EQUILIBRIUM MODEL OF BUSINESS ARCHITECTURE USING PREMISES OF AGENT-BASED MODELING

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Abstract: *Business strategy correlated with marketing and management actions are tested on the market. Their efficiency can be measured by looking at financial indicators. In order to be competitive on the market firms are striving to ensure values of financial results greater than the minimum threshold level of profitability. One way to achieve this goal is by correlating organizational structure of the business with its financial architecture. The need to find new ways of enterprise management that best fit the current economic context needs to create a link between financial structure of the business and its developmental goals. In this sense, the paper analyses the use of implementing project management as a solution to ensure company's performance by adapting financial architecture to business strategic goals. Businesses are seen as a "fractal structure" made up of projects developed according to objectives planned. Firm's have their own propensity to consume or to invest. Each propensity has its own specific implementation structure. Dynamic equilibrium of the firm is ensured between its investment projects and repetitive tasks that ensure continuity and survival of the business. Any risk appearing at micro level during project implementation is channeled into the business environment through agents' constraint. According to agent-based modeling an organizational environment is made up of various agents playing different roles. Their decisions affect equilibrium of the firm, acting in according to various criteria and restrictions. Agents' decisions are correlated to their objectives and degree of "risk tolerance". Elements of fractal theory, game theory, econophysics, behavioral finance and agent-based modeling are powerful tools to measure and estimate the optimal business strategy to getting sound financial results. The paper develops a mathematical equilibrium model of a business that connects strategic and operational level to financial architecture taking into account the agents' attitude to risk.*

Keywords: *strategic management; risk; agent-based modeling; fractals; propensity to consume/ invest; budget constraint.*

JEL Classification: *D92; L14; M21.*

Introduction

Financial policy of enterprises has as main objective the financing of enterprises on the basis of efficiency and effectiveness criteria established and assumed by the management of each company. It includes aspects related to the optimal allocation of capital towards the achievement of business development objectives or projects. Decision to financing various projects managed by an enterprise is subordinated to going over several stages that succeed in time in a well-established order. The final outcome of the decision-making process is the choice of the most appropriate source of funding for projects managed by the enterprise (Popovici-Coita I.F., 2015).

Research related to the mechanism of financing a company's objectives has undergone various different steps in economic theory - from classical to modern-regarding equilibrium models of resource allocation. Current research paper deals with the analysis of relevant factors affecting financial decision under risk and uncertainty related to financing projects managed by enterprises. Individual decisions give form and structure to the economy. One cannot isolate notion of "decision" with that of the "economy". Also, investors or agents in the economy are primarily humans. Risks that may arise in financial decisions relate to human unpredictable nature (Popovici-Coita I.F., 2015).

1. Decision-making process on financing business at company level – factors involved

Utility is another concept used in economics to describe human decision making. This is a trigger for financial decision. The differences between various decision alternatives are actually *stimulus* that triggers the decision-making process (Popovici-Coita I.F., 2015). The alternative choice that provides the highest *expected marginal utility* is preferred to *homo oeconomicus*. The fundamental assumption of classical finance is based on the concept of *homo oeconomicus* is characterized by rational behavior aimed at maximizing its “expected utility” (Neumann and Morgenstern 1944; Markowitz, 1952).

Analysts were just interested in measuring aggregate economic phenomena by the year 1970. Work of Robert Lucas (1995) brought to light the interest for micro level analysis. It attracted the attention of scientists that the implementation of policies is reflected by a number of decisions of the people. This raises the importance of the decision at company level and the solution found by the economic theory on this issue by implementing projects to achieve organizational goals (Popovici-Coita I.F., 2015).

Classical economic theory puts in the center of research the rational agent oriented towards maximizing its utility from every financial transaction. Modern theories like game theory, behavioral finance, economic psychology, agent-based modeling speak about agent’s behavior that is guided by emotions reflected into strategies followed in order to maximize benefits from transactions whether it is about monetary return, psychological satisfaction or social benefits (Popovici et al. 2010, Popovici-Coita, 2015; Kahneman and Tversky, 1979; 1992; Kirchler et al., 2002; Kirchler, 2007).

The company’s portfolio of projects viewed as a „fractal structure”

Any human activity may be defined as a process. A series of coordinated processes unique to a particular purpose arising in a project. The economy as a whole represents the summation of all individual project results so that the economy appears as a portfolio of projects. There are various links between objectives of various organizations and that of state institutions leading to a complex structure of the entire economy at local and national level. This structure involves an economic organization of activities of each entity eithr public or private according to the objectives of their individuals using projects to achieve them (Popovici-Coita, 2015). However, the concept of using projects to finance various objectives is structured according to the purpose for which it is designed for so that one can build a project to fulfill the consumption needs of human nature, material, financial or otherwise. Thus, any project needs an object set which fits a certain financial structure to ensure

achievement of that objective. It can be seen that it creates a network of links between concepts like: objective and project financing.
Economy can be seen as a network of projects driven by specific purposes. One can thus speak of a country's economy as a complex project. Its subcomponents are projects of territorial administrative units which are subdivided into various projects of their local communities. All projects that make up the economy are interconnected in a network of fractal nature (Popovici-Coita, 2015).
A project implemented by an organization that seeks to achieve its objectives in this way is led by the an individual agent called manager of the project. Agent theory tells us that between the agent and the owner of the company in whose name he acts, there are several conflicts involved between their interests and also due to temporal difference between short-term goals of the people and long-term goals of the company as a whole (Kahneman and Tversky, 1974; 1981). "Homo economicus" engages in various transactions bearing specific purposes. In order to achieve them he has available a number of "tools". He is "limited" by "inputs" or resources in order to reach the "outputs" of the intended purpose.

2. Business model premises of agents' based modeling

This paper presents the model of business architecture used for financing a specific investment project by a company. Agent-based modeling offers an alternative to equilibrium equations measuring economic phenomena by introducing the measurement of variables in dynamics (Scarlat, Chiriţă, 2001: pp.23-37).The model starts of the premises that economy is seen as being made up of a very big number of different agents continuously trading with one another (Kahneman, 2002; Macal and North, 2006; Taleb 2007). They play different strategies according to the purposes they follow. Each category of agents described in the decisional model presents a specific attitude towards risk. There are several category of subjects that may present either risk aversion or risk appetite in financial situations or switch between them (Popovici-Coita, 2015: 107-109; Kirchler et al., 2002)
Economic model described in this paper presents an approach to measuring financial balance at project level by inserting elements such as time in quantifying the different levels of revenue and expenditure. The reason why imbalances occur in the projects' budget between revenue and expenditure is due to the lack of synchronization between receipts and payments. Time factor entered into the equation is used to generate indicators in the model, such as velocity of cost (v_c) and revenue (v_v) (Popovici and Tulai, 2010a; 2010b; Popovici et. al, 2010; Popovici-Coita, 2015: 111-118). The utility of the model is to identify "risk areas" generated by the lower velocity of revenue (v_v) overcome by superior velocity of cost (v_c) due to the time sequence of receipts and payment during the life of a project. Capturing the gap between cost and revenue is quantified in the model by identifying an "area" bounded by the velocity of cost and revenue. This is the risky area called "profit or loss area" because it can reflect a risk of financial imbalance when the velocity graphics of cost is superior to that of revenue. The dimension of the „ risky area" is a warning sign to the project manager on the emerging risk of cost not being recovered from the revenue generated by the project (Popovici-Coita, 2015:112). Classical modeling based on equilibrium equations is trying to capture an image of

a state in time. Therefore, the analysis of the model in the flow of time is done in dynamics by using agent-based modeling.

2.1. Premises of the model

The agent facing business financing decisions may be the owner of the company, the shareholders, the project manager or the financial manager. No matter who is responsible for this decision, he will have to choose a financial architecture suitable for the activity developed, based on a detailed analysis between various financial sources. Agent-based modeling can be used for financing decisions because it provides a "smart" and "dynamical" tool for selecting appropriate sources of funding for the projects developed (Macal & North, 2006).

Modeling agent's financial decision involves applying selection criteria over financial under several restrictions (Bloomquist, 2004).The mechanism of selecting financing for projects is the subject of the model described. This process involves two subtasks, namely the comparative assessment of funding alternatives to be included in the model and the actual decision over the form of financing that will be used. The first step in the selection process refers to collecting information regarding possible ways to finance projects. The decision maker will make a comparative analysis between them choosing the option that will be used to finance a particular project.

The model considers the activity of an enterprise consisting of both repetitive and unique processes. Repetitive processes are taking place regularly, supporting the entire activity of the enterprise. These processes require a minimum level of strategy and their regularity supports businesses survival. Despite regular ones, activities trying to achieve developmental objectives treated as investments are unique. The latter are implemented through projects. Project management implies decision making aiming at achieving a unique goal in a limited period of time with specific allocation of human or physical resources to achieve it. The project, by its very complex structure, requires a more complicated decision-making process in contrast with the regular ones. Who is therefore the agent facing the decision of financing a project?

Activity of a company is shared between two main goals: one refers to ensuring continuity of its operations from one period to another and the second refers to business development made through investments. Every company has a certain propensity for consumption or in other words for spending to ensure its operating activities and a specific propensity for investments. These two indicators reflect the share of consumption and investment made from the disposable income of the company, after deducting tax expenses from the total revenue of the company. In the model analysis, revenue comes from business sales for its core functions and does not include the revenue generated from the installments generated by the external financing source accessed for project developing (Popovici-Coita, 2015: 127-129).

a) Depending on the two main objectives defined at *company level,* the *budget constraint* is as follows (Popovici-Coita, 2015: 127-129):

• Static balance equation: $V_d = V(1-t) \Rightarrow V_c + V_i = V_d$

$$c * V_c + i * V_i = V'_d \Leftrightarrow c = \frac{\Delta V_c}{\Delta V_d}, i = \frac{\Delta V_i}{\Delta V_d}$$

• Dynamic balance is defined as:

V_c = part of disposable income for operating activities
V_i = part of disposable income for investment projects;
c = rate of operating expenses or propensity for consumption
i = rate of investment expenses incurred or propensity to invest
t = tax rate (the average tax liabilities of the company)
V = income or company's turnover;

V_d *- disposable income for consumption and investment within the enterprise;*

V'_d *- disposable income effectively allocated to investment projects and consumption of the enterprise.*

b) There can also be defined, *at project level, the budget constraint* with the following formula:

• *equation of static equilibrium*: $V_d^p = V^p(1-t) \Rightarrow V^p{}_c + V^p{}_i = V_d^p$

• *dynamic balance is defined as:*

$$c * V^p{}_c + i * V^p{}_i = V'^p{}_d \Leftrightarrow c = \frac{\Delta V^p{}_c}{\Delta V^p{}_d}, i = \frac{\Delta V^p{}_i}{\Delta V^p{}_d}$$

Where all the indicators reflect values the project level as follows (Popovici-Coita, 2015: 127-129):

V_c^p *= share of disposable income for project operating activities;*

V_i^p *= share of disposable income for project investment costs;*

c = rate of operating expenses or propensity for consumption at project's level;

i = rate of investment expenses or propensity to invest at project's level;

t = tax rate (the average tax liabilities at project's level)

V^p *= income from the projects' turnover;*

V_d *- disposable income for realization and operating the investment made through the project*

V'_d *- disposable income effectively allocated for realization and operating the investment made through the project*

The *budget constraint equation* reflects the disposable income left after paying all tax liabilities. This in turn is shared between company's regular business functions and investment projects for business expansion. The first category of costs is incurred regularly at specific intervals of time. The second category of expenditure is used for investment, which is carried out along a limited period of time. Investment objectives are unique and can be implemented through a project aimed at establishing and operating that investment (Popovici–Coita, 2015:128-129). In general, investment objectives are of high financial values and the company is able to implement such objectives only by access to external financing, from financial market, in addition to its internal cash resources generated by economic activity of

the company. Access to external funding for investment involves a period when the reimbursement of the external financing takes place for a number of years.

2.2. Model description

The model is built starting from the principle *of budgetary constraint* of each individual, entity or project in the economy. The model is based on assumptions that any investment materialized through a project may support a cost in its budget endurance limit according to the maximum capacity of revenue generated. An investment achieved through a project involves access to a range of financial sources by paying a price, which generates a cost that will be supported up to the maximum capacity of an investment generating revenue. In other words, "any investor will finance a project up to the level he is willing to lose money" (Popovici–Coita, 2015:130; Popovici and Tulai, 2010). *Agents' financing decision of a project is subject to budgetary constraint* (Popovici – Coita, 2015:129).

Funding decision function of the agent is build upon the values of the indicator "profit or loss area" quantified at project level. Derivation of cost (C) versus time leads to the velocity rate of cost (v_c). Similarly, the velocity rate of revenue (v_v) in the project is the derivation of revenue (V) over time (W. Gellert et al., 1980: p.503, Popovici-Coita, 2015: 111-118; Popovici et al. 2010).

The indicator „profit or loss area" is the diference of surfaces generated by the overlaping of the two areas described by the graph of velocity of revenue and that of cost specific at project level (Popovici-Coita, 2015:124). *This is calculated according to the formula (it is considered that* t_0 *=0)*:

$$Z_R^n(t) = \int_{t=1}^{n} \left(v_v(t) - v_c(t)\right)dt$$

And, the component indicators are as follows.

$$\int_{t=1}^{n} v_V(t)dt = (t_1 - 0) * V_1 + (t_2 - t_1) * V_2 + (t_3 - t_2) * V_3 + ... + V_n(t_n - t_{n-1}) = \sum_n V_n(t_n - t_{n-1})$$

where: V_n *= represents the revennue realized along the period t,* $t = \overline{1,n}$.

$$\int_{t=1}^{n} v_C(t)dt = (t_1 - 0) * C_1 + (t_2 - t_1) * C_2 + (t_3 - t_2) * C_3 + ... + C_n(t_n - t_{n-1}) = \sum_n C_n(t_n - t_{n-1})$$

where: C_n *= the spending made along the period* $t = \overline{1,n}$.

Differentiating the above identities we get the following result:

$$Z_R^n = \sum_n \left(t_n - t_{n-1}\right) * \left(V_n - C_n\right),$$

Firstly, the funding decision function of the agent is defined according to the formula (Popovici–Coita, 2015:131):

$$F(Z_R, R) = \begin{Bmatrix} 1 \Leftrightarrow Z_R(t) \geq 0 \wedge R(a_r, t) \in \{0;1;1,5;2;2,5;3\} \\ -1 \Leftrightarrow Z_R(t) \geq 0 \wedge R(a_r, t) \in \{3,5;4;5\} \\ 1 \Leftrightarrow Z_R(t) < 0 \wedge R(a_r, t) \in \{3,5;4;5\} \\ -1 \Leftrightarrow Z_R(t) < 0 \wedge R(a_r, t) \in \{0;1;1,5;2;2,5;3\} \end{Bmatrix},$$

Secondly, a negative constraint of the disposable income of agents' decision is defined according to the following formula (Popovici – Coita, 2015:131-133):

$$Z_R(t) = V_i(t) \wedge Z_R < 0$$

This indicates the maximum negative value can be achieved by the project profitability indicator Z_R in terms of financial supportability of project expenditure from the disposable revenue of the enterprise budget for investment (V_i).

3. Applications of the model in the decision making process of financing a project

In the above formula for there is the indicator a_r that reflects likelihood of a financial imbalance in the equality of income and expenditure in the project's budget, at a point in time t. This indicator offers information to describe the shape of risk by providing a score for the type of risk associated (for a thoroughly explanation of a_r please see Popovici – Coita, 2015:133-134; Popovici et al., 2010). Function $R(t)$ is used for describing risk using scores attached to the likelihood of appearance (Popovici et al., 2010).

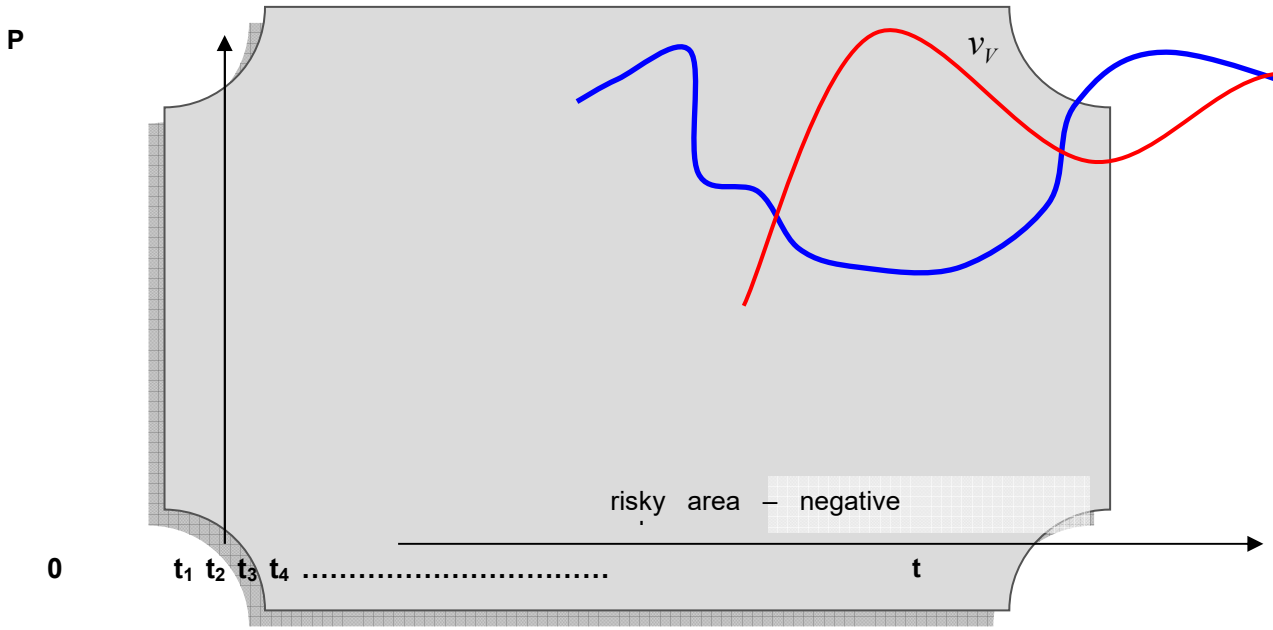

Figure 1 Negative value of the area described by the indicator Z_R
Source: Popovici-Coita I.F. (2015: 125)

Any negative value of the indicator Z_R shows the level of cost expressed by the velocity rate of spendings (V_{ch}) exceeds the limit imposed by the velocity rate of revenue (V_V) available for investment in the budget's company (V_i) and creates the premises for financial imbalances at project level. This restriction acts like a channel for inducing a potential financial imbalance to the company's budget. A negative value of the indicator reflects a shortage of liquidity in the project, whose maximum limit can be up to the revenue generated from investment added to the available revenue for the project from the enterprise self-financing sources (V_i). In this way, the risk of financial imbalance identified at the project level can lead to a financial risk for the company implementing the project through the negative influence of financial indicators due to the risk of financial imbalance at project level. This is caused by the erosion of disposable income at the company level from losses arising from a particular investment project (Popovici – Coita, 2015:133).

A positive value of this indicator (Z_R) shows a monetary surplus of the overall balance between revenue and expenditure of the project. Therefore, a negative value indicates that there is a gap between revenue and cost so this is a warning sign to the manager that the project may generate losses that income level may not be sufficient to cover its costs. Positive values of the indicator reflects a favorable state of the project able to ensuring necessary and sufficient financial resources for a high degree of profitability of the investment. Negative values act as a signal that the risk of financial imbalance must be removed (Popovici-Coita, 2015:127).

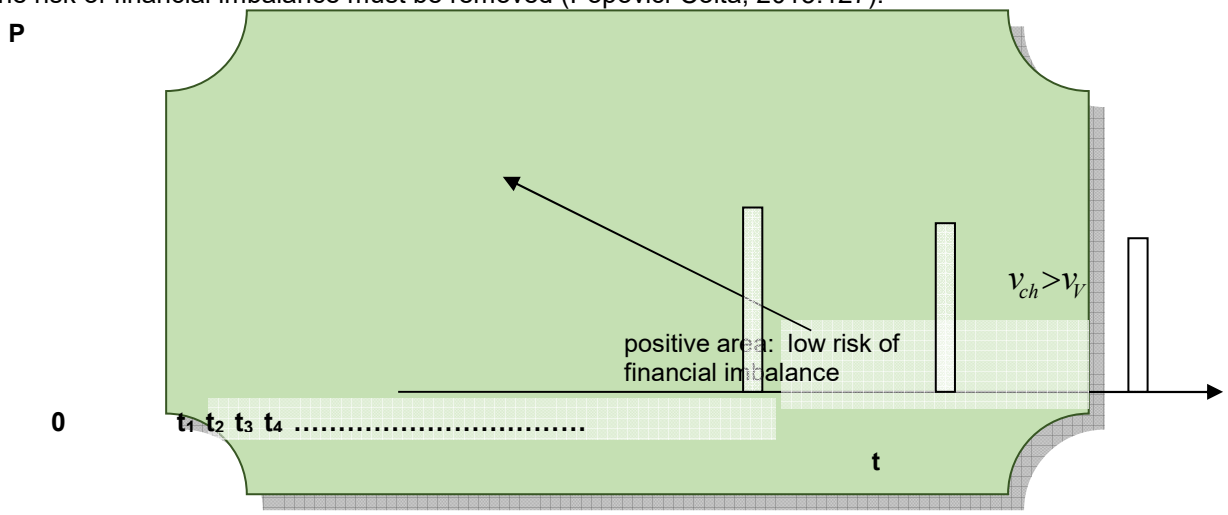

Figure 2 Positive value of the area described by the indicator Z_R
Source: Popovici-Coita I.F. (2015: 125)

If velocity of revenue and cost are used to measure and estimate the risk of financial dynamics (Popovici et al. 2010; Popovici and Tulai 2010a; 2010b), the "profit or loss area" (Z_R) reflects a state characterizing the *global equilibrium of financial*

*imbalance at project leve*l. The managers' financing decision is built according to the shape of the risk of a financial imbalance in the project based on the values of the indicator Z_R (Popovici-Coita, 2015:127-128).

Conclusions

Research limitations refer to the fact that no economic model will accurately capture all of the real phenomena because they act as theoretical abstractions used for studying different real phenomena.

Innovative elements of current research refer to defining a set of indicators for measuring financial balance at project level and consequently from a company's perspective. They are based on concepts of nonlinear dynamics, econophysics, and fractals. The indicators are used as selection criteria for decision making model of business financing mix. The agents' decision regards what type of funding will be used for project implementing according to the agents' degree of risk born, estimated through the indicators above.

Research has shown that concepts such as agent, project and goal are interconnected. The organization of human activity in general has a complex structure as a "fabric" that resembles to "Sierpinski's triangle", a geometrical fractal figure (Popovici-Coita, 2015:9). This is a geometric shape that has a fractal structure because the closer you look into it you can observe "copies" of the entire picture. In a similar way looks the structure of an organization (Mandelbrot, 1983). The company consists of projects to achieve objectives corresponding to humans, as well as individuals interconnected to each other through the network of projects.

Financing a business decision is connected to the goal, financial value and available sources of financing the project from the financial market.

The practical utility of the model consists of the fact that it sizes the possibility of financial imbalances in the project through the "profit or loss area". This is a warning sign for future financial troubles in the project budget. Analyzing this indicator, agent decides towards minimizing the losses of the project and reduces the probability of financial imbalances in the project according to his specific attitude towards risk, either appetite or aversion or a switch between them.

References

1. Bătrâncea L. (2009) *Teoria jocurilor, comportament* economic, experimente, Risoprint, Cluj Napoca
2. Bloomquist K. (2004) *A comparison of Agent-Based Models of Income Tax Evasion,* Internal Revenue Service, Office of Research Washington, D.C., USA
3. Kahneman D.& Amos Tversky (1981) *The Framing of Decisions and the Psychology of Choice*, Science, New Series, Vol. 211, No. 4481. (Jan. 30, 1981), pp. 453-458. URL: http://links.jstor.org/sici?sici=00368075%2819810130%293%3A211%3A4481%3C453%3ATFODAT%3E2.0.CO%3B2-3, accesed at 5.06.2008
4. Kahneman D. & Amos Tversky (1974) *Judgment under Uncertainty: Heuristics and Biases*, Science 185,n o. 415 (1974): 1124–1131
5. Kahneman D. (2002) *Maps Of Bounded Rationality: A Perspective On Intuitive Judgment And Choice*, Prize Lecture, December 8, available at http://www.nobelprize.org/nobel_prizes/economicsciences/laureates/2002/kahnemann-lecture.pdf, accesed at 19.04.17

6. Kahneman D. & Amos Tversky (1979) *Prospect Theory. An analysis of decision under risk*, Econometrica, Vol. 47, Issue 2 (Mar. 1979)
7. Kahneman D. & Tversky A. (1992) *Advances in Prospect Theory: Cumulative Representation of Uncertainty*, Stanford University, Department of Psychology, Stanford, Journal of Risk and Uncertainty, 5:297-323 (1992), Kluwer Academic Publishers
8. Kirchler E. (2007) *Psihologia economică a comportamentului fiscal*, Risoprint, (2013), Cluj Napoca, translation by Larissa – Margareta Bătrâncea of the book *The Economic Psychology of Tax Behavior,* Syndicate of the University of Cambridge, published 2007, 2009 (paperback)
9. Kirchler E., Hölzl E., Rodler C. (2002) *Hindsight Bias in Economic Expectations:I Knew All Along What I Want to Hear,* Journal of Applied Psychology, Vol. 87, No. 3, 437–443, American Psychological Association, Inc., DOI: 10.1037//0021-9010.87.3.437
10. Lucas R. (1995) Nobel Prize Lecture, available online at: http://www.nobelprize.org/ nobel_prizes/economic sciences/laureates, accesed at 04.04.2008
11. Macal C., North M. (2006) *Tutorial on agent-based modeling and simulation part two: How to model with agents*, Proceedings of the 2006 Winter Simulation Conference, Center for Complex Adaptative Agent Systems Simulation Decision & Information Sciences Division, Argonne National Laboratory, USA
12. Mandelbrot B. (1983) *The Fractal Geometry Of Nature, Updated anld Augmented*, International Business Machines Thomas J. Watson Research Center Freeman and Company, New York
13. Markowitz H. (1952) The Utility of Wealth, The Journal of Political Economy, Vol. 60, No. 2. (Apr., 1952), pp. 151-158.
14. Neumann J., Oskar Morgenstern (1944) *Theory of games and economic behavior*, Princeton University Press, Bulletin (new series) of the American Mathematical Society Volume 37, Number 1, Page 103,S 0273-0979(99)00832-0, Article electronically published on December 21, 1999
15. Popovici I., Scarlat E., Boloş M. (2010) *Agent-based modeling in decision-making for project financing*, published in the Journal „Economic Computation & Economic Cybernetics Studies & Research Services; Apr.2011, Vol. 45 Issue 2, p1
16. Popovici I (2010) *Premises of an Agent-Based Model Integrating Emotional Response to Risk in Decision-Making*, published in Intelligent Decision Technologies, Smart Innovation, Systems and Technologies Volume 10, 2011, pp 237-245
    a) Popovici I. F., Tulai I. C. (2010) *Modeling Risk using Elements of Game Theory and Fractals*, paper published in Finante - provocarile viitorului (Finance - Challenges of the Future) 01/2010; 1(11):79-83. Source: RePEc
    b) Popovici I. F., Tulai I. C. (2010) *Premises of a decision model in financing projects*, paper published in the Annals of the University of Oradea : Economic Science 01/2010;
17. DOI:http://www.doaj.org/doaj?func=openurl&genre=article&issn=1222569X&date=2010&volume=1&issue=1&spage=394, Source: DOAJ.

18. Popovici-Coita I.F. (2015) *Iluzia deciziei raționale? – aspecte inovative din prisma teoriei fractalilor, econofizicii, finanțelor comportamentale*, Casa Cărții de Știință – Cluj Napoca, ISBN: 978-606-17-0813-0.
19. Scarlat E. & Chiriţă N. (2001) *Macroeconomie dinamică*, Ed. Economică, Bucureşti
20. Taleb N. (2007) *The Black Swan: The Impact of the Highly Improbable*, Penguin, London.