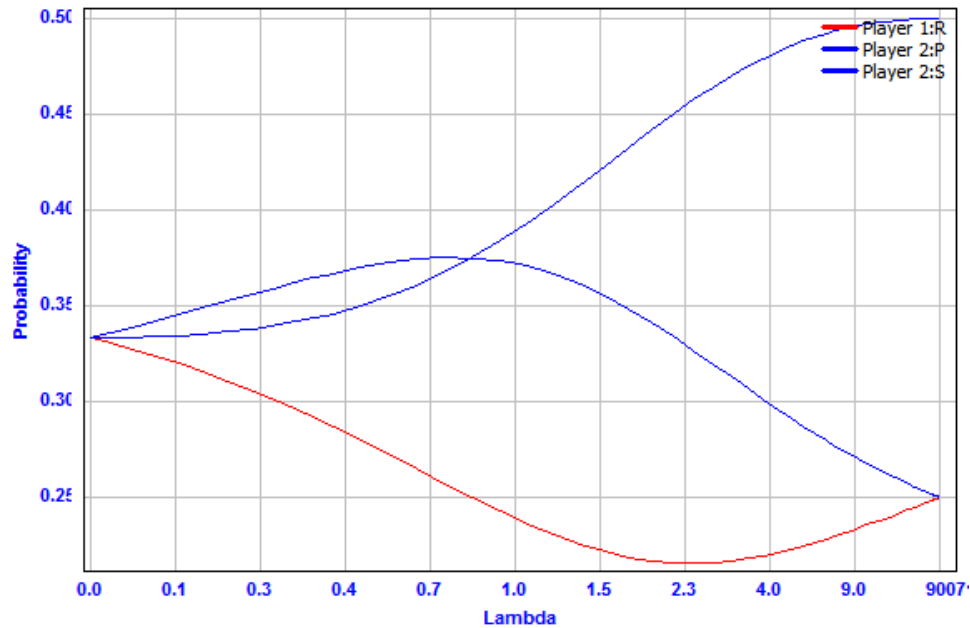
Source: Author.

Even if in order to correct for the small number of rounds played between the subjects we allow a perturbation around the probability percentages for each strategy (caused by an abrupt ending of the game) we still only find that 3% of strategies were consistent with the MSNE within 0.05 vicinity. These results are however clearly insufficient from my point of view to support the claim that individuals act either intentionally or “as if” with the purpose of reaching an MSNE.

6. Quantal Response Equilibrium performance in predicting strategy choices

6.1. QRE predictive power in RPS-1

Figure 8. *Quantal Response Functions in RPS-1*⁽³¹⁾



Source: Author.

Since the QRE can take an entire array of values due to the fluctuation of its λ error parameter as opposed to the Mixed Strategy Nash Equilibrium which predicts a single value for each probability, the QRE will naturally perform at least as well as the MSNE in predicting individual strategies.

However, it is not my only intention to see if the QRE significantly outperforms the MSNE solution, but also to see if the QRE solution is able to adequately capture individual decision-making in the RPS games on its own. Figure 8 plots the quantal response functions according to the error parameter λ . As I mentioned in the previous section, as λ increases from 0 to $+\infty$, i.e. the probability of making an error is decreasing, the Quantal response function moves from random probability assignments to probability assignments which converge upon the prescriptions of the MSNE. Since the game is symmetrical, both Player 1 and Player 2 have the same quantal response functions. In Figure 8, the red convex function represents $P(r)$, the blue concave function converging to 0.25 represents $P(p)$ and the blue concave function converging toward 0.5 represents $P(s)$.

Table 3. Percentage of strategies included in the set of possible QRE for RPS-1

	Minimum	Maximum	% of pure strategies included (in only 1 set)	% of mixed strategies included (in all 3 sets)
$P(r)$	0.21	0.33	54%	31.81%
$P(p)$	0.25	0.37	45%	
$P(s)$	0.33	0.5	50%	

Source: Author.

By examining Table 3 we immediately notice that only about half of the probabilities assigned by participants to each strategy in RPS-1 would be included in the set of possible QRE. Still, considering the fact that the set only expands for 13% (for $P(r)$ and $P(p)$) and 17% (for $P(s)$) of the entire probability domain, it would be reasonable to conclude that the quantal response functions have indeed some explanatory power regarding the strategies of individuals, especially since almost a third of the mixed strategies are fully included in the sets. However, in order to conclude that the QRE itself has any explanatory power, we need to see not only if the pure strategies separately belong to the QRE set, but if all three strategies correspond to the same level of λ since in a normal interpretation of the parameter it must be considered as a trait of the individual not the strategy. The λ parameter therefore must be fixed for every mixed strategies. But is this the case here? Table 4 shows the λ parameter estimates for the probability of playing each pure strategy for the 7 mixed strategies which are in the QRE set, with λ being estimated for both the actual value and a vicinity of 0.05 which tries to correct, as in the previous section, for any negative side-effects of the short number of rounds, accepting a ± 1 error for any pure strategy.

Following this procedure we notice that for 6 of the 7 mixed strategies it is possible for the λ to be unique while for the 6th strategy this is impossible since the three sets $\lambda P(r) \sim 0.05$ and $\lambda P(p) \sim 0.05$ do not have any common elements.

I will subsequently call all strategies within the QRE set which cannot possibly have a unique error parameter λ – *unfeasible* and all strategies within the QRE set for which we cannot state with certainty that there isn't a unique λ for the mixed strategy, λ – *feasible*.

Table 4. λ estimates for mixed strategies within the QRE set for RPS-1

Nr.	$P(r)$	$\lambda P(r) \sim 0.05$	$P(p)$	$\lambda P(p) \sim 0.05$	$P(s)$	$\lambda P(s) \sim 0.05$	$\cup$
1	0.29	0-0.71	0.33	0-4.72	0.37	0-1.35	0-0.71
2	0.25	0.28-3.81	0.33	0-4.72	0.41	0.81-2.45	0.81-2.45
3	0.25	0.28-3.81	0.37	0-2.18	0.37	0-1.35	0.28-1.35
4	0.29	0-0.71	0.29	0-0.05; 2.18- $+\infty$	0.37	0-1.35	0-0.05
5	0.25	0.28-3.81	0.37	0-2.18	0.37	0-1.35	0.28-1.35
6	0.29	0-0.71	0.25	4.24- $+\infty$	0.45	1.35- $+\infty$	$\emptyset$
7	0.29	0-0.71	0.33	0-4.72	0.37	0-1.35	0-0.71

Source: Author.

Proposition 1: *In any normal-form game, a mixed strategy $\sigma_i(s_i)$ can only determine a Quantal Response Equilibrium if it is λ – feasible .*

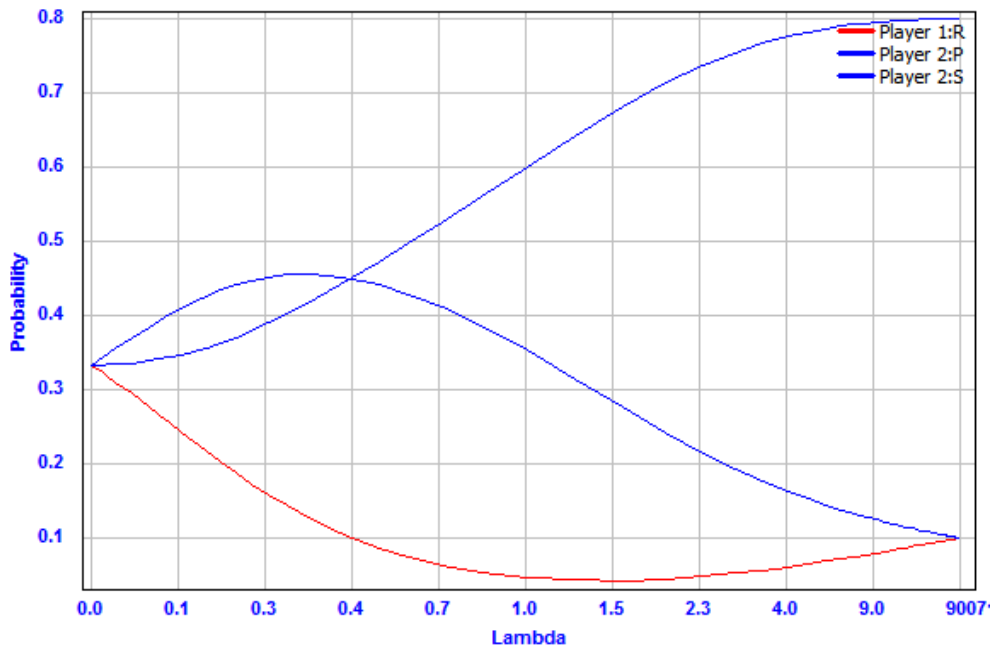
Corollary 1: *In any normal-form game, a random strategy is always λ – feasible .*

Corollary 1 naturally results from Proposition 1 since the random strategy, i.e. the mixed strategy which plays every pure strategy with an equal probability has a unique λ , as $\lambda = 0$.

In RPS-1 there are 6 strategies which are in the QRE set and are λ – feasible , a percentage of **27.27%** of total strategies.

6.2. QRE predictive power in RPS-2

Figure 9. *Quantal Response Functions in RPS-2*



Source: Author.

Figure 9 plots the quantal response functions for RPS-2. Like in the previous case, due to symmetry there are only 3 functions described. The convex function drawn in red corresponds to the $P(r)$ strategy, the concave function which converges to 0.1 corresponds to the $P(p)$ strategy and the blue concave function which converges to 0.8 represents the $P(s)$ strategy.

Table 5. Percentage of strategies included in the set of possible QRE for RPS-2

	Minimum	Maximum	% of pure strategies included (in only 1 set)	% of mixed strategies included (in all 3 sets)
$P(r)$	0.04	0.33	72%	31.81%
$P(p)$	0.1	0.45	68%	
$P(s)$	0.33	0.8	54%	

Source: Author.

Although the percentage of pure strategies included within the QRE set for RPS-2 is somewhat greater than that for RPS-1, especially since in this case the Quantal response functions encompass a wider area of the co-domain (29% as opposed to 13%, 44% as opposed to 13% and 47% as opposed to 17%), the number of mixed strategies included in the QRE set is identical, namely 7 strategies or 31.81% of the total.

Just as in the case of RPS-1 we proceed to eliminate any possible mixed strategies which are λ – *unfeasible*.

Table 6. λ estimates for mixed strategies within the QRE set for RPS-2

Nr.	$P(r)$	$\lambda P(r) \sim 0.05$	$P(p)$	$\lambda P(p) \sim 0.05$	$P(s)$	$\lambda P(s) \sim 0.05$	$\cup$
1	0.2	0.09-0.22	0.45	0.13-0.67	0.33	0-0.22	0.13-0.22
2	0.33	0-0.04	0.16	2.86-10.6	0.5	0.43-0.67	$\emptyset$
3	0.04	0.49-21	0.45	0.13-0.67	0.5	0.43-0.67	0.49-0.67
4	0.12	0.25-0.49; 9- $+\infty$	0.25	1.57-2.38	0.62	1-1.25	$\emptyset$
5	0.25	0.04-0.17	0.29	1.25-1.57	0.45	0.32-0.57	$\emptyset$
6	0.16	0.17-0.32	0.33	0-0.05; 1-1.25	0.5	0.43-0.67	$\emptyset$
7	0.33	0-0.4	0.16	2.86-10.6	0.5	0.43-0.67	$\emptyset$

Source: Author.

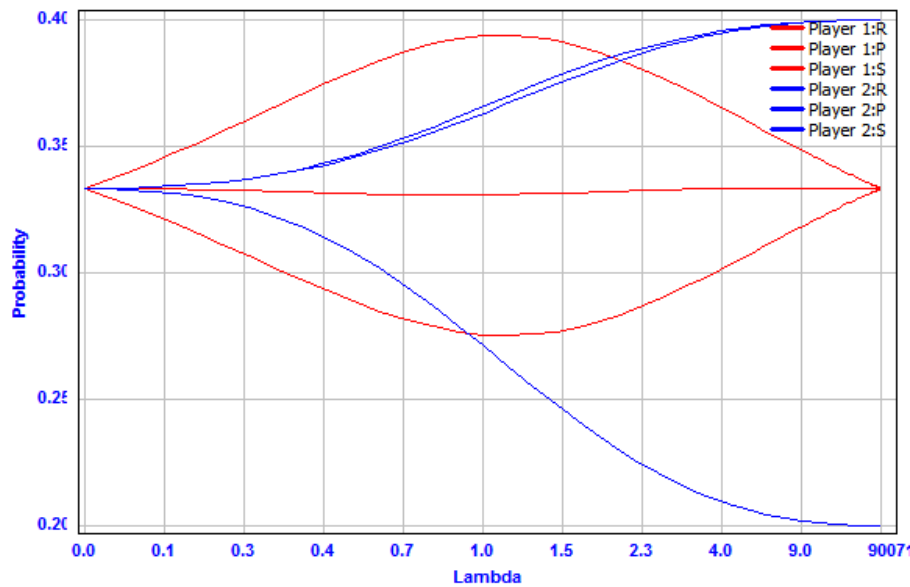
By looking at the last column of Table 6 we can notice that although there are 7 mixed strategies in the QRE set, five of them could never have a unique error parameter and are eliminate as being λ – *unfeasible*. From the total set of 22 strategies analyzed, we can therefore conclude that only 2, a mere **9.09%** are in the QRE set and are λ – *feasible*.

6.3. QRE predictive power in RPS-3

Figure 10 plots the quantal response functions for RPS-3. Due to the fact that the game is asymmetrical, we have all 6 quantal response functions plotted for this game. The red functions correspond to Player 1 with the concave function representing $P(r)$, the convex function $P(p)$ and the function which is almost horizontal function $P(s)$. In regard to Player 2, the two functions which converge

towards 0.4 are the $P(r)$ and $P(p)$ strategies, with the latter placed slightly above and the downward sloping function representing $P(s)$.

Figure 10. *Quantal Response Functions in RPS-3*



Source: Author.

Table 7 describes the percentage of strategies included in the set of possible QRE. As seen from Figure 10, the functions spread out over a very small area of the co-domain, unlike the graphs in RPS-1 and especially RPS-2. This is problematic for the QRE solution because it severely limits the possibility that even pure strategies can be a part of the QRE set.

For Player 1 the functions are particularly restrictive since the fact that strategy s has a minimum and maximum likelihood to be played of exactly 0.33 means that the requirements for the existence of a QRE are resembling the requirements imposed by the Nash Equilibrium.

Table 7. *Percentage of strategies included in the set of possible QRE for RPS-3*

	Minimum	Maximum	% of pure strategies included (in only 1 set)	% of mixed strategies included (in all 3 sets)
$P_1(r)$	0.33	0.39	9%	4.54%
$P_1(p)$	0.27	0.33	18%	
$P_1(s)$	0.33	0.33	9%	
$P_2(r)$	0.33	0.4	9%	
$P_2(p)$	0.33	0.4	27%	
$P_2(s)$	0.2	0.33	27%	

Source: Author.

As we can see from Table 7 there is only one single mixed strategy which is a part of all three QRE sets, i.e. the mixed strategy in which all pure strategies are played with the same probability. Following corollary 1, we note that the strategy is λ -feasible since the choice is completely random $\lambda = 0$ and therefore the union of the subsets cannot be void. To maintain uniformity I still detail the subsets in Table 8 however.

Table 8. λ estimates for mixed strategies within the QRE set for RPS-2

Nr.	$P(r)$	$\lambda P(r) \sim 0.05$	$P(p)$	$\lambda P(p) \sim 0.05$	$P(s)$	$\lambda P(s) \sim 0.05$	$\cup$
1	0.33	0-0.31	0.33	0-0.31	0.33	0-0.16	0-0.16

Source: Author.

The consistency between individual choices and the QRE is even lower in this game than in RPS-2. In fact, in RPS-3, the Quantal Response Equilibrium manages to explain a single strategy, which incidentally is also the strategy of randomization.

6.4. Section conclusions

In spite of its critical acclaim which began ever since it was developed by McKelvey and Palfrey in (1995) and continues up until the present time, the Quantal Response Equilibrium does not appear to be a useful solution for 3×3 games in general, or at least for variations of the RPS game. Although registering some very mild success in explaining the behavior of participants in RPS-1, where it correctly framed 27.27% of the mixed strategies used by participants, in RPS-2 it only managed to explain 9.09% of the mixed strategies used and in RPS-3 only 4.54%, which is equivalent to the Nash Equilibrium prediction.

The experiment has shown that the QRE faces at least two major problems when increasing the number of players from two to three, problems which will only amplify as the number of players is further increased. The first problem regards what I have termed the issue of λ -feasibility, namely the fact that the QRE is predicated on the fact that there exists a unique λ per player per round. Although the parameter can change over time as the game progresses and different players can have different λ 's in the same round, it is impossible for the same individual to have two different error parameters during the same round. The problem is amplified with the increase in the number of strategies since in order for a mixed strategy to determine a QRE, all pure strategies played must be in the QRE set and the mixed strategy itself must be λ -feasible, i.e. to have a non-empty subset of elements after the union of all sets of λ estimates. This first problem was visible

in particular in RPS-2 where 5 out of the 7 mixed strategies within the QRE set were eliminated for being λ -unfeasible. The second problem regards the possibility that the quantal response functions cover only a narrow area of the co-domain, a possibility which, *ceteris paribus*, increases with the addition of new strategies. An example in this respect is the problem with the narrowness of the functions in RPS-3, especially the function for $P(s)$ of Player 1 which was identical to the Nash Equilibrium prescription.

7. Conclusions and limitations

In this paper I have comparatively tested the classical solution concept within game theory, i.e. the Mixed Strategy Nash Equilibrium, with one of its main contemporary challengers, namely the Quantal Response Equilibrium, seeking to find out if the latter significantly outperforms the former in experimental cases. In order to achieve this objective I conducted an experiment on 22 subjects (all of them students belonging to various universities in Bucharest) by using 3 modified versions of the RPS game, with 759 rounds of the game played in total.

The results of the experiments show that the QRE does not perform substantially better than the Nash Equilibrium for two of the three games studied and that it does represent a slight improvement in one of the games, where it manages to accurately predict the behavior of players in 27% of cases as opposed to the MSNE which only manages to do it in 4% of the cases. This result lies in stark contrast to the bulk of the literature developed thusfar on QRE which consistently promotes the idea that the QRE is not only a superior predictor of individual behavior than the MSNE (which is almost guaranteed by definition) but that it significantly outperforms the MSNE in every case. The results might also point to a decrease in the success of the QRE solution as the payoff structure becomes more complex, since it yielded the worst predictions in RPS-3.

Aside from the testing of this hypothesis, alongside the potentially relevant result which I have obtained in respect to the empirical difficulties of the QRE in games with more than two strategies, another important contribution could be the introduction of the QRE solution to the literature on political science and economy in Romania, since, to my knowledge, no article has been published in Romania thusfar on this subject.

However, the reader should also be aware of the limitations and drawbacks of this paper. First of all, the experiment was somewhat underdeveloped from both a human resources perspective (with only 22 participants) and from the perspective of the incentive scheme (with only 20 lei as a maximum reward). The number of turns was not communicated to the participants beforehand in order to avoid

potential end-game effects, which, might be raise other types of problems since even if players were trying to play the Mixed Strategy Nash Equilibrium, it could have been possible for them to be desynchronized in mixing strategies when the game ended abruptly⁽³²⁾.

In spite of potential shortcomings, however, the experimental results obtained are relevant for the game theoretical literature, since the weak performance of the QRE solution depicted in this paper may be a signal to reconsider the displacement of traditional solution concepts from game theory with innovative, but less falsifiable, solution concepts imported from other scientific fields, which in many circumstances fail to significantly add to our understanding of human behavior.

Notes

- ⁽¹⁾ I would like to thank Adrian Miroiu for comments on a previous draft of this paper and for his support in the implementation phase of the experiment. I am also grateful to Andra Roescu and Mihai Ungureanu for discussions on some of the aspects of the paper, in particular for their inputs concerning the experimental design. The standard caveat applies.
- ⁽²⁾ Alexandru Volacu is a beneficiary of the Sectoral Operational Programme for Human Resources Development 2007-2013, co-financed by the European Social Fund, under the project number POSDRU/159/1.5/S/134650 with the title "Doctoral and Postdoctoral Fellowships for young researchers in the fields of Political, Administrative and Communication Sciences and Sociology".
- ⁽³⁾ For a brief introduction into the main concepts of game theory see Volacu (2014, pp.109-125) and for a more comprehensive one see McCarty and Meirowitz (2007).
- ⁽⁴⁾ Henceforth QRE.
- ⁽⁵⁾ These details are broadly explained in section 2.
- ⁽⁶⁾ Henceforth MSNE.
- ⁽⁷⁾ As in the case of the Stag Hunt for instance (see for instance Skyrms and Irvine: 2001).
- ⁽⁸⁾ I use McCarty and Meirowitz's (2007) notation system.
- ⁽⁹⁾ While it is not the case that every finite game has a Nash Equilibrium, every finite game *does* have a Mixed Strategy Nash Equilibrium
- ⁽¹⁰⁾ McKelvey and Palfrey state that the name "is borrowed from the statistical literature on quantal choice/response models in which individual choices or responses are rational, but are based on latent variables [...] that are not observed by the econometrician" (McKelvey, Palfrey: 1995, p.7). The concept of quantal (or discrete) choice is originally introduced by McFadden (1976) to contrast with the typical quantitative choice modelling of standard economic models.
- ⁽¹¹⁾ Although three games were played using 6 rounds instead of 4.
- ⁽¹²⁾ The MSNE prediction for the choice of s_1 by player 2 fared no better, with s_1 being chosen at a level of over 0.3 for both games although the MSNE predicted it to be played with probability of 0.1 for the second game and 0.2 for the third one.
- ⁽¹³⁾ And for extensive-form games by McKelvey and Palfrey (1998).
- ⁽¹⁴⁾ For a formal characterization see McKelvey and Palfrey (1995, pp. 8-10).

- ⁽¹⁵⁾ Simon (1947 [1976]) introduces the concept of *bounded rationality*, which places limits on both an individual's "ability to perform" and on his "ability to make correct decisions" (Simon: 1947 [1976], p.39). His main project is to "replace the global rationality of economic man with a kind of rational behavior that is compatible with the access to information and computational capacities that are actually possessed by organisms, including man, in the kinds of environments in which such organisms exist" (Simon, 1955, p. 99).
- ⁽¹⁶⁾ To the extent that it is sometimes "referred to as a boundedly rational version of Nash Equilibrium" (Palfrey, 2007, p. 425).
- ⁽¹⁷⁾ I use Goeree et al. (2005) notation.
- ⁽¹⁸⁾ Existence of a QRE in any game is proven by McKelvey and Palfrey (1995, p. 10).
- ⁽¹⁹⁾ Henceforth RPS.
- ⁽²⁰⁾ The widespread familiarity with the game was also confirmed by the experiment presented in this paper, where 100% of the participants stated that they knew how the standard game is played before receiving the explanations for the particular games of the experiment.
- ⁽²¹⁾ Although the game is not very widely discussed in game theory, the history of its study is quite long, as it appears in von Neumann and Morgenstern's (1944) paradigmatic work and is commonly used nowadays in introductory game theoretical courses on mixed strategy equilibria.
- ⁽²²⁾ To my knowledge, Shapley (1963) proves the cycling result for 3x3 games such as RPS for the first time. He states that "rather than converging to the unique equilibrium point (at which all probabilities are equal), the sequence of mixed-strategy pairs generated by the algorithm oscillates around it, keeping a finite distance away" (Shapley: 1963, p.2). On the problem of cyclicity in RPS games see also Xu et al. (2013), who experimentally show that the cycling result observed via evolutionary game theory (and specifically using the replicator dynamics equation) is empirically superior to the MSNE of classical game theory which predicts random behavior for the classical RPS.
- ⁽²³⁾ And it can be applied analogously.
- ⁽²⁴⁾ Anecdotal evidence suggest that the proportion of tied rounds in standard RPS games between players who were previously acquainted is higher than normal. This is not confirmed for the one pair in which due to logistical issues the players knew each other before the game as the percentage of rounds which ended in ties during their three games was only 34% in comparison with the 37% average for the other 10 pairs. Thus, it cannot be stated that the prior acquaintance between players, *in this particular case*, had any negative side-effects of the type mentioned above.
- ⁽²⁵⁾ By convention, it was decided that the winner of the round would become Player 1.
- ⁽²⁶⁾ The standard conventions applied: a closed fist for *rock*, an open palm for *paper* and two pointing fingers for *scissors*.
- ⁽²⁷⁾ It was my initial intention not to have players physically play the game but only to chart their options down on a sheet of paper during each round in order to avoid. Mihai Ungureanu however pointed an interesting issue to me regarding the possibility that the actions of the players may be influenced by social factors such as the direct interaction between them and taking out these factors might distort the experimental results in some way. Since the sample size of the experiment was decidedly low, it was not possible to test for differences between the two types of mechanisms, therefore this issue remains opened for future research.
- ⁽²⁸⁾ Which was available to them at all stages, as the choices on each rounds were written on their Experiment forms.
- ⁽²⁹⁾ By providing the players with a detailed history of the game at each of its rounds we cancelled any possible noise attributed to mistakes in estimating the frequency of each strategy throughout the game history.
- ⁽³⁰⁾ I thank Andra Roescu for her useful suggestion in this respect.

- ⁽³¹⁾ In order to construct Figures 8-10 I used the Gambit software (McKelvey et al., 2014).
- ⁽³²⁾ However, since the experimental form contained no more than 26 rows and the number of turns was 24, 24 and 21, I do not consider that this had a significant effect on the results obtained.

References

- Aumann, R. (2000). "Game Theory", in *Collected Papers*, Vol. 1, MIT Press, Cambridge (Massachusetts), pp. 47-106
- Binmore, K., Gale, J., Samuelson, L. (1995). "Learning to be imperfect: The ultimatum game", *Games and Economic Behavior*, 8, pp. 56-90
- Goeree, J., Holt, C., Palfrey, T. (2005). "Regular Quantal Response Equilibrium", *Experimental Economics*, 8 (4), pp. 347-367
- Guth, W., Schmittberger, R., Schwarze, B. (1982). „An Experimental Analysis of Ultimatum Bargaining“, *Journal of Economic Behavior and Organization*, 3 (4), pp. 367-388
- Haile, P., Hortacsu, A., Kosenok, G. (2008). "On the Empirical Content of Quantal Response Equilibrium", *American Economic Review*, 98 (1), pp. 180-200
- McCarty, N., Meirowitz, A. (2007). *Political Game Theory: An Introduction*, Cambridge University Press, Cambridge
- McFadden, D. (1976). "Quantal Choice Analysis: A Survey", *Annals of Economic and Social Measurement*, 5 (4), pp. 363-390
- McKelvey, R., Palfrey, T. (1992). "An Experimental Study of the Centipede Game", *Econometrica*, 60 (4), pp. 803-836
- McKelvey, R., Palfrey, T. (1995). "Quantal Response Equilibria for Normal Form Games", *Games and Economic Behavior*, 10, pp. 6-38
- McKelvey, R., Palfrey, T. (1998). "Quantal Response Equilibrium for Extensive Form Games", *Experimental Economics*, 1(1), pp. 9-41
- McKelvey, R., McLennan, A., Turocy, T. (2014), Gambit: Software Tools for Game Theory, <http://www.gambit-project.org>
- Nash, J. (1950). "Equilibrium points in N-person games", *Proceedings of the National Academy of Sciences*, 36(1), pp. 48-49
- von Neumann, J. Morgenstern, O. (1953[1944]). *Theory of Games and Economic Behavior* (3rd Edition), Princeton University Press, Princeton
- Ochs, J. (1995). "Games with Unique, Mixed Strategy Equilibria: An Experimental Study", *Games and Economic Behavior*, 10, pp. 202-217
- Palfrey, T. (2007). "McKelvey and the Quantal Response Equilibrium", in Aldrich, Alt and Lupia (eds.), *Positive Changes in Political Science: The Legacy of Richard McKelvey's Most Influential Writings*, University of Michigan Press, Ann Arbor, pp. 425-440
- Shapley, L. (1963). "Some Topics in Two-Person Games", *RAND Corporation*, available online at <http://www.dtic.mil/dtic/tr/fulltext/u2/407345.pdf>, accessed on 20.06
- Skyrms, B., Irvine, U.C. (2001). "The Stag Hunt", *Proceedings and Addresses of the American Philosophical Association*, 75 (2), pp. 31-41
- Simon, H. (1947 [1976]). *Administrative Behavior*, Free Press, New York
- Simon, H., (1955). "A Behavioral Model of Rational Choice", *Quarterly Journal of Economics*, 69 (1), pp. 99-118
- Volacu, A. (2014). "Games and Cooperation", in Mihai Ungureanu (ed.), *Economic and Evolutionary Approaches in Social Sciences*, Wolters Kluwer, Bucharest, pp. 109-142
- Xu, B., Zhou, H.-J., Wang, Z. (2013). "Cycle frequency in standard Rock-Paper-Scissors games: Evidence from experimental economics", *ESA North American Conference 2013*