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Editor's Introduction to Volume 4, Issue 1 of Expert Journal of Economics

Simona VINEREAN*

Sprint Investify Research Unit

In our fourth year of publishing academic articles on economics, the first issue of volume 4 of *Expert Journal of Economics* includes studies on the law of one price and optimal consumption, existence of Ricardian or Non-Ricardian regimes for CIS countries, analysis of market economies from the perspective of information production, policy, and self-organized equilibrium, and the impact of certain financial ratios on the development of Poland's stock exchange. Further, I present a short description of each article published in *Expert Journal of Economics*, vol. 4, issue 1.

The first article of this issue, namely *'Law of One Price and Optimal Consumption-Leisure Choice Under Price Dispersion'*, authored by Sergey Malakhov, concludes that the analysis of propensity to search, that optimizes satisficing purchasing decisions, shows that the "law of one price" is valid in an imperfect homogenous market if there are consumers with zero search costs. The Author also addresses the issue of the equilibrium price level, that does does not eliminate price dispersion, because consumers have different willingness to pay and they meet heterogeneous sellers. When sellers encounter a zero-search-costs demand, a new market is organized. Sergey Malakhov also proposes new interesting avenues for future research related to the heterogeneity of sellers, which is not entirely covered by the re-allocation of transaction costs from producers to consumers.

Gulcin Guresci Pehlivan and Esra Balli published their article entitled *'Testing the Existence of Ricardian or Non-Ricardian Regimes for CIS Countries'*, which emphasizes the importance of determining the dominant fiscal regime in a country group for policy prevision. More specifically, this empirical paper examines whether the Ricardian fiscal regime or non-Ricardian fiscal regime is dominant in the Common Wealth of Independent States (CIS), and concludes that Ricardian regime dominates in Kyrgyz Republic, Russian Federation, Tajikistan, Uzbekistan, Moldova and Turkmenistan's fiscal policies. Their findings indicate that these countries attempt to decrease their debt to GDP ratio by obtaining a surplus in the budgets.

In *'Analyzing Market Economies from the Perspective of Information Production, Policy, and Self-Organized Equilibrium'*, C-René Dominique argues that modern market economies should be viewed as complex social constructs designed to facilitate exchanges. In this framework, the Author provides theoretical contributions by establishing a quadratic map to showcase a spectrum of equilibria of albeit dissipative dynamic systems. This paper also emphasizes the essential role of policy and stable equilibria, while examining the role of self-organized equilibria in the assessment of the information produced by a chaotic system.

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In *'Is the Development of WIG Index Determined by Certain Macroeconomic and Financial Factors?'*, Krzysztof Drachal uses quarterly data from the Warsaw Stock Exchange to form an empirical analysis and test the impact of certain macroeconomic and financial factors within a linear regression framework on the development of a stock exchange.

A Final Thought

On behalf of our Editorial Board, I would like to extend our appreciation to our Authors for choosing Expert Journal of Economics as their scientific publishing outlet, to our Reviewers for their involvement and their input on the articles published in this issue, and to all the Readers and Researchers for downloading, citing, and expanding on the theoretical and empirical economics articles we publish.

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Law of One Price and Optimal Consumption-Leisure Choice Under Price Dispersion

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In memory of Gulya – my wife, friend, and colleague

If the demand under price dispersion is formed by consumers with zero search costs and consumers with positive search costs, the law of one price holds at the equilibrium price level, where the lowest willingness to pay between consumers with zero search costs meets the willingness to accept or to sell of consumers with positive search costs. Consumers with positive search costs maximize their utility with respect to their optimal decisions when marginal losses in labor income during the search are equal to marginal savings on purchase. Optimal decisions move their willingness to accept to the equilibrium price level. Suboptimal decisions of consumers with positive search costs result in willingness to accept below the lowest willingness to pay of consumers with zero search costs and arbitrage takes place. Arbitrage drops down the equilibrium price to the level where willingness to accept of consumers with positive search costs meets the new lowest willingness to pay of consumers with zero search costs and where purchasing decisions of consumers with positive search costs become optimal.

***Keywords**: propensity to search, propensity to produce at home, consumption-leisure choice, Veblen effect*

***JEL Classification:** D11, D83*

1. Introduction

During last decades the problem of price dispersion has become one of the most intriguing issues of modern economics (Adams (1997), Burdett and Judd (1983), Carlson and McAfee (1983), Diamond (1971, 1987), Fishman (1992), Janssen and Moraga-González (2004), Janssen, Moraga-González, and Wildenbeest (2005), Lach (2002), Manning (1997), Pratt, Wise, and Zeckhauser (1979), Reinsdorf (1994), Rosenthal (1980), Rothschild (1974), Salop and Stiglitz (1977, 1982), Stahl (1989), Stigler (1961), Stiglitz (1979), Varian (1980)). In 1994, J. McMillan and M. Rothschild summarized the growing interest to the question of price dispersion in the "Handbook of Game Theory". In 2006 M.R. Baye, J. Morgan and P. Scholten presented the comprehensive overview of that problem for "Economics and Information Systems" where they introduced that phenomenon with the proposition that empirical studies had revealed the fact that price dispersion was the rule rather than the exception in many homogeneous product markets. In addition, the authors strengthened

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their opinion by very famous statement: "Economists have belatedly come to recognize that the "law of one price" is no law at all" (Varian 1980, p.651).

The persistence of price dispersion that cannot be eliminated by arbitrage is explained by many economic and institutional factors where the consumers' heterogeneity is one of the most important reasons for stable price differences. Usually analytical approaches to consumers' heterogeneity envisage two groups of consumers. There are consumers that do not search, i.e., price-takers, and there are consumers that search for low price: "Some consumers have zero search costs, while all others have a positive search cost" (Stahl, 1989, p.700). The model of the optimal consumption-leisure choice under price dispersion (Malakhov, 2013, 2014a, 2014b, 2014c, 2015) also uses this dual approach. Examining *shoppers* with zero search costs and *searchers* with positive search costs, the model proposes some additional reasoning to the question whether Walras' law holds or not under price dispersion in homogeneous product markets.

The model of the optimal consumption-leisure choice under price dispersion argues that market transforms everyday satisficing buying decisions into optimal consumption-leisure choices that equalize marginal costs of search with its marginal benefits. The model describes the analytical framework that demonstrates why an explicit satisficing decision becomes optimal. Observing behavior of *searchers*, this paper specifies the role of optimization of search costs in the establishment of the equilibrium price level.

2. Willingness to Pay, Equilibrium Price, and Willingness to Accept

The optimal consumer choice under price dispersion represents the result of the trade-off between consumption and leisure with respect to two constraints – the wage rate w and marginal savings on purchase, i.e., the price reduction with regard to the time of search S at the moment of purchase $\partial P/\partial S<0$. The trade-off between consumption Q and leisure H is provided by the propensity to search $\partial L/\partial S<0$, i.e., the propensity to substitute labor L for search as for another source of income. When the problem of the maximization of consumption-leisure utility $U(Q,H)$ is constrained by the equality of marginal values of search $w\partial L/\partial S=Q\partial P/\partial S$, where the left side of the equation represents the value of marginal loss in labor income during the search and the right side represents the value of marginal benefit of search, the marginal rate of substitution of leisure for consumption takes the following form (1):

$$\frac{\partial U/\partial H}{\partial U/\partial Q}=-\frac{w}{\partial P/\partial S}\partial^2 L/\partial S\partial H \quad (1)$$

The analysis of the propensity to search discovers the time-based structure of this apparently complex psychological variable with respect to the time horizon $T=L+S+H$ of the consumption-leisure choice (Malakhov, 2013, 2015):

$$w\frac{\partial L}{\partial S}=-w\frac{L+S}{T} \quad (2)$$

And the derivative of the propensity to search with respect to leisure time simplifies the presentation of the *MRS(H for Q)*:

$$-\frac{L+S}{T}=\frac{H-T}{T}\Rightarrow \partial^2 L/\partial S\partial H=\frac{1}{T} \quad (3)$$

$$\frac{\partial U/\partial H}{\partial U/\partial Q}=-\frac{w}{T\partial P/\partial S} \quad (4)$$

And we see that this consideration gives us another form of the constraint for the utility maximization problem:

$$w\frac{\partial L}{\partial S}=Q\frac{\partial P}{\partial S}\Rightarrow w(L+S)=-TQ\partial P/\partial S \quad (5)$$

The static maximization problem simply requires the equality of marginal values of search $w\partial L/\partial S=Q\partial P/\partial S$. It tells us that any optimal choice should respect this equality. However, a common consumer choice usually represents the result of some dynamic sequential search for the predetermined quantity Q. The search starts at the reservation level or the willingness to pay wL_0 and goes along the dispersion of prices that produce different marginal savings on purchase $\partial P/\partial S$. And the final decision, for example, the choice of the first quote below the reservation level of labor income $wL<wL_0$, that could be spent and restored by labor after the purchase, represents the choice of the price of purchase $P_P=wL$ for the given quantity Q with corresponding marginal savings $Q\partial P/\partial S$. If we follow step by step a common purchasing decision, it gives us the following picture (Figure 1):

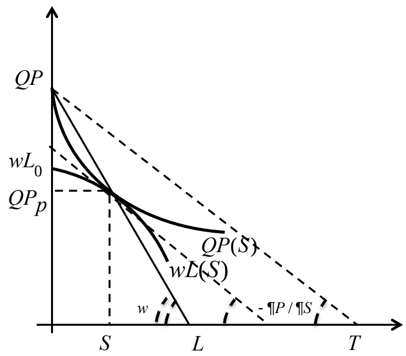

Figure 1. *Satisficing optimal decision*

We see the graphical presentation of consumer decision develops Equations 4 and 5. It gives us some price P at the zero-search-costs level. And this price is greater than the willingness to pay $WTP=wL_0$.

To understand better this hypothetical price let us take home production, say, preparing a meal, as a particular form of search where the purchase price is equal to the price of inputs for home production6 here meal's ingredients, or $QP_p=wL$, and costs of production are equal to their opportunity costs, or to the wS value. The model presented here simplifies the vision of the allocation of time. While it takes into account only labor, leisure, and search, the $\partial L/\partial S<0$ rule takes the search as any form of activity that reduces price of purchase. However this simplification doesn't look methodologically inconsistent because even the detailed analysis of the allocation of time can assume that "the price of time (is) the same for the shopper and for the home producer" (Aguiar and Hurst 2007, p.1536). And that "price of time" here really "does not necessarily equal a market wage (ibid.). Being compared with marginal savings on purchase, or $\mu=Q\partial P/\partial S$, it gives us $\mu=w\partial L/\partial S$. And the value of total costs $w(L+S)$ should give us the price of the prepared meal, or $w(L+S)=QP$. This assumption gives us an understanding that the value of our hypothetical price P at the zero-search-costs level is equal to the ***willingness to accept or to sell*** the prepared meal. The same thing happens when a consumer decides at what price he should sell the item that has been found and bought. If a consumer decides to sell this item he should recover not only labor costs wL but also search costs wS. Hence, the marginal rate of substitution of searcher's consumption to his leisure takes the final form:

$$\frac{\P U/\P H}{\P U/\P Q} = -\frac{w}{\P P/\P S}\P^2 L/\P S\P H = -\frac{w}{T\P P\P S} = \frac{w}{P} \quad (6)$$

However, searchers are not willing to pay this price and they start the search with the reservation level wL_0. Who can pay this price? Obviously, there are consumers that are not interesting in search. Really, zero search costs don't mean that consumers have not the propensity to search at all. Equation (2) simply takes the following form:

$$w\frac{\P L}{\P S} = -w\frac{L}{T} \quad (7)$$

The search is not interesting for *shoppers* because at this price level, where all *shoppers* are still *price-takers* and therefore *price-reduction-takers*, the search, let's take for illustrative simplicity a single unit purchase, produces absolute marginal savings that are not greater then absolute marginal losses in labor income, or:

$$\left|-w\frac{L}{T}\right| \geq \left|\frac{\partial P}{\partial S}\right| (8)$$

It means that the zero-search-costs level collects all buyers with willingness to pay higher or equal to the price that represents the full attractiveness of an item. However, the inequality of marginal values of search is not stable. *Shoppers* with very high wage rate need less time to restore their cash balances and they reduce the expected time-horizon. The cut in the expected time horizon by saving in labor time decreases the absolute value of propensity to search (Figure 2):

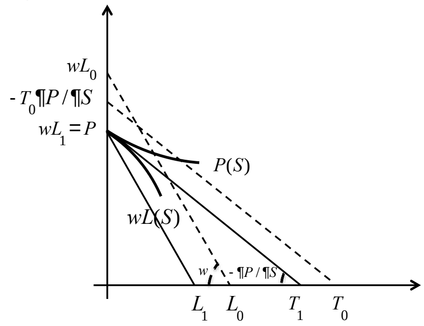

Figure 2. *Adjustment of high WTP*

$$wL_0 >> P; \left| w\frac{L_0}{T_0} \right| > \left| \frac{\partial P}{\partial S} \right| \Rightarrow wL_0 > -T_0\frac{\partial P}{\partial S};$$
$$L_1 < L_0; T_1 = T_0 - dL;$$
$$\left| w\frac{L_1}{T_1} \right| = \left| \frac{\partial P}{\partial S} \right| \Rightarrow wL_1 = P = -T_1\frac{\partial P}{\partial S} (9)$$

The process of adjustment of time horizon of consumers with different high willingness to pay eliminates the inequality of marginal values of search in Equation (8) and all consumers with high willingness to pay equalize their marginal losses in labor income with marginal savings at this price level:

$$w_a L_a = w_b L_b = ... = w_n L_n = -T\partial P / \partial S = P \Rightarrow \frac{\partial P}{\partial S} = w_n \frac{L_n}{T} (10)$$

However, when the value of price reduction is given, we see that at this price level market adjusts different perceptions of time horizons and makes itself really homogenous with the unique time horizon.

The existence of that unique or the ***equilibrium time horizon*** explains why economics prefers to envisage a calendar time horizon – a day, a week, a year. When markets are perfect and search costs are equal to zero, it is rational to compare consumers on the basis of some calendar period. However, consumers take into account another consideration. They esteem time horizon as the ***period from one purchase to another***. This period might correspond to the calendar and might be shorter or longer – two-three days, a couple of weeks, or some years. We will see that consumers with positive search costs have different time horizons. The equilibrium time horizon exists only for consumers with zero search costs because it corresponds to ***the level of equilibrium price***. If we do not take into account for the moment the existence of upper price niche where consumers with high willingness to pay, suffering from the “snob effect” at the equilibrium price level, can search and make ambitious purchases, we can say that the equilibrium price level is equal to the lowest willingness to pay between high-income consumers with zero search costs.

For the moment, these considerations follow the assumption that “the price in the high-price stores is the reservation price of shoppers with high willingness to pay, not their maximum willingness to pay for the good” (Diamond 1987, p.434). However, the possibility to adjust time horizon attracts to this price level or to the high-price store also some low-income consumers. Impatient low-income consumers can compensate at this price level the low wage rate by high propensity to search that results in earlier and more intensive consumption. The acceleration of consumption changes the time horizon. And impatient low-income consumers should accept not only the equilibrium price but also the equilibrium time horizon, which is shorter than the time horizon of their easy-going low-income neighbors. The reduction in the time horizon transforms the initial inequality of marginal values of search that encourages easy-going low-income consumers to search, into the optimal equation for their impatient low-income neighbors that eliminates the need to look or to wait for low price:

$$\left| w\frac{\partial L}{\partial S} \right| < \left| \frac{\partial P}{\partial S} \right|; -w\frac{L}{T_0} < \frac{\partial P}{\partial S}; T_1 < T_0; -w\frac{L}{T_1} = \frac{\partial P}{\partial S} \quad (11)$$

In fact, the famous example of tourists, looking for a restaurant (Salop and Stiglitz 1977), can be revised under this assumption of impatience. Even low-income tourists don't want to waste time, they choose the restaurant for a lunch on their way, and in the evening they become hungry earlier and they are ready to take a dinner.

Generally, low-income consumers do not accept the equilibrium price level, which is appropriate for their high-income friends or low-income impatient neighbors. Easy-going low-income consumers can take an advantage of their low wage rates and low propensity to search with respect to great marginal savings produced by the equilibrium price level. *Searchers* begin to look for low prices with regard to their willingness to pay. Of course, they esteem the total *aller-et-retour* time of search, i.e. the time to get in and out. Some of them search in out-of-town commercial centers and some of them at factories' outlets where purchase prices P_p are really different (P_a, P_b...P_n). However, ***wherever they make purchases their willingness to accept comes to the equilibrium price level*** (Figure 3):

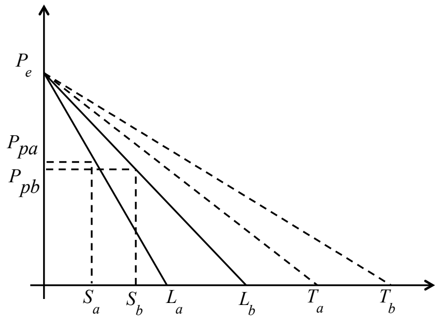

Figure 3. *Equilibrium price, purchase prices, and WTA of heterogeneous searchers*

$$w_a(L_a+S_a) = -T_a\partial P_a/\partial S_a = w_b(L_b+S_b) = -T_b\partial P_b/\partial S_b = \ldots = w_n(L_n+S_n) = -T_n\partial P_n/\partial S_n = P_e \quad (12)$$

Really, our hypothetical price P from Figure1 is equal to the equilibrium price P_e. It equalizes different costs of purchase $w(L+S)$ of heterogeneous consumers with positive search costs.

3. Arbitrage of Suboptimal Purchases

What happens when price dispersion is distorted and some prices don't result in corresponding marginal savings? This is the same thing that takes place when ***satisficing decision seems to be suboptimal***.

Generally, *searchers* begin to look for low prices when the search is interesting, or the marginal loss in labor income is less than the marginal saving:

$$\left| w\frac{\partial L}{\partial S} \right| < \left| \frac{\partial P}{\partial S} \right| \quad (13)$$

Let us suppose that the satisficing choice of the first quote below the reservation level ($\partial^2 L/\partial S^2<0$) stays suboptimal in accordance with Equation (13). However, if it is suboptimal, the *searchers*' willingness to accept or to sell stays below the equilibrium price level, more definitely, below the lowest zero-search-costs willingness to pay (Figure 4):

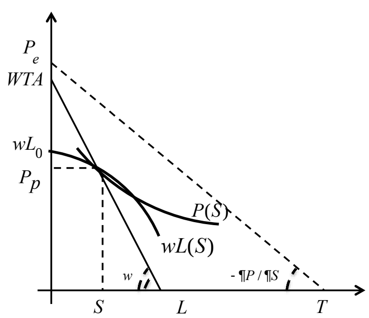

Figure 4. *Resale of suboptimal purchase*

$$\left| w\frac{\partial L}{\partial S} \right| < \left| \frac{\partial P}{\partial S} \right|; \left| -w\frac{L+S}{T} \right| < \left| \frac{\partial P}{\partial S} \right| \Rightarrow w(L+S) < -T\frac{\partial P}{\partial S} = P_e (14)$$

If it happens, ***searchers will sell their purchases to shoppers***. This extra supply drops the equilibrium zero-search-costs price level down to the level where arbitrage becomes unprofitable for *searchers*, i.e., to the level where they equalize marginal values of search, and, to its turn, this equality matches their willingness to accept with a new equilibrium price.

In addition, this new equilibrium price level reinforces the team of *shoppers* by newcomers from lower income bracket of *searchers* that makes the high-price store noisy and the equilibrium price level really becomes intolerable for snobs among *shoppers*.

The same effect takes place when a *searcher* finds an unexpected great discount, which results in unexpected low price. And, facing Equation (13), either the *searcher* adjusts the time horizon of his choice according to Equation (11), for example, due to shorten shelf-life of a product (Malakhov, 2014a), or he makes an arbitrage. Adjustments of time horizon, i.e., decision to cut or to extend products' lifecycles at the moment of purchase reduce possibilities of arbitrage. The analysis of the increase in the time horizon with the increase in quantity to be purchased when the quote is dissatisfying is presented in Malakhov (2014b). It means that we can expect resale to be a common economic phenomenon in markets with fixed time horizons where adjustments are not possible. And it really takes place in markets of tickets for events (Courty, 2003).

Hence, arbitrage and adjustment of time horizon transform suboptimal decisions of *searchers* into satisficing optimal choices. Finally, the equilibrium price level collects different willingness to accept of *searchers* with different wage rates and different propensities to search.

Thus, the equilibrium price is equal to the willingness to accept of *searchers*, which is equal to the lowest willingness to pay of *shoppers* with zero search costs and where *all individuals* equalize their marginal losses in labor income with their marginal savings on purchases.

This assumption takes us back to the classical optimal consumption-leisure choice:

$$\frac{\partial U/\partial H}{\partial U/\partial Q} = -\frac{w}{\partial P/\partial S}\partial^2 L/\partial S\partial H = -\frac{w}{T\partial P/\partial S} = \frac{w}{w(L+S)} = \frac{w}{P_e} \quad (15)$$

We see, that slight modifications in Stigler's revolutionary equation do not change the general economic sense of exchange. The "law of one price" holds in spite of persistent price dispersion. Consumers with positive search costs optimize their purchasing decisions that result in the corresponding marginal rate of substitution of leisure for consumption not with respect to the purchase price but with respect to the equilibrium price.

The detailed answer to the question, whether sellers agree with that conclusion or not, stays beyond the scope of this paper but it might be framed by some comments.

In the model presented here sellers meet different willingness to pay. They try to discriminate *shoppers* and to propose additional services to consumers with very high willingness to pay that could suffer from the "snob effect" at the equilibrium price level in order to separate them. The discrimination might be explicit when sales are made on high streets where consumers get a positive externality of prestige purchases, or implicit, like it happens in web 'clearinghouses' where a set of different prices does not exhibit the total sellers' heterogeneity. However, *searchers* can adjust their propensity to search to different quotes when they reconsider time horizons of their purchases with regard to seller's reputation, post-purchase services, etc. When this uncertainty begins to worry *shoppers* they become *searchers*. They either begin to investigate seller's reputation, or they look for a new market with more guarantees. The appearance of stable upper price niche, i.e., ***the organization of a new market***, does not change the logic of consumers' decision-making. The search model presented here slightly decorates a Walrasian market. ***The stable upper price niche can be considered as a new market if it creates a new group of zero-search-costs consumers.*** If such a group appears, other consumers with high willingness to pay become *searchers* and they either make satisficing optimal purchases when they search for prestigious items, or their purchases are suboptimal and a new *searchers* immediately finds some *shopper* who can buy at zero search costs an item that has been already found and bought. And numerous web sites for resale of luxuries demonstrate that it is possible. If such a group does not appear, all consumers with high willingness to pay can make resale only at the original equilibrium price level and a consumer who has overpaid for an item can sell it only with a loss at this level to other zero-search-costs consumers. The satisficing purchases are made within the "common model" of behavior even on markets of luxuries. This is not true for the "leisure model" of behavior that produces Veblen effect (Malakhov, 2015).

The sellers' tactics in front of *searchers* is definitely artless – they redistribute transaction costs in order to charge consumers' costs of search, especially when search entails travel costs. The idea to sell for *searchers* at the equilibrium price level, like it is presumed by the Diamond's Paradox, is not fruitful even if sellers have a monopoly power to reinforce consumers to pay a monopoly price. There, producers should incorporate all transaction costs and they sell at the zero-search-costs level only in the high-price store. If *searchers* should buy at this equilibrium price, they will bring to labor market all time of search. This extra labor supply decreases wage rates and makes the equilibrium price level unattainable. Hence ***sellers should also stay heterogeneous***. And information clearinghouses, newspapers and web sites, simply “discount” different terms of sale to some one-dimension list of price quotes. In practice, readers of newspapers and sites’ visitors see only the vertical axis of Figure 3, where the price dispersion is evident. It might not be stable if some searchers find a possibility of arbitrage. But in general these information clearinghouses demonstrate some persistent price dispersion where different price quotes correspond to different income levels, different propensity to search, and different time horizons.

4. Conclusion

The analysis of propensity to search that optimizes satisficing purchasing decisions shows that the “law of one price’ holds in an imperfect homogenous market if there are consumers with zero search costs. These consumers have different willingness to pay but they make purchases at the level of the lowest zero-search-costs willingness to pay. Consumers with positive search costs are also heterogeneous but they have the same willingness to accept or to sell that matches the lowest willingness to pay of consumers with zero search costs at the equilibrium price level. Arbitrage adjusts not only prices but also the propensity to search that equalizes marginal losses in labor income during the search with marginal savings on purchase on a new equilibrium price level. When purchase decisions of consumers with positive search costs are optimal arbitrage doesn’t take place.

The equilibrium price level does not eliminate price dispersion. Consumers have different willingness to pay and they meet heterogeneous sellers. Sellers try to discriminate consumers and, if they find a zero-search-costs demand, the new market is organized.

The arbitrage of suboptimal purchasing decisions can be used as the starting point for the analysis of equilibrium price level under persistent price dispersion. There are some important issues that should be covered by following studies. Usually, arbitrage does not represent a common practice but there are searchers who can use it by definition, i.e., marginal searchers who live near productive units. They are still consumers but they also operate as part-time sellers. Saturday markets represent the perfect exhibition of this practice.

Although the re-allocation of transaction costs from producers to consumers does not cover the total sellers’ heterogeneity it can be followed by very interesting studies. Producers also might differ in their search tactics. Some of them are sellers with zero search costs, here in search for buyers, and some of producers are searchers. This type of heterogeneity needs some efforts in the theory of games because here sellers meet searching consumers and shoppers meet searching producers.

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Testing the Existence of Ricardian or Non-Ricardian Regimes for CIS Countries

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It is important to determine the dominant fiscal regime in a country group for policy prevision. This paper examines whether the Ricardian fiscal regime or non-Ricardian fiscal regime is dominant in the Common Wealth of Independent States (CIS). We attempted to show that CIS' behavior after the debt stock increase. Using panel data method, this paper finds that Ricardian regime dominates in Kyrgyz Republic, Russian Federation, Tajikistan, Uzbekistan, Moldova and Turkmenistan's fiscal policies.

Keywords*: CIS, Panel Data Analysis, Common Correlated Effect Model, Debt Stock, Ricardian Fiscal Regime*

JEL Classification*: C23, E62*

1. Introduction

Determination of the type of fiscal regimes is very important for policy previsions and economic policies. Sims (2005) and Benigno and Woodford (2007) suggest that the fiscal policy regime has important consequences, particularly monetary policy rules for the inflation targeting. Leeper (1991) uses the terminology of ''active'' and ''passive'' for the differentiation of policies. According to Leeper (1991), an active authority does not take the consideration of government debt. On the other hand, a passive authority takes an action for government debt shocks. Aiyagari and Gertler (1985) were the first economists to define the differences between Ricardian and non-Ricardian regimes. The general principle of Ricardian regime is that when monetary authority issues government bonds, financial authority increases current and future tax rates and/or current and future expenses to pay for both the principal and interest payments. (Resende, 2007). In the case of Non-Ricardian regime, monetary policy rules are chosen independently from fiscal policy rules. When the government adapts strong fiscal discipline, it can arrange an optimal policy rule without taking consideration the fiscal policy. On the other hand, if the fiscal condition in the economy is unsteady, it would be risky to adapt a monetary policy without paying attention to the fiscal policy (Ito et al., 2011).

Ricardian and non-Ricardian regimes result in different economic policies. One of the differences between Ricardian and non-Ricardian regimes is that in a Ricardian regime, individuals know that today's lending will cause tax increase in the future. Hence changes in public budget will not lead to the changes in current or future budgets' present values. However, in a non-Ricardian regime, public authority determines the policy without considering debt stock. The other difference is that while in a Ricardian regime exchange rate

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is determined by the monetary indicators, in a non-Ricardian regime, exchange rate is determined by the fiscal policy. In addition, in a Ricardian regime government bonds do not create net wealth effect, however, in a non-Ricardian regime, the government bonds create net wealth effect. Hence, budget deficit financing increases private sector consumptions via domestic borrowing (Uysal and Guresci Pehlivan, 2013). For the Ricardian regime, governments have to follow a strong monetary policy to have low inflation rate. An independent central bank with institutional pledge about price stability should enforce the fiscal authority to accept appropriate fiscal policy. For the non-Ricardian regime, if additional measures are not taken into consideration to limit fiscal authority's independence, an adequate monetary policy is not enough to provide low inflation (Moreira et al, 2011).

Bohn (1998) examined the sustainability of the fiscal policy for USA for the period 1916 to 1995. He found that US government has responded to increases in the debt-GDP ratio by raising the primary surplus. Cochrane (1999) found that the positive changes in budget surplus reduce the public debt using the VAR analysis for USA. According to Melitz (2000), basic budget balance and government debt have a positive and statistically significant relationship, a domination of Ricardian regime. Canzoneri et al. (2001) used a two-variable VAR analysis to test the existence of Ricardian regime for USA and, concluded that Ricardian regime dominates the United States. Creel and Sterdyniak (2001) found that Non-Ricardian regime dominates both France and Germany using panel data analysis. Sala (2004) found that that the US fiscal policy for the period of 1960 to 1979 can be classified as "Non-Ricardian", while it is "Ricardian" since 1990. Rocha and Silva (2004) showed that Ricardian regime dominates Spain because of the financial difficulties Spain faces. These financial difficulties seem to require fiscal policy interventions. Favero and Monocelli (2005) examined fiscal policy rules for the United States for the period of 1960-2002 using Markov-switching regression methods. They found that fiscal regime was active from the 1960s to 1980s, passive in the early 1990s and active in early 2001. Davig and Leeper (2007) analyzed the regime changes for monetary policy and tax policy over the post-war period in the United States and they found that U.S. monetary and fiscal policies have changed between active and passive rules. Afonso (2005) found that Ricardian fiscal regime dominates the EU-15. Moreira et al. (2011) investigated whether the Brazilian economy is hold for the Ricardian equivalence hypothesis. They found that non-Ricardian regime dominates in the Brazilian economy. Ito et al. (2011) examined fiscal policy rules in Japan, the United States, and the United Kingdom for more than a century. They found that a Ricardian or a non-Ricardian regime dominated in Japan through the entire period and the US and the UK government's fiscal behavior is characterized by Ricardian policy.

The rest of the paper is organized as follows. Section two presents the theoretical model on Ricardian regime. In section three, econometric methodology and empirical findings are discussed. Section four concludes.

2. Theoretical Model on Ricardian Regime

Theoretical model that is developed to employ in this paper is shown below:

$$s_{it} = \beta_i + \delta s_{it-1} + \theta b_{it-1} + u_{it} \quad (1)$$

i indicates the country; t indicates the period; β_i is the individual effects which is estimated for each country; s_{it} is current account balance as a percentage of GDP for country; s_{it-1} is previous period of current account balance as a percentage of GDP for country; b_{it-1}, general government net debt-to GDP ratio in the period (t-1); u_i is disturbances. According to the fiscal policy rule the current account balance of this year depends on the current account balance of the previous year.

To determine which regime is dominant in CIS (Ricardian or non-Ricardian) the following two conditions are answered:

1. If $\theta = 0$, current account balance depends on the level of public debt in which case the non-Ricardian fiscal regime is applied,

2. If $\theta > 0$, in response to the current public debt, governments attempt to improve the current account balance. In this case, Ricardian fiscal regime is applied.

3. Econometric Methodology and Empirical Findings

In this paper panel data method is employed. Panel data consists of time series and cross-sectional data. When we use panel data technique, we will face with the same problems as time series. It has to be examined whether variables include unit root or not. If the variables are not stationary, regression estimates obtained will be spurious. In order to obtain correct estimate values, panel unit roots tests are applied. Before applying unit root tests for the series, heterogeneity and cross sectional dependence tests are used. According to these results first or second generation unit root and cointegration tests are used. The annual data set covers from the period 2000 to 2011. The data was obtained from the IMF, World Economic Outlook Database.

Table 1 presents the codes of countries which are used in this paper.

Table 1. *Country Codes*

1	Ukraine
2	Kazakhstan
3	Kyrgyz Republic
4	Russian Federation
5	Tajikistan
6	Uzbekistan
7	Azerbaijan
8	Moldova
9	Turkmenistan

Pesaran and Yamagata (2008) developed Delta test to examine the heterogeneity between cross section units. According to the Delta test, null hypothesis and alternative hypothesis are shown like below:

$$H_0: \beta_1 = \beta_2 = \cdots = \beta_n = \beta$$
$$H_1: \beta_1 = \beta_2 = \cdots \neq \beta_n$$

The series are homogeneous in the case of the null hypothesis cannot be rejected. The null hypothesis for all β_i is identical; alternative hypothesis at least for one i is shown different. If the null hypothesis can be rejected, it indicates that at least one series is different from the others and the series are not homogeneous. The results of Delta test are shown in the following table.

Table 2. *Delta Test Results*

Test	Test Statistics	Probability
Δ	3.42	0.01
Δ_{adj}	4.19	0.01

Table 2 represents Pesaran and Yamagata (2008) Delta test results. According to these results H_0 hypothesis is rejected. It indicates that these series are heterogeneous. It is important to determine the cross sectional independence before implementing the unit root tests. In order to determine the cross sectional independence, we used CD_{LM} test of Pesaran (2004). The test statistics is computed in the following way (Pesaran, 2004, p.5):

$$CD_{LM} = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{p}_{ij}^2$$

and

$$\widehat{p_{ij}} = \frac{\sum_{t=1}^{T} e_{it} e_{jt}}{\left(\sum_{t=1}^{T} e_{it}^2\right)^{\frac{1}{2}} \Big/ \left(\sum_{t=1}^{T} e_{jt}^2\right)^{\frac{1}{2}}}$$

The assumptions for the computed test statistics are:

$$H_0: \rho_{ij} = \rho_{ji} = cor(u_{it}, u_{jt}) = 0$$
$$H_1: \rho_{ij} = \rho_{ji} \neq 0$$

H_0 indicates that there is no cross sectional dependency between cross sections; H_1 indicates that there is dependency between cross sections. The cross sectional independence test results are shown in the Table 3.

Table 3. *Cross Sectional Dependence Test (CD_{LM} Test)*

Variable	Test Statistic	Probability
s	2.727	0.003
b	7.664	0.001

There is a cross sectional dependence between series in the case of the null hypothesis is rejected. Therefore, it requires to use the unit root tests which take into consideration of the cross sectional dependence. Otherwise, the results will be biased. The results of tests indicate that there is heterogeneity and cross section dependence. Therefore, Pesaran (2007) CADF (Covariate Augmented Dickey-Fuller) can be used as a unit root test. The computed test statistics values require to be compared to Pesaran (2007) table values when we used this test. For the CADF panel unit root tests, null hypothesis and alternative hypothesis are shown below.

$$H_0: \beta_i = 0$$
$$H_1: \beta_i < 0$$

According to CADF unit root test and CIPS statistics all series have unit root. As in panel unit root tests, in panel cointegration tests, tests which take the consideration of cross sectional dependence are known as a second generation panel cointegration tests. Westerlund (2008) proposed the Durbin–H which allows more powerful results than the other panel cointegration tests. It is more convenient to apply Durbin-H Panel if there is homogeneity and cross section dependence between cross section units. If there is a heterogeneity and cross sectional dependence between cross section units Durbin-H group tests are applied. Therefore we used Durbin-H group test. The assumptions of model are listed below:

H_0: no cointegration

H_1: cointegration

The null hypothesis is no cointegration against the alternative hypothesis of cointegration. The test statistics which computed in Durbin-H group cointegration analysis is compared to the critical value of normal distribution value which is 1.645. H_0 is rejected if computed test statistics is bigger than critical value. It indicates that there is a cointegration. Table 4 represents Durbin-H (2008) Group results.

Table 4. *Durbin-H (2008) Group Test Results*

	Test Statistics	Probability
Durbin-H Group	11.535	0.002

Durbin-H group test results show that there is a cointegration between our variables. Then we used Common Correlated Effect Model which was suggested by Pesaran (2006) to determine the country specific effects in the long run. The results show that there is a positive relationship between primary balance and gross debt to GDP ratio in Kyrgyz Republic, Russian Federation, Tajikistan, Uzbekistan, Moldova and Turkmenistan. These countries' governments determine their policies with considering present debt stocks. This is consistent with the Ricardian regime. In these countries, public authorities get some precautions according to changes in debt to GDP ratio. However, Ukraine, Kazakhstan and Azerbaijan government policies are consistent with the non-Ricardian regime. On the other hand, there is a positive relationship between debt to GDP ratio and primary balance in Ukraine, Kazakhstan and Turkmenistan. However, there is a negative relationship between debt to GDP ratio and primary balance in Kyrgyz Republic, Russian Federation, Tajikistan, Uzbekistan, Moldova and Azerbaijan.

4. Conclusion

In this paper, we analyzed the existence of Ricardian or Non-Ricardian fiscal regimes for CIS' fiscal policies using the annual data from 2000 to 2011 for the nine countries of CIS. Given the data set and econometric techniques employed, the results show that Ricardian regime dominates in Kyrgyz Republic, Russian Federation, Tajikistan, Uzbekistan, Moldova and Turkmenistan' fiscal policies. It indicates that these countries attempt to decrease their debt to GDP ratio with obtaining a surplus in the budgets. When public debt increases, governments take some precautions. The paper improves upon the existing empirical studies on the determination of the fiscal regimes in a group country, particularly for CIS countries. The findings show that all countries of CIS do not exhibit the similar fiscal policies. There are some different preferences with determining the fiscal policies in these countries.

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Analyzing Market Economies from the Perspective of Information Production, Policy, and Self-Organized Equilibrium

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A modern market economy is an exceedingly complex, infinite-dimensional, stochastic dynamical system. The failure of mainstream economists to characterize its dynamics may well be due to its intractability. This paper argues that the characterization of its dynamics becomes almost trivial when it is analyzed from the perspective of information production. Whether its Jacobian matrix is specifiable or not, a Lyapunov spectrum can be constructed from which the potential Kolmogorov-Sinai or Shannon entropy can be assessed. However, a self-organized equilibrium must first obtain, and for that a suitable policy must be operational.

***Keywords**: Complexity, Kolmogorov-Sinai Entropy, Shannon Entropy, Lyapunov Spectrum, Lyapunov Dimension, Efficient Policy, Self-Organized Equilibrium.*

***JEL Classification**: B41, C52, C61*

1. Introduction

Market economies are often blamed for their bad outcomes such as thermodynamic entropy production, and unequal distribution of income or wealth which, in turn, is a source of conflicts. There is now sufficient evidence to argue factually that when market economies are unregulated or simply mildly regulated, they tend to become unstable, voracious, and predatory. For the proponents of unregulated markets, on the other hand, market economies are only sources of wealth creation.

In truth, modern market economies should be viewed as complex social constructs designed to facilitate exchanges, in which decisions regarding investment, production, and distribution are driven by supply and demand. Neoclassical economists model them as micro-founded-dynamic-stochastic-general-equilibrium constructs (DSGE) based on rational expectations, Walrasian market clearing, unique and stable equilibrium. Agents are infinitely-lived optimizing households with homothetic and identical preferences bent on maximizing outcomes. Despite the persistent reminders from people such as Dani Rodrick and Paul Krugman (Rosenberg, 2016), DSGE (the latest vintage of macro-models) is a poor guide to decision-making. If the modeling effort of the International Monetary Fund or Federal Reserve Bank of New York is an indication of DSGE's ability to explain and predict, one must conclude that it cannot fulfill these promises. For, in the absence of

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shocks and changes in model's structure, one could perhaps predict next year's outcome more accurately using a ruler. The reason is that market economies are infinite-dimensional webs of interrelationships with multiple feedbacks and feedforwards in which agents operate according to their own schema or local and public knowledge, while learning and adapting to emergent characteristics; that is, a process with many more affinities with biological rather than chemical or thermos-dynamical systems.

The 'deep parameters' of DSGE, namely elasticity of substitution, preferences, resource limitations, etc. are so-called, because they are supposed to be invariant to policy changes. But the only things "deep" in the capitalist economy (imagined by Professor Lucas in his "critique") are the inherent modes of action constituting the law of motion, such as monotonic increasing preferences, the attraction to incentives, and the quest of safety in domination. In reality, the structure of the economic model consists of exchange ratios, rates, identities, fractions of preference assigned to endowments, etc., that are constantly varying in response to changes in preferences, endowments, and policies, while the aggregate flows are noisy and sampled at large intervals. Furthermore, market economies share many attributes with biological systems in the sense that they can grow or decay, making their outcomes non-stationary and therefore non-ergodic. Otherwise put, market economies are complex-adaptive systems which are in addition subject to risks and uncertainties. Hence they are unable to throw-out fundamental statements. Conventional mainstream modelling of a large modern market economy appears almost an intractable problem. Nonetheless, model builders of such complexity could draw valuable lessons from both the logistic map (see below) and classical mechanics. Imagine a box filled with n particles. Putting together the space ($x \varepsilon \Re^3$) and momenta ($p \varepsilon \Re^3$) dimensions in one vector space called the phase space, X, which is a collection of all possible states $x \varepsilon X$, forming an abstract mathematical space in $\Re^{6n}$. With a sufficiently regular Hamiltonian function, one can find a unique solution of the position and momentum of each particle. However, one must first face a strongly coupled system of 10^{24} equations. The question that was subsequently raised was: If the system starts at a certain state (x_0, p_0), will it eventually return to a state close to that initial conditions? According to Sarig (2008), solving such a large system did appear intractable until Henri Poincaré made it trivial by viewing the problem from a different perspective. That new perspective led Poincaré to the Recurrence Theorem.

It is worth repeating that market economies are multi-dimensional, dissipative and heavily interconnected systems. For every event that occurs anywhere within them, small effects and uncertainties multiply over time, cascading into unpredictability (Petersen, 1983; Frigg, 2004). Being infinite-dimensional, they requires an infinite set of independent numbers to specify an initial condition. Similar to the well-known problem of classical mechanics, described in note 1 below, modelling them may be made trivial if viewed from the perspective of information production. In this respect at least, theorists are not powerless. For, Farmer (1982) has shown that such a system can be approximated by a finite-dimensional iterated system. And being dissipative, it almost surely possesses a chaotic attractor of finite-dimensions. Instead of attempting to tract elusive parameters and aggregate flows, the perspective of information simplifies the task, for it only requires that the focus be mainly on chaotic and predictable behaviors.

The main difference between predictable and chaotic behaviors is that predictable trajectories do not produce new information, whereas chaotic trajectories continuously do. That being the case, one can appeal to the notion of Kolmogorov-Sinai (or just metric) entropy as it provides a quantitative knowledge of how chaotic a dynamical system is. Moreover, chaotic attractors of finite dimensions have discrete spectra of Lyapunov characteristics exponents. These exponents provide a summary of local stability properties as well as the Lyapunov dimension of the attractor. Positive exponents measure the average exponential divergence of nearby trajectories, while negative exponents measure exponential convergence on the attractor; and together, they constitute the Lyapunov spectrum. We will make use of them, including the Kaplan-Yorke conjecture (1979a; 1979b) (which does not distinguish between infinite and finite-dimensional systems) to de-fang the infinite-dimensional dynamical market economy.

In Part II, we use the quadratic map to first establish a *spectrum of behaviors* within which we think this class of growth models lives, and in which we think a market economy belongs, and where it can easily be analyzed from the perspective of information production. Generally, the market economy is a dynamic pricing construct that may be analyzed as a pair of objects (X, T) consisting of a complete metric space X (i.e. the set of all possible states x of (X, T)) and a family T_t of continuous mappings of the space X into itself with the property $T_{t+\tau} = T_t \circ T_\tau$, where $t, \tau \varepsilon T_{+}$: $T_0 = I$. $T_+ \varepsilon \Re_+$ or $T_+ \varepsilon \mathbb{Z}_+ = \{0, 1, 2,\ldots\}$. X is called the phase space Λ, whereas the family T_+ is the evolutionary operator (a semi-group); the parameter $t\ e\ \varepsilon T_+$ plays the role of time. If $T_+ \varepsilon \mathbb{Z}_+$, the dynamic system is discrete. The law of motion indicates that if the system is at state x now, will it then evolve to state T(x) after Δ t? $\{T^n (x)\}_{n \varepsilon \mathbb{Z}}$ is a record of the time evolution of the system, and understanding the behavior of T^n (x) as $n \to \infty$ is the same as knowing the state of (X, T) in the future. The iterates of the map T are defined by induction. That is, $T^0 :=$ id, $T^n := T \circ T^{n-1}$, and the aim of the theory is to describe the behavior of $T^n(x)$ as $n \to \infty$. Since (X, T) is dissipative, it is not volume preserving and therefore does not preserve the Lebesgue measure.

Part III emphasizes the essential role of policy and stable equilibria. Part IV examines the role of self-organized equilibria in the assessment of the information produced by a chaotic system. Part V summarizes our findings.

2. The Spectrum of Equilibria

The quadratic map is one-dimensional and it is non-hyperbolic. It nevertheless offers a gamut of valuable lessons in the form of a spectrum of behavior of growth models. Using symbols such as ∟to indicate "power on", → "imply", ∧ for "and", ∨ for "or", and ⇔ means 'equivalent to'. One can succinctly express equation (01) as:

$$X_{t+1} = f(x) = R\,X_t(1 - X_t); \qquad (1)$$

$$R\ \varepsilon\ \Re\ \varepsilon\ (0, 4]\ \llcorner\ X_t \wedge R \Leftrightarrow \omega$$

$$X_t(1 - X_t)|X_t > 0 \wedge R > 1 \Leftrightarrow \pi;$$

ω and π represent, respectively, the structure (or the Jacobian) and the policy set. Choosing the initial condition X_0 determines the outcome of n discrete steps in the following way: $X_1 = f(X_0) = f^1(X_0)$: $x_2 = f^2(X_0)$: …, $f^n(X_0) = f \circ f \circ \ldots \circ f(X_0)$ (n times), while ℜ stands for the real line.

One alternative is to use the Bernoulli shift map whose iterated dynamics can produce complicated motion as well. For example, let T: (0, 1) → (0, 1), $T_{(x)} := 2X$, mod 1, and the unit interval is divided in two segments at X = ½ . Assume now that the unit interval is filled with a uniform distribution of points. We can decompose the action of the shift map into 2 steps: i) the map stretches the distribution by 2 which in turn leads to divergence of nearby trajectories, and ii) cuts the line segment in the middle as per the modulo action mod 1, which leads to bounded motion on the unit interval. Thus the Bernoulli shift is an example of a nonlinear stretch-and-cut strategy to generate deterministic chaos in a closed dynamical system. Suppose now that points can leave the unit interval and escape to infinity, then the total number of points filling the unit interval is no longer conserved. We would have then an open system. We will deal mainly with open systems in what follows, but for now we return to the quadratic map, which in some respects is more suitable for the present purpose; furthermore, most of the concepts developed therein carry over to higher-dimensions.

Table 1 then displays the changes in the spectrum of equilibria as R in (1) is varied. As it can be seen, as the value of R is increased, the spectrum displays various modes that can be expected, depending of course on the structure of the process. For example, there is ω_L at ($1 < R < 3$) for which *all equilibria are stable sinks*; ω_{2c} ($3 < R \leq 3.57$) would produce *stable cycles-2*; ω_{Dc} ($R = 3.57$) would give some form of *deterministic chaos*; ω_{Hc} ($3.57 < R < 3.82$) is for *high-dimensional chaos*; ω_{3c} is for *cycles-3*; and ω_{Lc} is for *low-dimensional chaos.* In this study high and low dimensional chaos are distinguished only by the geometry of the attractor as measured by the Hausdorff dimension. With regard to modern markets, because of wild and irregular gyrations of output and feedbacks, one can safely rule out $\omega_{L,}$ ω_{2c}, and ω_{3c}. Another reason for discarding them is that they do not produce new information. We will assume that the structure of the market economy is either ω_{Hc} or ω_{Lc}.

Los (2000) has computed the third iterate of the quadratic map and he next ruled out negative and complex R values, but at R =3.832, in the middle of the so-called Li and Yorke interval, he found a cycle 3 x 2^k (k = 1). Los does not say whether or not the unstable equilibria were about to bifurcate, but he noticed 3 distinct periods, and therefore all other periods become possible. However, for the present purpose, it is worth underlining that the Lyapunov exponents in that interval are negative in steady states. We ruled out ω_{3c} because no actual markets with these characteristics have been observed, but just before that interval i. e., at R = 3.82, Los found 2 stable equilibria at x* = 0.154 and x* =0.958 in the midst of high dimensional chaos. It goes without saying that if these equilibria were unstable instead, an appropriate policy (see next section) could elicit a phase change, which in turn could lead to a locally stable self-organized equilibrium. We will return to the concept of self-organized equilibrium in Part IV.

2.1. A Model of the Market Economy

If 'complexity' implies diversity and arises from a multitude of connections between a wide variability of elements, it is then safe to say that the complexity of market economies is observable daily and is ubiquitous in aggregate data (Cohen and Stewart, 1994). Our contention is that being dissipative dynamical systems, their phase spaces (Γ) therefore contain invariant sets or attractors. Thus, valid or invalid assumptions notwithstanding, casual observations show that a market economy belongs to the class of models given by:

$dX/dt = F_{(\pi)\,\omega}(x(t))$ (2)

$\Lambda_{\Pi}\,\Lambda_{\omega}$ (π ∟(ω ∧ x $(t_0) = x_0$) ∧ ω ε $\mathfrak{R}^m$ → dim X ∧ π ¬ ω;

φ : π_i ∟ ω_{jk}|j, k ε q < m.

That is, for π and ω, where π has power over ω and x_0; ω determines the dimension of X, and π is not ω. In other words, *ω is the structure of the model* or a vast networks of connections with nodes in the phase space ∧, and π is a policy space in which ω is embedded. φ is a reflexive "onto" map or a veto power either on ω, (i. e., capable of eliminating a few degrees of freedom) or capable of resetting x_0 in an attempt to put the system in a stable sub-space E^s (see below).

Table 1. ***Equilibria and LCEs as a Function of R in the Quadratic map.***

Value of R (1)	Equilibria x*	Lyapunov coefficient λ
0 ≤ R ≥ 1	no solution	Violation of π
1 < R ≤ 3	linearity	< 0
3 < R ≤ 3.57	Period 2^k, {k = 0, 1, 2 …	< 0
R = 3.57	Periodic & aperiodic cycles	= 0
3.57 < R < 3.82	Stability & instability	⋦ 0
3.8284 ≤ R 3.8414 (2)	P- 3^k {k = 0, 1, 2,…}	⋦0
3.8414 < R ≤ 4	Low dim chaotic	> 0

(1Ac) counting for instrument noise. (2) Computed by Medio (1992).

First, suppose that *ω is known explicitly*, then its Jacobian is also known. That is,

J (t) = $\partial T_i / \partial X_i$, i ε m, (3)

where T_i is the mapping in note 2, the ijth elements of the matrix $J_{ij} = \partial X_i(t)/\partial X_j$, where X_i (t) is the ijth component of the state vector at time t, and J (t) is the observed square determinant (as it takes 2 for a connection) describing the overall contraction of the phase space volume, while its eigenvalues describe the divergence and convergence of trajectories. We first suppose that the square matrix J (t) has k distinct eigenvalues with negative real parts, h eigenvalues with positive real parts, and g = (m – k – h) eigenvalues with zero real parts.

The attractor Д of J (t) in this case is non-hyperbolic. However, a center manifold will not add anything to our discussion even though non-hyperbolic attractors are more common in the real world. For simplicity of exposition, we suppose that the attractor of (2) is hyperbolic, and that all equilibria are translated to point **0** located at the origin. In the case in which of an attractor of (2) is hyperbolic, there exist a stable subspace E^s of dim k ∨ unstable sub-subspace E^u of dim (m –k). E^s span ($v_1, v_2, \ldots, v_k$) ∧ E^u span ($v_{k+1}, \ldots, v_m$) such that $E^s \oplus E^u = \mathfrak{R}^m$. We then have a differentiable manifold $Ш^s$ tangent to E^s at **0** ∧ $Ш^u$ tangent to E^u at **0**. Then ∀t ≥ 0, the flow $\varphi_t(Ш^s) \subset Ш^s$, ∀$x_0$ ε $Ш^s$|lim t → ∞, x_0 = **0**. Similarly, ∀t ≤ 0, $\varphi_t(Ш^u) \subset Ш^u$, ∀$x_0$ ε $Ш^u$|limit t → - ∞, $\varphi_t(x_0)$ = **0**, where as before, x_0 stands for initial conditions. If J (t) has pure imaginary eigenvalues in the form of $\sigma_j = a_j + ib_j$, then the generalized eigenvectors are $w_j = u_j + iv_j$.

If J (t) has pure imaginary eigenvalues in the form of $\sigma_j = a_j + ib_j$, then the generalized eigenvectors are $w_j = u_j + iv_j$. We will not spend much time on negative eigenvectors except to repeat that if the dominant eigenvector is negative, then no new information could be had since it would be known in advance that the flow would end up in the stable manifold ($Ш^s$); perhaps that is the reason why Kolmogorov initially thought that deterministic systems did not provide information (Sinai, 1959).

3. Measuring the Metric Entropy and the Level of Chaoticity

The Kolmogorov-Sinai entropy (KS) notion is examined relative to another notion called partition (Kolmogorov, 1958). A partition γ = {γ_i|i = 1, 2, …, n} of X is a collection of non-empty, non-intersecting sets that can cover X. That is, $\gamma_i \cap \gamma_j$ = ⪰⪯, ∀ i ≠ j and X = $\cup_i^n \gamma_i$. Thus, if γ is a partition, so is $T_t^{-1}\gamma$:={$T^{-1}\gamma$ | i ε n.

Given the partition γ in a dynamical system, let

$H_n (\gamma T) := (1/n) (\gamma V T^{-1} \gamma V,\ldots,T^{n+1} \gamma)$.
(4)

In the limit $H (\gamma T) := \lim_{n\to\infty} (H_n,T)$ exists. Then the KS entropy is defined (Frigg, 2004; Petersen, 1983; Kolmogorov, 1958; Shannon, 1949) as:

$S_{KS} := \sup_\gamma \{H (\gamma, T)\}$
(5)

The KS entropy is linked to the Shannon entropy H (P). In the latter, it is assumed that there exists a source that is producing discrete messages and a receiver. Let a complete messages be $M =\{m_1, m_2, \ldots, m_n\}$ and its probability distribution be $P =\{p_1, p_2, \ldots p_n\}$, where $p_i > 0$ and $\sum p_i = 1$. Then the discrete Shannon entropy is:

$H (P) := - \sum p_i \log_2 (p_i)$
(6)

Thus $H_n (\gamma, T)$ measures the average amount of information produced by the system per step over the first n-steps relative to the coding γ. A positive KS entropy indicates that the system is unpredictable. To make this clearer, let us emphasize that the KS entropy measures the amount of information contained in an individual object (say a string) x by the size of the smallest program that generates it. It naturally characterizes a probability distribution over all possible binary strings Ɱ.

The Shannon entropy (H (P)) of a random variable X, on the other hand, is a measure of the average uncertainty. That is, the smallest number of bits required to describe x (the output of X) when the receiver comes to know the probability distribution. In the context of communication theory, it amounts to the minimum number of bits that is required to transmit x. Hence, it would seem that KS entropy and Shannon entropy H (P) are conceptually different concepts. The former is based on the length of programs, while the latter is based on probability distributions. Yet, for any distribution computable by a Turing machine, the total value of KS entropy is equal to H (P) up to a constant term Ɱ as shown below.

To recapitulate, we suppose a set of independent messages (M) and probability distributions (P). The receiver receives m_i and he gets $\log_2 (1 / p_i)$ of information. For Ɱ independent messages, he or she receives a total of information I, given by:

$I = \sum_{i=1}^{m} (Ɱ\, p_i) \log_2 (1/p_i)$ (7)

Then, the average information he gets per individual messages is:

$\langle I \rangle := (1/ Ɱ) \sum (Ɱ\, p_i) \log_2 (1/p_i)$ (8)

$= \sum p_i \log_2 (1/p_i)$.

According to Shannon, given a probability distribution P, its entropy is:

$H (P) := \sum p_i \log_2 (1/p_i)$ (9)

Therefore, $H (P) = \langle I\rangle$, implying that the entropy of P is just the expected value of the information given by P. If the Shannon entropy is equivalent to the potential information gained once the experimenter learns the outcome of the experiment, t*hen, the more entropy a system has, the more information one can potentially gained once one knows the outcome of that experiment or is able to apprehend its probability distribution.* Another way of seeing H (P) is that it is a way to quantify the potential reduction of one's uncertainty once one has learnt the outcome of a probabilistic process.

The KS entropy is also linked to the Lyapunov characteristic exponents (LCE) via the concept of exponential divergence. The LCEs measure the mean exponential divergence or convergence of solutions originating near x. Positive ones indicate that solutions diverge exponentially on the average and in some directions. One can then appeal to Persin's Theorem (1977) (see also Eckman and Ruelle (1985)) which asserts that under certain assumptions the sum of the positive LCEs is a measure of the KS entropy. If the system is chaotic then at least one of the LCE is positive. In addition, it may have dense orbits and sensitive dependence on initial conditions (SDIC), which is a critical hallmark of chaos. In fact, we consider the presence of SDIC as the main distinction between high and low-dimensional chaos in this study. For, whenever SDIC is present, the positivity of these exponents increases. Given their crucial role in the determination of chaotic behavior, a brief review their derivation might further increase understanding.

Suppose that initially we have two trajectories separated by a small distance d_0 on the unstable manifold. The trajectories will diverge at time t later by a distance d_t. The rate of separation of the two trajectories is measured by the Lyapunov exponents (λ) as $|d_t|\approx e^{\lambda t}|d_0|$. In statistical mechanics, one is mainly interested in limits as t goes to infinity. Here the final separation of the two trajectories depends on λ. We may then define the maximum λ as the normal exponent in the limit. The reason is that a chaotic trajectory will automatically follow its maximum expanding direction. That is,

$\lambda := \lim_{t\to\infty} \lim_{d\to 0} (1/t) \ln|d_t / d_0|$

(10) →

there are m such exponents and whenever one is positive we know that we are in a chaotic regime.

3.1. The Lyapunov Spectrum

Focusing on prediction errors observed in economic forecasts made by institutions such as the Federal Reserve Bank of New York, on can safely infer the complexity of economics. From the above discussion, it is supposed that the Jacobian of (2) is known and that its attractor is hyperbolic. Consequently, there are k negative LCEs and h positive ones, and the so-called *Lyapunov spectrum* can be set up as:

$\{\lambda^+_{1h}, > \lambda^+_{2h} >, \ldots, > \lambda^+_{hh}, > \lambda^-_{1k}, > \lambda^-_{1k}, > \lambda^-_{2k} >, \ldots, > \lambda^-_{kk}\}$.

Then from the Persin's Theorem, the *metric entropy* of the attractor is:

$E_n\,(Д) := \Sigma_1^h \lambda^+_{hi}$

(11)

that is, the metric or the KS entropy is just the sum of the positive LCEs or the average information generated by system (2).

The Kaplan-Yorke conjecture states that for an m-dimensional system, the index (D_{KY}) may be computed from the Lyapunov spectrum. In other words, *the information dimension* is the *Lyapunov dimension* as measured by the D_{KY} index:

$D_{KY} :=$ (the order of λ_{hh}^+) + $(\Sigma_{ih} \lambda^+_{ih}) / |\lambda^-_{1k}|$

(12)

where by 'the order of' it is meant the cardinal of the order of the least positive LCE in the spectrum.

It is worthwhile to recall here that it's all started with a conjecture by Kolmogorov to the effect that only stochastic systems produce information. However, it was also found later that several deterministic systems had positive Kolmogorov-Sinai entropy (KS). This is probably due to Yakov Sinai who, inspired by Kolmogorov and Shannon, was the first to come up with the mathematical foundation for quantifying the complexity of a dynamical system. Nowadays, it is widely accepted that the Kolmogorov-Sinai entropy is the basic tool used to capture the property of both stochastic and deterministic systems to produce information as the KS entropy measures the highest average information received from the present state of a dynamic system endowed with a coding, given its past states (that is, information that has already been received). Hence, the KS entropy measures the unpredictability of a dynamic system, a concept that is in harmony with the Shannon entropy where the next sequence is equivalent to new information

Suppose now that *ω is unknown*. According to Farmer, an infinite-dimensional system can be approximated by a finite-dimensional one. And simulation carried out by Farmer has effectively shown that the metric entropy does not vary much beyond a 20-D attractor. However, even a changing, finite-dimensional system may prove to be intractable. Economists can avoid such torment of trying to construct ω by appealing to Takens (1981; Mané, 1980; Liu, 2009; Medio, 1992) who have asserted that *in lieu* of an attempt to determine ω, a pseudo phase space can be constructed from observed data such as a time series. Obviously, a measured time series is only a scalar measurement from one variable which is not a trajectory. This difference is resolved by the delay coordinate embedding technique proposed by Takens. For if the dynamical system and the measured variable are generic, then the delay coordinate map from a smooth compact manifold of dimension, say, M to $\mathfrak{R}^m$ is a diffeomorphism on M. Therefore, under fairly general conditions, the unknown dynamical system can be reconstructed from the time series. After all, we have learned since Henri Poincaré that exact solutions are not necessary to understand and to analyze non-linear dynamical processes. Instead, the emphasis should be on describing the geometrical and topological structure of ensemble of solutions, and the structural elements of a non-linear process are attractors, subspaces, and the types of behavior.

If the structure of the market economy cannot be specified due to excessive complexity and high dimensionality, economists should focus on proven techniques used in other disciplines to recover information of an unknown model through the observations of one of its output. Thus, two theorems (see Takens, 1981; Mané, 1980) provide the link between the true model and the dynamics of the model reconstructed from observed data. This is straightforward when the unknown model is dissipative, because one can be assured that the process converges on an attractor. Even though the true system might be infinite-dimensional, the resulting attractor may be low-dimensional. If the reconstructed attractor exhibits chaoticity, one can be sure that the unknown attractor is non-linearly deterministic and that its behavior is also unpredictable. If it is, then it produces information that can now be computed by following the procedure outlined in Part III.

The reconstruction process begins with a univariate time series such as:

$Z(t), Z(t+\tau), Z(t+2\tau), \ldots, Z(t+(n-1)\tau)$,

where τ is the time delay. Medio observes that under mild conditions, it can be shown that the dynamics of the reconstructed phase space have the same asymptotic properties as those of the unknown attractor for almost any choice of τ, provided that the length of the univariate series is long enough and that the sampling period is short.

The Takens' method. Takens' Theorem asserts that if n is large enough compared with the dimension of the attractor, then the n-dimensional image of the reconstructed attractor provides a close topological picture of the unknown one. The question now is how large should n be? Both Takens and Mané suggest a condition on the size of n that is sufficient to produce a good projection; that is, if m is the dimension of the unknown attractor, then $n \geq 2m + 1$. Obviously, this is helpful if m is known and finite; anyhow, the reader is referred to these two sources for more details on that method.

Knowing that economic time series are seriously contaminated with noise, Medio recommends filtering before using the Takens' method in order to extract meaningful information. In sum, a good use of that method requires a long time series, short sampling period, proper window length, and filtering.

The Caterpillar-SSA method. According to Medio, Takens' method is very sensitive to noise. He recommends the *Caterpillar-singular spectrum analysis* (SSA hereafter) which gives a more accurate picture of the attractor, principally when the signal to noise ratio is low.

The SSA method is a powerful method of time series analysis developed independently in St-Petersburg (Russia) under the name 'Caterpillar' and in the US-UK under the name SSA. It is a model-free method that consists of the transformation of a one-dimensional series into a multi-dimensional series by one parameter translation procedure, singular value decomposition, and reconstruction of the series according to its principal components. It can analyze short and long series, stationary and nonstationary, almost deterministic and noisy series, and it can detect chaos. This is not the place for a detailed description of the method. The interested reader is referred to Golyandina and Zhigljavsky, (2005), (2013), Danilov and Zhigljavsky, (1984). It suffices here to emphasize the fact that the SSA method is widely and successfully used in many other disciplines. Once the attractor is reconstructed, formulae (11) and (12) can again be used; even though ω is not known explicitly. We would then have a situation similar to a case in cosmology. That is, by observing the angular velocity of visible masses around a galactic center, cosmologists can infer the presence of a black hole at the center of masses even though the black hole itself cannot be observed.

4. Self-Organized Equilibria

Neo-Keynesian economists such as Paul Krugman are firmly attached to the notion of equilibrium. For Krugman, there is no alternative to "maximization" and "equilibrium". We do not think that maximization is compelling, but there is no doubt that equilibrium is of central importance in the present context. It is well-known that flipping a fair coin once provides us with one bit of information per throw, but the information may not be accessible unless the outcome is actually observed. In the present set-up, the potential average information produced by system (2) is observable and accessible only if a self-organized equilibrium obtains. The law of physics says that information cannot be destroyed. Hence, on a chaotic attractor, information can only be dissipated on the unstable manifold (see note 3), while the true probability distribution remains unknown. Our central objective in this paper is to learn how to conserve the information produced by system (2). The only way to achieve this is to call on an appropriate policy that would induce a change in decision-making (the equivalent of a phase shift in physical systems). Put differently, a change in decision-making acting on ω would hopefully create a stable subspace of a self-organized equilibrium nearby.

The reason for this is motivated by the lesson of the quadratic map. Los' analysis reveals that a phase shift of 180 degrees always preceded a bifurcation. For example, as R increases from 3, a phase shift occurs at R = 3.44 followed by the first bifurcation at R = 3.50. Another phase shift occurs at R = 3.54 followed by the second bifurcation, and so on until R = 3.57. If the same phenomenon occurs in mathematical, chemical, cosmological, and biological systems, why not in social dynamical system? This lends support to the belief that in social dynamical system, a phase shift may well be the equivalent of a change in decision-making due to an efficient policy. It is worth repeating that we are assuming that a policy that inspires confidence will lead to changes in decision-making which in turn may lead to a change in the structure (ω). As shown above, at R =3.82, the process, on its own, alternates between stability and chaos. If a market were to show such intermittency, it would be safe to simply assume that economic agents would respond to a change in policy or a phase change leading to a self-organized equilibrium, where equation (11) can then be evaluated.

Self-organization is usually defined in various ways. One definition refers to the spontaneous order that arises out of local interactions between smaller parts. Another claims it arises out of random fluctuations that are subsequently amplified by positive feedbacks. In Prigogine and Stangers (1984), Nicholis and Prigogine, (1977), Hazy and Ashley, (2004), it is defined as some sort of order far from equilibrium. In chaos theory, self-organization is discussed in terms of islands of stability within a sea of chaos. In this paper we will adhere to the definition of von Foerster who defines it as the case where random fluctuations (but also a change in policy) increase the chance that a chaotic system may fall into the basin of a stable equilibrium arising out of a phase shift (Ashley, 1947; Mitchell *et al*., 1994).

In nature, self-organization is ubiquitous. It is regularly observed in physical, chemical, biological, and cognitive systems. It is also observed in ecology, neural networks as well as in social and mathematical systems. It obviously exists in cosmology judging by the apparent stability of our solar system; a stability that has lasted long enough to allow for the presence of conscious beings on planet earth.

It is of course legitimate to ask whether or not self-organization arises in market economies. It must be first recalled that economic agents can learn and adapt. The economy itself is a path-dependent system. Los' analysis among others clearly shows that following a phase shift of 180^{o}, previously stable equilibria become unstable while the resulting bifurcation reestablishes stability. We have argued that in a social dynamical system such a market economy, the equivalent of a phase shift is a change in decision-making (preceded by the observation of instability and followed by a change in policy that strengthens the confidence of agents in the immediate present and the near future). I do not have a definition of such a policy, but whatever it may be, it must be a policy that instills sufficient confidence to elicit a positive attitude on the part of economic agents.

The importance of striving for a stable outcome cannot be over emphasized. It is a *sine qua non* condition for the actual assessment of the average information produced by the market economy. Because, the average information rate, i.e., the entropy, enriches the collectivity through abundance and high productivity that in turn drives the growth of the economy.

5. Concluding Remarks

This paper argues that while market economies are often decried for their undesirable outcomes, besides producing goods and service, they have another beneficial side, i. e., they produce information. Modern market economies are very complex infinite-dimensional systems. Economists have built a plethora of models in an attempt to capture their dynamics. Yet the performance of these models leaves much to be desired. The alternative is to approach the problem from a different perspective. That is, from the perspective of information production.

To export our main argument we first draw on the quadratic map to establish a spectrum of equilibria of albeit dissipative dynamic systems as the set $\omega = \{\omega_L, \omega_{2c}, \omega_{Dc}, \omega_{Hc}, \omega_{3c}, \omega_{Lc}\}$. We next concluded that ω_L (that yields linear time invariant models), ω_{2c} and ω_{3c} (that produce period-doubling cascades) can be safely be ruled out either from observations of real markets or due to their inability to produce new information. The structure of a modern market economy most likely falls either within the intervals of high-dimensional or low-dimensional chaos. Therefore, they produce information.

After locating market economies in the spectrum, we next restrict ourselves to procedures for which there is a consensus such as the metric entropy and the Lyapunov spectrum in order to measure the level of chaoticity of a proposed model. We have also emphasized that the structure ω may not be specifiable. In such a case, one may proceed to reconstruct the unknown attractor from observed data such as a time series.

After observing the enormous waste that public institutions are capable of, neoclassical economist such as von Hayek, Friedman, Lucas, etc. tend to fall in the category of opponents of government policy. However, this is tantamount to go from one extreme to another even though extremes have no place in human affairs. There is plenty of evidence that in the absence of appropriate policies, market economies will soon become unstable. We have then argued for a more central role for policies that can induce confidence in economic agents. Efficient policies giving rise to change in decision-making are equivalent to a phase change in physical and mathematical systems. Such phase changes are necessary to bring about self-organized equilibria, where the entropy generated by the economy can be evaluated.

If new information produced by a chaotic economic process is not properly harnessed due to the presence of stop-gap policies or policies bought outright by powerful agents, one should observe wild gyrations of output and falling total factor productivity; that is, falling total factor productivity is evidence that the economy is trapped in unstable regimes. The US market presents a clear case in point. Since the later part of the 1990s, government policies have freed huge corporations from both their social responsibility and ethical market behavior. Moreover, the government has unwisely deregulated and subsidized the financial market thus allowing it to become ever since truly destructive and predatory. As a consequence, the market has moved on unstable trajectories. It could have been otherwise. When policies are conducive to stability, new information obtains, and it manifests itself through, say, the difference between, a Ford Model A and the Lincoln Continental, or between the slide rule and the computer, among many other examples. In sum, information + policy + innovation = growth. It suffices to think of the space program, internet, iPhone, solid-state memory, GPS, etc. Hence, any notion that associates market economies to linear time invariance or that claim that markets should be unfettered is untenable.

Thus, instead of going to the torment of building DSGE models, students of economics would do well to focus their attention on statistical methods, dynamic analyses, attractor reconstruction, and on the task of learning what constitutes policies conducing to self-organization. Because, in a self-organized equilibrium, competitive markets through-out new information which is the true modern asset of a society.

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Is the Development of WIG Index Determined by Certain Macroeconomic and Financial Factors?

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The aim of this paper is to present an analysis whether certain financial ratios can have a significant impact on the development of a stock exchange index. In particular the benchmark stock exchange index is considered, as well as, the selected ratios are considered as the average ones for the whole economy. Quarterly data between 2005 and 2015 were analyzed for the Warsaw Stock Exchange (Poland).

Keywords: *efficient market hypothesis, financial ratios, ratio analysis, stock exchange*

JEL Classification: *C22, G14, G17*

1. Introduction

The ratio analysis is an important tool for a potential investor on the market. It helps to determine the evaluation of a company based on objective criteria. Moreover, it allows to compare a selected company with other ones from the similar market sector. As a result, a company can be valued in comparison to its competitors. Actually, it can happen that the data from financial reports of various companies cannot be compared with each other, but in general there are certain commonly accepted rules and guides to assess a business organization. For example, Micherda (2005) stated that a company has to obtain a relatively high profitability in order to survive on the market. This is however not a sufficient condition. Moreover, Mayo (2008) stated that investors on any stock market usually make choices based on technical analysis and (or) fundamental analysis.

Indeed, according to Bauman (1996) and Penman (1992) the most important task for an analysts is to derive the information on the potential future earnings of a company from the already available financial statements. In other words, the aim of the fundamental analysis is to use the core accounting data available into a reliable prediction on the company's value.

Herein, it will be checked whether the development of WIG index (a benchmark index on the Warsaw Stock Exchange) can be determined by certain macroeconomic and financial factors within a linear regression framework.

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2. **Literature Review**

Within the above presented context, it can be expected that investors make their decision based on the profitability of companies. Narrowing the considerations to the companies listed on a stock exchange, companies with good financial ratios should be more attractive to investors. And, vice versa, if a company has poor financial ratios, it should be not interesting for the majority of investors. This conclusion assumes that investors are risk averse. In other words, there can always be an investor who would rather buy poorly performing stocks, because they are currently cheap, but he or she expects that if in the future the financial performance will be better, then the price of the stocks will go higher. This is connected with extraordinary risk, because if a company has already poor financial situation it is already connected with higher probability of bankruptcy than in the case of a well financially performing company.

As a result, one can expect that if a company announces good financial information, then its stock prices are going higher, and vice versa. If a company announces bad financial information, then its stock prices are going down. Such a behavior can be also extrapolated on the whole market. In other words, it can be expected that if financial ratios are on average good for the whole market, than a certain benchmark measure of this market indicates this situation. If the financial situation reflected by poor financial ratios on average is bad, than it should also be reflected by decrease of a benchmark index.

The above hypothesis is however connected with certain very important assumptions. First of all, it is assumed that the market reaction through stock prices happens after the announcement of financial statements. In other words, the financial ratios cannot be know before the publication of a financial statement. Secondly, that the financial fundamental information plays a role significant enough to impact stock prices. The first assumption is quite important and significant. If one could somehow forecast future stock prices, based on previous data, then the semi-strong market efficiency hypothesis would not be true (Fama, 1970). Although such a hypothesis is a classical topic already, it is still highly disputable whether markets are efficient or not (Dimson and Mussavian, 1998; Constantinides et al., 2003). In other words, if the market is efficient, then the prices always reflect all the available information.

It has to be emphasized the efficient market hypothesis is based on certain assumptions about the underlying market structure. For example, Fama (1970) assumed that there are no transaction costs and the method of valuing the impact of a new information available on the prices are the same for every market player. These assumptions are hardly met in practice. Therefore, sometimes it is also assumed that there are a lot of market players, the products are homogeneous (i.e., roughly the same), the market is organized (for example, there is a supervised stock exchange, regulated by law, supervised by a certain commission, etc.), and the information arrives on the market in a random way (Dimson and Mussavian, 1998; Constantinides et al., 2003).

Usually, the market efficiency is discussed in a three stage classification. In particular, it is said that the market is weakly efficient in no market player can gain abnormal returns from the market by a strategy based on historical data. This should be due to the fact that such historical information is already reflected in the current prices. The semi strong efficiency is understood as the fact that no market player can obtain abnormal gains by using all publicly available sources of information. This is assumed because of the fact that such information are already reflected in the current prices. The third – strong efficiency – assumes that no market player can gain extraordinary returns, even if he or she would use all the information, both publicly available and hidden. This is assumed due to the fact that such information should be already reflected in the current prices (Dimson and Mussavian, 1998; Constantinides et al., 2003).

Testing the strong version of market efficiency is very hard. It is questionable how the hidden information can be measured. However, in case of semi strong efficiency hypothesis usually most important financial ratios are included in the analyzed model. Bulski and Gorski (2012) have, for example, indicated the following ratios: market capitalization, price to earnings ratio, price to book value, dividend yield, and beta risk factor.

The problem of the relevance of financial information has been discussed in literature. Usually, such considerations have been done within the context of a simple linear regression model. The independent variables have been taken as several financial ratios and the dependent variable is then the stock price. Often, instead of stock prices and financial ratios for several stocks a benchmark reflecting various stocks is taken and certain average of financial ratios.

It should also be mentioned that financial and non-financial organizations prepare in Poland financial statements ruled by different law regulations. In particular, banks are financial institutions, whose balance sheets and income statements differ slightly from those of non-financial institutions. As a result, their ratio analysis looks a bit different.

The most exploited by researchers are of course the developed markets. Among them a lot of studies have been taken on the U.S. market. For example, Baruch and Thiagarajan (1993) considered in their model several fundamental factors like: the change of inventories, the change of accounts receivables, the change of sales, the change of industry capital expenditures on research and development, the change of gross margin, the change of sales and administrative expenses, the change of gross receivables, the change of doubtful receivables, the effective tax rate, the change in order backlog, the change of labor efficiency, LIFO earnings and audit qualification. Currently, their research can seem to be a bit old. Indeed, they have examined selected financial reports from the period beginning on 1974 and ending on 1990.

Baruch and Thiagarajan (1993) constructed year by year cross sectional regressions. For each year they have taken between 140 and 180 sample consisting of companies' financial reports and their stock prices. They have not found a one significant behavior patterns. Certain variables impacted stock prices in some years positively, whereas in some year the impact was opposite. Also, the predictive power of the constructed models have been quite marginal. It was between 4% and 21% measured by R squared. Nevertheless, they have found that certain variables included in their models are statistically significant.

If the developed markets can be more efficient, the emerging ones can be less efficient in the context of accounting information. This can be the result of the fact that beginning investors are not used to developed analysis. If this statement is just a hypothesis, it is commonly accepted among researchers that emerging markets needs a careful attention and findings from the developed markets cannot be moved without any consideration on emerging markets. Indeed, they can be even more likely than developed countries to be influenced by local information (Harvey, 1995).

More recent analysis has been provided by Jung et al. (2015). They have examined a sample beginning on 2002 and ending on 2009. They have found that the analysis interest (i.e., the onset of analysts not covered in a company, but just participating in its earnings conference call) is positively correlated with future stock prices. Abarbanell and Bushee (1998) examined a sample of data beginning on 1974 and ending on 1993. For each year they have examined a sample of a size between 469 and 785 observations. As a result, they have found that the fundamental analysis can lead to abnormal returns from the market. In other words, the market efficiency was indicated no to be fulfilled. The significant determinants of stock returns were found to be inventories levels, accounts receivables, gross margin, selling expenses, capital expenditures, effective tax rate, inventory methods, audit qualifications, labor sales productivity. With these information they have claimed that the abnormal return of 13.2% yearly can be generated.

Bartram and Grinblatt (2015) have claimed that fundamental analysis can lead to abnormal returns of 9% per year. They have examined a sample beginning on 1977 and ending on 2012. They have not constructed simple linear models with independent variables as financial ratios, but rather estimated more developed financial models. Moreover, they focused on estimation of a fair value and mispricing of stocks.

Piotroski (2002) has constructed a specific factor score for a company. This score is based on return on assets, cash flow from operations, net income before extraordinary items depreciated by cash flow from operations, gross margin ratio, asset turnover ratio, leverage ratio, current ratio, and the binary variable indication issuing common equity. He has analyzed the period beginning on 1976 and ending on 1996. The finally selected sample consisted of over 14 000 observations (companies) from the American market. Piotroski (2002) has shown that by using certain strategies based on these financial information an investor can generate between 7.5% and 23% annual return.

Omran (2004) have examined a quite exotic emerging market, i.e., Egyptian one. For such a market it is important to notice that except common risks, a political risk is extremely high. Such effect can significantly influence its stock market. Omran (2004) have studies 46 Egyptian companies beginning the sample on 1996 and ending on 2000. Initially the sample consisted of more companies, but due to through check certain companies were excluded from the sample. The reliability of data is quite high as they were obtained from the Egyptian Capital Market Authority. Omran (2004) initially included as potential independent variables return on sales, return on assets, return on equity, earnings per share, assets turnover, inventory turnover, current ratio, quick ratio, debt ratio and inverse time interest earnings. By the stepwise backward regression variables were excluded from the model until all included variables become statistically significant at 5% significance level. As a result, only return on equity remained in the model as the independent variable. Omran (2004) considered two models: buy and hold strategy and cumulative one. However, this has not impacted the number of significant independent variables. The first model had quite poor predictive power – R-squared was only 14% for the buy and hold model and 6% for the cumulative strategy.

Lopes and Galdi (2007) have examined selected stock from Sao Paulo Stock Exchange (Brasil) between 1994 and 2004. They have found that returns between 6% and 27% can be generated if an investor would stick to fundamental analysis. As a potential stock returns determinants they have selected book value of equity, market value of equity, return on assets, current year change in cash and cash equivalents, net income, changes on non cash current assets decreased by current liabilities (except short term debt) and depreciation, changes in current ratio, changes in gross debt, changes in sales and changes in gross margin.

Martani et al. (2009) have analyzed the Indonesian Stock Exchange between 2003 and 2006. They have constructed simple linear regression models with independent variables as net profit margin, return on equity, current ratio, debt to equity ratio, total assets turnover, price to book value, total assets and cash flow from operations dividend by sales. For each year they have analyzed 195 companies. The obtained R squared for models were around 40%. It have been found that net profit margin, return on equity, sales divided by total assets, price to book value and total assets are statistically significant determinants of returns from stocks. Finding that total assets is significant determinant is an interesting result. It means that the returns from stocks depends on whether the firm is small or big (i.e., the size effect exists). Such an effect has been first observed by Banz (1981).

In case of the Polish stock market, there have also been some researches in the considered direction. For example, Czekaj et al. (2001) have examined the period beginning on 1994 and ending on 2000. In this time, Poland was not a member of the European Union and the country was during the economy transition. Indeed, the Warsaw Stock Exchange has been set up in 1991, and initially only five share were quoted. It is therefore not surprising that Czekaj et al. (2001) have found that although the market was usually efficient in this period, there used to be significant periods of notable market inefficiency. Indeed, Papla (2003) have examined also the very beginning period, dating back to 1991. He has found that the big stocks with high turnover and high market share behaved in an efficient way. On the other hand, small companies could have been assumed as inefficient ones. Drachal (2011) considered a small sample of biggest companies listed on the Warsaw Stock Exchange (from the WIG 20 list), and found no significant linear correlations between changes in total assets, net profit, sales, ROS, ROE and ROA with the change in a share price for the quarterly data from 2001 – 2010.

3. Methodology and Data

Basing on the above literature review and data availability, five financial information indicators have been selected for the purpose of this research. Additionally, five macroeconomic indicators have also been included. The following notation has been used herein:

- WIG – level in points of the benchmark index WIG,
- GM – average gross margin of firms (in percentages),
- ROS – average return on sales for firms (in percentages),
- CR – average current ratio for firms,
- PN – (in percentages) the number of firms generating positive net income divided by the number of all registered firms,
- SALES – total revenues of all firms (in mln PLNs),
- R – average interest rate for short term deposits (in percentages),
- INF – inflation (in percentages),
- GDP – gross domestic product in current prices (in mln PLNs),
- U – unemployment rate (in percentages),
- CA – current accounts divided by gross domestic product (in percentages).

The selection of the variables has been based on data availability and reliability. Indeed, all time series (except WIG) have been obtained from the Central Statistical Office of Poland (CSO, 2015). The WIG time series has been taken from Stooq (2015). Quarterly data have been used. The analysis has covered the period beginning on the first quarter of 2005 and ending on the second quarter of 2015.

The computation has been done in a free econometric software package (Gretl). A standard statistical and econometric methods have been applied (Brooks, 2008).

From Figure 1 it can be seen that when stock price are high, gross margin is also high, and vice versa. It can also be seen (although it seems less clear) that higher deposit rate occurs when stock prices are high and vice versa. It seems like deposit rate follows stock prices (the reaction is delayed in time). However, the selected time series presented on Figure 1 are not stationary. In other words, they do not look like scattered randomly around some flat axis, but indicate some trend patterns.

In order to fulfill the assumptions of the linear regression models the analyzed time series have been transformed. The subscript t denotes time indexing. For example, WIG_t represents the value of the variable WIG in time t.

In particular, the following linear equation has been at first estimated and analyzed:

$$\Delta WIG = \alpha_0 + \alpha_1 * \Delta GM + \alpha_2 * \Delta ROS + \alpha_3 * \Delta CR + \alpha_4 * \Delta PN + \alpha_5 * \Delta SALES + \alpha_6 * \Delta R + \alpha_7 * \Delta INF + \alpha_8 * \Delta GDP + \alpha_9 * \Delta U + \alpha_{10} * \Delta CA, \quad (1)$$

where

$\Delta WIG = \ln (WIG_t / WIG_{t-1})$,
$\Delta GM = GM_t - GM_{t-1}$,
$\Delta ROS = ROS_t - ROS_{t-1}$,
$\Delta CR = CR_t - CR_{t-1}$,
$\Delta PN = PN_t - PN_{t-1}$,
$\Delta SALES = \ln (SALES_t / SALES_{t-1})$,
$\Delta R = R_t - R_{t-1}$,
$\Delta INF = INF_t - INF_{t-1}$,
$\Delta GDP = \ln (GDP_t / GDP_{t-1})$,
$\Delta U = U_t - U_{t-1}$,
$\Delta CA = CA_t - CA_{t-1}$.

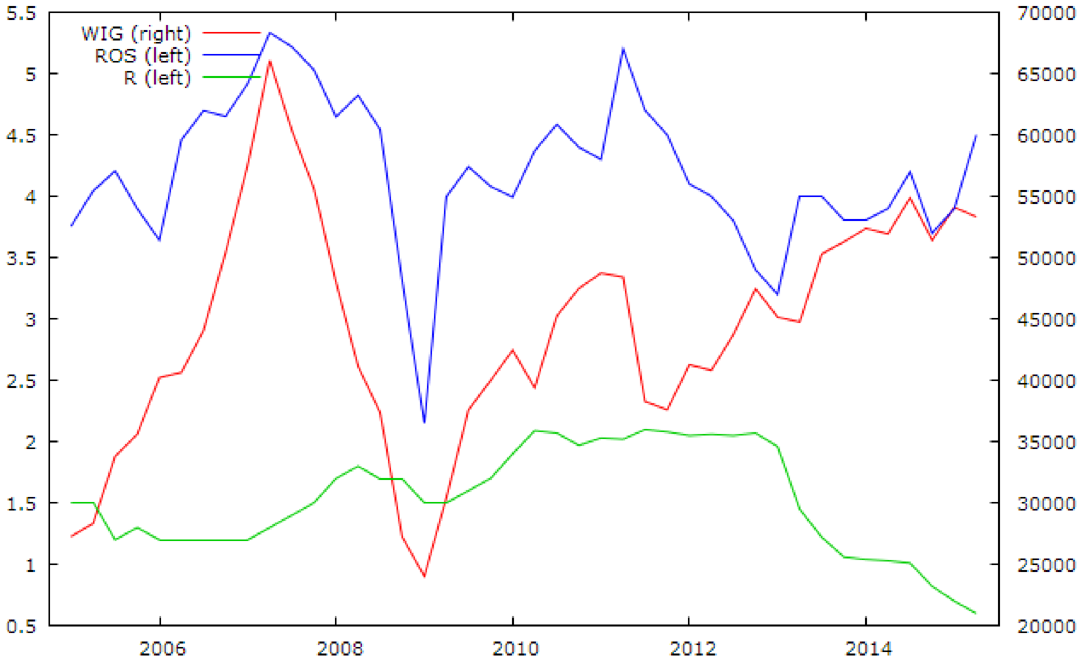

***Figure 1**. Selected time series*
Source: Own elaboration in Gretl

***Table 1**. ADF test*

variable	statistics	p-value
ΔWIG	-4.0980	0.0001
ΔGM	-6.2625	0.0000
ΔROS	-6.4058	0.0000
ΔCR	-2.5992	0.0091
ΔPN	-2.5992	0.0091
ΔSALES	-1.4194	0.1454
ΔR	-3.9728	0.0001
ΔINF	-4.7755	0.0000
ΔGDP	-0.8946	0.3288
ΔU	-2.1721	0.0287
ΔCA	-7.4697	0.0000

Source: Own elaboration in Gretl

Such transformations helped to obtain stationary data. The stationarity has been checked at 5% significance level by the ADF test. Lag order for the ADF test has been taken as 9, testing down from maximum lag order has been done with respect to the AIC criterion. The test without constant has been performed. The results have been presented in Table 1. After transformations all-time series (except SALES and GDP) are stationary. However, the KPSS test (p-value = 0.05) has indicated that SALES are stationary at 1% significance level. Also, for GDP (p-value = 0.01) KPSS test indicated that this variable is stationary at 1% significance level. In order to maintain the simplicity of the model no further transformations were made.

The above considerations allow to perform the linear regression for the Equation (1).

4. Results

Unfortunately, the first model estimated is not good. Assuming the 5% significance level, none of the included variables are statistically significant. On the other hand, the obtained model has moderate R squared (58%). Very high R squared would indicate very good predictive power, which could contradict the efficient market hypothesis. Therefore, moderate values seem to be more reasonable. The results of the first estimation are presented in Table 2.

In order to continue the analysis the backward regression has been performed. This method assumes that first all potential independent variables are included in the model. Then, such a model is estimated and it is checked whether all variables (except the constant term) are statistically significant at the given significance level. If yes, the model is further diagnosed. If not – the variable with highest p-value is dropped and such a modified model is estimated. The dropping of variables is performed until a model with all variables statistically significant is found.

Table 2. *First regression estimation*
OLS, using observations 2005:2-2015:2 (T = 41) Dependent variable: ΔWIG

	Coefficient	Std. Error	t-ratio	p-value
α_0	0.0170713	0.0197987	0.8622	0.3954
α_1	0.228099	0.195052	1.1694	0.2514
α_2	−0.0971563	0.212301	−0.4576	0.6505
α_3	1.02741	0.629921	1.6310	0.1133
α_4	0.00665947	0.0123705	0.5383	0.5943
α_5	−0.0622827	0.0970669	−0.6416	0.5260
α_6	−0.0972201	0.109548	−0.8875	0.3819
α_7	−0.0130641	0.0244371	−0.5346	0.5969
α_8	0.198215	0.58456	0.3391	0.7369
α_9	0.0400666	0.0278675	1.4378	0.1609
α_{10}	−0.0149587	0.0111237	−1.3448	0.1888

Mean dependent var	0.016360		**S.D. dependent var**	0.114511
Sum squared resid	0.221464		**S.E. of regression**	0.085919
R-squared	0.577770		**Adjusted R-squared**	0.437026
F(10, 30)	4.105128		**P-value(F)**	0.001261
Log-likelihood	48.85536		**Akaike criterion**	−75.71071
Schwarz criterion	−56.86142		**Hannan-Quinn**	−68.84684
rho	0.327765		**Durbin-Watson**	1.332021

Source: Own elaboration in Gretl

By the stepwise backward regression the model presented in Table 3 has been found. Finally, from ten initial variables only three remained in the model. Only one accounting information has remained in the model, i.e., the gross margin. However, two macroeconomic variables have remained: unemployment rate and current accounts. Herein, 10% significance level has been assumed. But, even at a 5% significance level GM and U are still statistically significant.

The model has moderate R squared, i.e., 51%. It means that only 51% of the variability of ΔWIG can be explained by the variability of the changes of gross margin, unemployment rate and current accounts. Therefore, it cannot be said that this research managed to beat the efficient market hypothesis in case of Poland.

Also, the diagnostic of the final model has been performed. The White's test has slightly indicated the heteroskedasticity of the residuals. However, from the Breusch-Pagan test there is no evidence at 5% significance level of heteroskedasticity. In other words, the variance of the error term of the model is constant with time, as the assumptions of the linear regression model require.

By the Jarque-Bery test there is also no evidence (a very high p-value) that errors are not normally distributed at 5% significance level. Therefore, another assumption of a linear regression is met.

By the Lagrange Multipliers test there is also no evidence of autocorrelation of residuals (p-value higher than 5%) at the 5% significance level. This is in agreement with the linear regression model assumptions.

Finally, the RESET specification test has indicated that the model specification is adequate at the 5% significance level.

The above considerations allow to state that the constructed model is good from the theoretical point of view. In other words, the estimated model has not violated the underlying theoretical assumptions. (Notice also that all the variables are stationary according to the ADF test at 5% significance level.)

Table 3. *Final regression estimation*

OLS, using observations 2005:2-2015:2 (T = 41) Dependent variable: ΔWIG

α	Coefficient	Std. Error	t-ratio	p-value	Sig.
α_0	0.0305104	0.0136376	2.2372	0.0314	**
α_1	0.162412	0.0290544	5.5899	<0.0001	***
α_9	0.0614518	0.0178973	3.4336	0.0015	***
α_{10}	−0.0181726	0.00939557	−1.9342	0.0608	*

* stands for 10% significance level, ** for 5% and *** for 1%

Mean dependent var	0.016360		**S.D. dependent var**	0.114511
Sum squared resid	0.257773		**S.E. of regression**	0.083468
R-squared	0.508546		**Adjusted R-squared**	0.468698
F(3, 37)	12.76224		**P-value(F)**	7.09e-06
Log-likelihood	45.74308		**Akaike criterion**	−83.48616
Schwarz criterion	−76.63187		**Hannan-Quinn**	−80.99020
rho	0.357111		**Durbin-Watson**	1.263461

White's test for heteroskedasticity - Null hypothesis: heteroskedasticity not present Test statistic: LM = 16.9929 with p-value = P(Chi-square(9) > 16.9929) = 0.0488278	**Test for normality of residual -** Null hypothesis: error is normally distributed Test statistic: Chi-square(2) = 0.83169 with p-value = 0.659783
Breusch-Pagan test for heteroskedasticity - Null hypothesis: heteroskedasticity not present Test statistic: LM = 5.52053 with p-value = P(Chi-square(3) > 5.52053) = 0.137416	**LM test for autocorrelation up to order 4 -** Null hypothesis: no autocorrelation Test statistic: LMF = 2.30751 with p-value = P(F(4,33) > 2.30751) = 0.0787195
RESET test for specification - Null hypothesis: specification is adequate Test statistic: F(2, 35) = 1.46498 with p-value = P(F(2, 35) > 1.46498) = 0.244906	

Source: Own elaboration in Gretl

As a result, the Equation (1) has been modified and estimated to have finally the following form:

$$\Delta WIG = 0.03 + 0.16 * \Delta GM + 0.06 * \Delta U - 0.02 * \Delta CA.$$

(Scatter plot and correlation matrix are presented in the Appendix.) The obtained estimates are interesting. First of all, the positive constant term indicate that there is a steady trend of increase of stock prices. Secondly, it seems natural that increase in gross margin results in an increase in stock prices, and vice versa. Third, it can be seen that increase in current accounts results in decrease of stock prices. This can be understood, if much of the demand on Polish stocks would be generated by foreign investors. Indeed, the negative current accounts indicate net borrowing by Poland from the rest of the world. The net inflow of foreign capital results then in increase of stock prices. But the forth conclusion seems to be a bit strange and shocking. The increase of unemployment rate results in higher stock prices. This result seems quite unnatural. High unemployment is not a positive sign in economy, therefore in such an economy investors should rather avoid investing their money. However, one can remind that there is a negative relationship between unemployment rate and inflation. Actually, the inflation variable and other interest rates has been dropped from the model. But one can follow the reasoning that if unemployment goes up, it is connected with smaller inflation. This can be connected with general decline in interest rates. This leads to "cheaper" capital, which can be invested on the market. So the demand on stocks can increase, and therefore, their prices.

5. Conclusions

The present research is robust to many factors. For example, it can be questioned whether the chosen ratios as the representatives of the information from the financial statements are proper. Indeed, it has been shown that although in literature there are certain sets of commonly used ratios, different researchers usually consider different ratios. Moreover, because of different habits, laws, policies, etc. the accounting information can slightly differ between various countries. As a result, the relevance of certain financial ratios can vary between countries and stock exchanges. Secondly, the financial ratios were considered for the whole economy - not restricted to stock exchange listed companies (this was done due to data availability).

Also, the behavioral aspect is an important one. In certain countries, investors can be more risk accepting, whereas in others the opposite may be true. On certain stock exchanges the role of investors using fundamental analysis can be higher and on others – smaller. This question can be widened on a following general problem: do the investors behave in a rational way? And finally, what is the quality of the used financial statement data (i.e., the audit quality).

Happily, in case of Poland most of the potential problems are the same as for the developed markets. Indeed, the Warsaw Stock Exchange is the biggest one in the Central and Eastern Europe. The audit standards are high and worldwide accepted. Poland is a member of European Union and perceived as a country with good "economic health". Nevertheless, it must be remembered that the problem of rationality of investors has been questioned and nowadays, it is not a dogma any more. Indeed, the behavioral finance are a dynamically expanding branch of finance in contrast with "homo oeconomicus" assumptions.

Herein, it has been shown that an increase in unemployment rate and/or gross margin leads to higher stock prices, whereas an increase in current account results in stock prices decrease. But the obtained model is characterized by relatively small R squared (indicator of a predictive power). The presented research, therefore, rather failed to show that the development of WIG index is really determined by certain macroeconomic and financial factors. However, such a result can still serve as another argument in favor of the efficiency of the Polish Stock Exchange.

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Appendices

Table 4. *Correlation matrix*

Correlation coefficients, using the observations 2005:2 - 2015:2

5% critical value (two-tailed) = 0.3081 for n = 41

ΔWIG	***ΔGM***	***ΔU***	***ΔCA***	***Δ***
1.0000	0.5665	-0.0042	-0.2990	***ΔWIG***
-	1.0000	-0.5535	-0.2247	***ΔGM***
-	-	1.0000	0.2227	***ΔU***
-	-	-	1.0000	***ΔCA***

Source: Own elaboration in Gretl

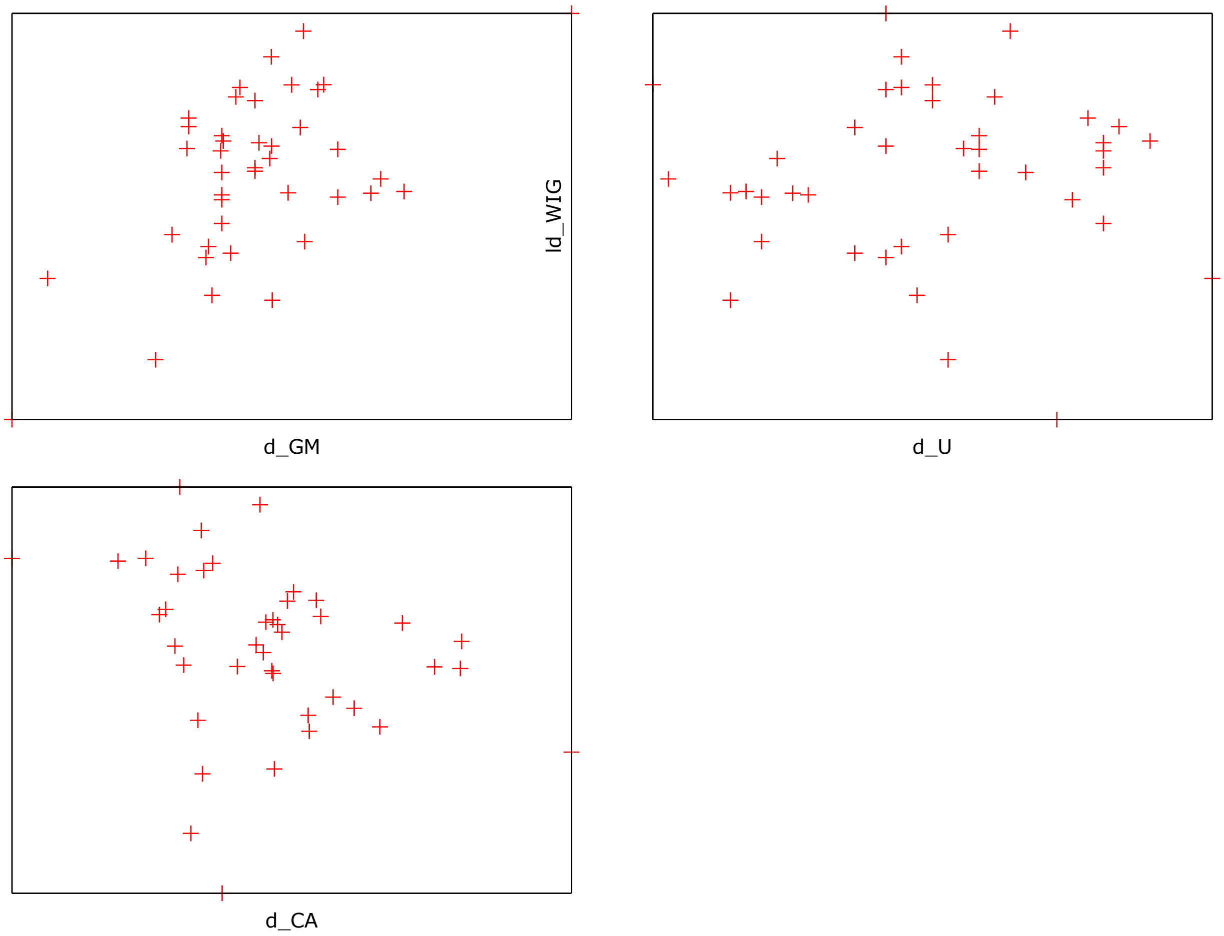

Figure 2. *Scatter plot of ΔWIG and ΔGM, ΔU and ΔCA*
Source: Own elaboration in Gretl

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