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Econophysics, Sociophysics & Multidisciplinary Sciences Journal (ESMSJ) of Research Center for Advanced Materials provides a resource of the most important developments in the rapidly evolving area of Econophysics, Sociophysics & other new multidisciplinary sciences, advanced materials, and related fundamental concepts. The journal contains articles from Physics, Econophysics, Sociophysics, Quantum Economics, etc and advanced materials.

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EXPLORATORY DOMAINS OF ECONOPHYSICS.NEWS

Papers of the workshops

EDEN III

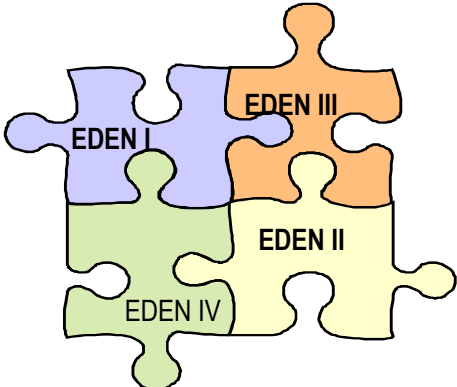### The first part

The 15th of July 2010

English version and harmonization of the scientific language
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UPIT - CCMA

INTERNATIONAL WORKSHOP PROGRAMME
EDEN III
THE 15TH OF JULY 2010

	9h30 – 14h00 **MORNING SESSION** **Econophysics. New Exploratory Domains**	**15h30 – 19h00 -** **AFTERNOON SESSION** **Econophysics. New Exploratory Domains**	
9h30	**Opening speech** **Rector of the University of Pitesti – Gheorghe BARBU**	**S. S. MISHRA and D. C. SHUKLA** *Cost and profit analysis of a non-empty queue*	15h30
9h50	**Gheorghe SĂVOIU Ion Iorga-SIMAN** **Ioan ŞTEFĂNESCU, Ondrej JAŠKO,** **Ana JAŠKO, Mladen ČUDANOV** *A multiverse of disciplines in contemporary scientific research*	**Mircea GLIGOR** *Statistical properties of weighted macroeconomic networks*	16h00
10h20	**Mircea GLIGOR, Marcel AUSLOOS** *Mapping macroeconomic time series into weighted networks*	**Gheorghe SĂVOIU, Ion IORGA-SIMĂN** *The concept of time in the physical way of thinking, and its impact on knowledge and the evaluation of inflation as an economic phenomenon*	16h30
10h50	**Daniel Traian PELE** *Revisiting stock market assumptions. Application for Romanian stock exchange*	**Mila MITIC** *Clouds over information systems development process*	17h00
11h20	**S. S. MISHRA and D. C. SHUKLA** *Performance analysis of truncated multi-channel queue*	**Constantin MANEA, Maria-Camelia MANEA** *Some significant aspects and problems of translation in multidisciplinarity scientific research*	17h30
11h50	**Coffee break**	**Coffee break**	18h00
12h20	**Ondrej JAŠKO, Mladen ČUDANOV, Jovan KRIVOKAPIĆ, Jevtić MILOŠ, Gheorghe SAVOIU** *Classical solutions for improvement of restructuring process and representation of organizational structure and alternative future solutions of quantum economics*	**Moderators: Gheorghe SAVOIU** **Ion IORGA-SIMAN**	
12h50	**Ioana-Roxana CHISLEAG LOSADA,** **Radu CHISLEAG** *Corruption from antique astronomy to contemporary everyday life*	**Final discussions**	18h30
13h20	**Aretina Magdalena DAVID-PEARSON** *Calculating credit risk for a portfolio of fixed-rate bonds*	**Workshop closing**	19h00
13h50	**Lunch break**		

EDEN III
EDEN I
EDEN II
EDEN IV

CONTENT

A BRIEF PRESENTATION OF
THE EXPLORATORY WORKSHOPS

EDEN I	EDEN II	& EDEN II
2008, 20th of March,	**2009, 20th of March,**	**2010, 15 [th] of July,**
University of Pitesti	**University of Pitesti**	**University of Pitesti**
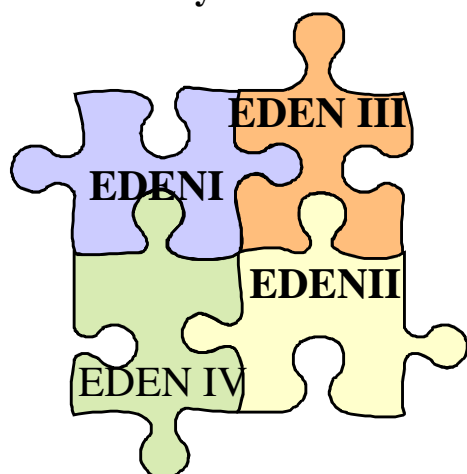
The objectives of the workshops are a brief presentation of the history of Econophysics and the remarkable evolution of research in this inter-, multi-, and trans-disciplinary field, an applicative detail presentation emphasizing its impact on the sphere of the issues relevant of educational, research, banking, finance and administrative institutions, as well as an inventory-drawing of the resources, authors, links, institutes and forms of actively and permanently promoting the new domain in Romanian banking, financial, academic and higher education institutions; the final round tables will make a thematic repertory of new exploratory domains to be applied in Romanian banks and universities, as well as scientific research in Romania, some possible alliances of the Romanian economists and physicist within the new domains in Econophysics, and the necessity of the workshop as a good collaborative work by economists, engineers, physicists, informaticians, statisticians, econometricians, and mathematicians.

The themes of the workshops are defined by the prospective exploration of the Romanian and European academic potential and the inventorying of other exploratory domains of applicative research through Econophysics. The detail presentation of the extraordinary evolution of the researches carried out within the inter-, multi- and trans-disciplinary science of Econophysics is followed by the results of two researches on financing and accreditation of a number of academic and research institutions, the drawing of the resource repertory, and the nucleus of the first national association of econophysicists. The aim of EDEN II and III is to draw the repertory of some new fields of using Econophysics and other multidisciplinary slutions, which can be reordered along the classical coordinates of Econophysics, but also along the new coordinates of Sociophysics, also intending to detail the evolution of the econophysical models already turned classical, too. The detailed presentation of the applied researches of Econophysics on modelling uncertainty in economy, on decision in today's specific uncertainty context, of interest conflicts, in international

academic mobilities, or in the didactic processes specific to this new discipline, continues with drawing a repertory of the resources, and, concretely, by founding the first association of the econophysicists in Romania, as well as the papers' presentation of the new RCAM & Econophysics Journal (on–line).

Detailed presentation of workshop's research themes:

The neologizing of the term Econophysics by Rosario Mantegna and H. Eugene Stanley, during the second Statphys-Kolkata Conference in 1995, represents the official document of Econophysics, born as a new, interdisciplinary, multidisciplinary and transdisciplinary science. Physics has probably had a dominating effect on the development of formal economic theory; however, the historical interdisciplinarity between physics and economics, established through Econophysics, seems very likely to be a model for the future of the multidisciplinary sciences. Transdisciplinarity suggests a deeper synthesis of approaches and ideas from the two main disciplines involved in Econophysics, during a short or medium period of time. The same importance must be given to all interactions between economics and physics, and also between the two types of scientific researchers and demographers, sociologists, mathematicians, linguistics, etc. The periodical meeting of such a multidisciplinary group capable, at first, of constituting the initial nucleus of a potential association of the Romanian econophysicists will be done in the coming years, too, more extensively during the annual workshop (EDEN II,III,IV), to which will be added, starting with 2009, a national conference with international participation, which would be able to develop both the academic scientific research, and the curricula of a number of multidisciplinary MA programmes, primarily oriented towards the graduating physicists and economists. All these aspects represent a necessary detailing of the initial thematic presentation, as well as a welcome prologue before the presentation of the historical evolution of contemporary Econophysics. The contemporary stage of development and especially the dynamics of Econophysics, are really exceptional. Some historical opinions about it maintain that statistical mechanics or physics was developed in the second half of the 19th century by James Clerk Maxwell, Ludwig Boltzmann, and Josiah Willard Gibbs, but others reveal that the role of physics models as foundations for the standard neoclassical model that current econophysicists seek to displace is much older than two centuries, the best arguments being N.F. Canard's 1801 work, where supply and demand were ontologically presented as contradicting physical forces, or central concept of general equilibrium theory in economics, in which its author, Léon Walras, was deeply influenced by the physicist Louis Poinsot, and mostly because the father of American mathematical

economics, the well-known statistician Irving Fisher, was a student of the father of statistical mechanics, none else but Josiah Willard Gibbs. But all of these historical opinions agree unanimously that the primordial roots in statistical mechanics approach date back to 1936, when Majorana wrote a pioneering paper, published in 1942 and entitled *Il valore delle leggi statistiche nella fisica e nelle scienze sociali*. First of all, the application of concepts as power-law distributions, correlations, scaling, unpredictable time series and random processes to financial markets was possible only after physicists have achieved important results in statistical mechanics, due to other significant statistical investigations and mathematical formalizations. The oldest example of an adequate law or mathematical distribution to the wealth of individuals in a stable economy belongs to the Italian economist and statistician Vilfredo Pareto. Secondly, the progress of the financial mathematics realized by Louis Bachelier in his doctoral thesis entitled *Théorie de la speculation*, published in 1900, which quantifies the probability of price changes and the differences of the logarithms of prices that are distributed in a Gaussian manner, and thus is an anticipation of Albert Einstein's or Norbert Wiener's researches. Three major events underline the evolution of econophysics, first in 1973, with the appearance of a rational option-pricing formula, such as Black & Scholes' formula, then after 1980, the huge amount of electronically stored financial data readily available, and finally since the 1990s, a growing number of physicists have attempted to analyze and model financial markets and, more generally, economic systems, new interdisciplinary journals have been published, new conferences have been organized, and a lot of new potentially scientific fields, areas, themes and applications have been identified by this new trans-disciplinary science. The researches of econophysics deal with the distributions of returns in financial markets, the time correlation of a financial series, the analogies and differences between price dynamics in a financial market and physical processes as turbulence or ecological systems, the distribution of economic stocks and growth rate variations, the distribution of firm sizes and growth rates, the distribution of city sizes, the distribution of scientific discoveries, the presence of a higher-order correlation in price changes motivated by the reconsideration of some beliefs, the distribution of income and wealth, the studies of the income distribution of firms and studies of the statistical properties of their growth rates. The new real characteristics of Econophysics in a medium and long term will be a result of its new research like rural-urban migration, growth of cities, etc. The real criticism of econophysics is the absence of age variable, because models of Econophysics consider immortal agents who live forever, like atoms, in spite of the evolution of income and wealth as functions of age, that are studied in economics using the so-called overlapping-generations models (Paul Anglin). The first econophysics models published by physicists in a physics journal were those of Mantegna (1991) and Takayasu (1992), though developed a few years earlier. Even a Monte Carlo simulation of a market was published as early as 1964 by Stigler from the Chicago economics school. Nobel laureate of Economics, Markowitz H.M. published, too, with Kim a model for the

1987, about the crash on Wall Street. After the year 2000, econophysics has matured enough to allow generalized applications, their field being called sometimes econo-engineering. We believe that the second workshop EDEN II is a welcome resuming of EDEN I, which was conducted in good felicituosly, as well (as can be seen on the site of the centre for research in advanced materials of the University in Piteşti (http://www.upit.ro/ccma/), from the own resources of the moderators and organizers (Gheorghe Săvoiu and Ion Iorga–Simăn), or supported by the keyspeakers, using the academic spaces and equipment of the University in Piteşti (the moderators and organizers acknowledge to the leading staff of the University in Piteşti for their accommodation support). EDEN II's main aim is to draw the repertory of some new fields of using econophysics, which can be reordered along the classical coordinates of econophysics, but also along the new coordinates of sociophysics, also intending to detail the evolution of the econophysics models already turned classical, but also along the new coordinates of index physics or the physics of the price indexes (able to measure both inflation, and the specialized stock-exchange evolutions), of demographysics, or through econophysics prognosis, a sub domain that combines a better time projection of phenomena, much better calibrated extrapolations and interpolations in the economic, demographical, crime-related, electoral, etc. world. The workshop also materializes in its presentations, through those invited holding the quality of keyspeaker, two practical approaches of econophysics resulting from applying statistical physics, in an original manner and with very interesting results, to the field of financing and accreditation of a number of academic and research institutions. The special potentiality of econophysics will thus be able to reveal to the rest of the people invited, more especially to those belonging to the academic milieus and the disciplines related to management, statistics and finance-banking, to bank managers, mathematicians, physicists, linguists, etc. Its innovative and applicative character is also evinced by the careful repertory-drawing of the principal applications of econophysics, substantiated in the papers that are to be published and presented during the international conferences and symposia, and, moreover, through the investigation, in the latter half of the workshop, of the part played by econophysics, and its main potential fields of application. In order to manage a good collaborative work by economists and physicists, the workshop presents, in its second part, some of the differences existing at present between economics and physics in their own scientific research work, but also between economists and physicists. Since econophyisics was officially born, Romanian scientific researchers in this multidisciplinary field have published a lot of important papers. Among these pioneers one must necessarily mention Adrian Drăgulescu, Radu Chişleag, Mircea Bulinski, Carmen Costea, Mircea Gligor, Margareta Ignat, etc. Since 2003, when the first book entitled *Econophysics* was published, in Romania, by Mircea Gligor and Margareta Ignat, followed four years later by *Investment Econophysics*, written by Anca Gheorghiu and Ion Spinulescu, and up to now, a few round tables and satellite workshops have been dedicated to econophysics, including

even summer schools of econophysics and complexity – its 3rd edition was held in 2007. The above facts trigger the need for the workshop EDEN II to invite some well-known engineers, IT specialists and econophysicists, to a European and international level, as key-speakers (H. Schjær-Jacobsen, Wolfgang Ecker-Lala, Aretina-Magdalena David-Pearson), and to continue a process of repertory-drawing for the internal resources, and making up the nucleus of the first Romanian association of the econophysicists, followed by at least two other workshops, and annual conferences or symposia, which will consolidate the young school of Romanian econophysics (the first ones, EDEN I and II, have already taken place) the third workshop, EDEN III, we hope will take place and be honoured by the participation of the representatives of the Belgian school led by Professor Marcel Ausloss, hence the invitation addressed to Professor Mircea Gligor from Romania, who has been part of professor Ausloss's team, and the fourth edition, EDEN IV, aims at ensuring the participation of the representatives of the school of econophysics in Boston, including the Romanian Adrian Drăgulescu, whence the invitation to the Romanian researcher Constantin Andronache from Boston. The young econophysicists will grow up within this context of Romanian econophysics, turning to account the relations formed, in the course of time, with schools of international research in the domain, which have already reached scientific prestige). Debating the role and the potential of econophysics for Romanian scientific research is now not only an opportunity, but also a necessity for normal evolution both teaching and research in physics and economics. Consequently, the objectives of the workshop are a brief presentation of the history of econophysics' models and the remarkable evolution of research in this inter-, multi-, and trans-disciplinary field, and in the contemporary multiverse of disciplines. An applicative detailed presentation emphasising its impact on the sphere of the issues relevant for the decision in education, research, banking, finance and administrative institutions, as well as to continue an inventory-drawing of the resources, authors, links, institutes and forms of actively and permanently promoting the new domain in Romanian banking, financial, academic and higher education institutions. All the final round tables and discussions identify differences and resemblances existing at present between economics and physics, in their own scientific research work, but also between economists, mathematicians, informaticians, engineers, statisticians, econometricians, and physicists in this new job called econophysicist.

Estimated outcomes

1. The publication, in a newly created journal having this purpose, already named *RCAM & Econophysics Journal*, of the abstracts of the lectures and presentations delivered by the key-speakers, as well as the syntheses of the potential domains, and the summarized contents of the debates on the round table topic;

2. The integral publication of the papers and discussions in a book entitled *Exploratory Domains of Econophysics. News* (**EDEN I & II**);

3. The detailed presentation of an approach to econophysics and its specific model of analysis of financing and accrediting a number of institutions within the framework of higher education, available of the site of the Research Center for Advanced Materials.

4. The concrete identification of a number of criteria of potential demand as far as research of the Romanian banking market by means of Econophysics is concerned.

5. Scheduling and achieving, in 2011, a special workshop devoted to econophysics (EDEN IV);

6. Scheduling and achieving an international conference, starting 2012, also devoted to econophysics and to other aspects of multidisciplinarity (EDEN V).

7. A site of econophysics for permanent and malleable dialogues meant to promote the future international workshops and conferences (http://www.upit.ro/ ccma/).

List of keyspeakers during EDEN I, II & III:
Professor Hans Schjær-Jacobsen, PhD, Copenhagen University College of Engineering,
Professor Wolfgang Ecker-Lala, PhD, MATH-UP, Viena University,
Professor Radu Chişleag, PhD, Polytechnical University, Bucharest,
Professor Carmen Costea, PhD, A.S.E Bucharest,
Professor S. S. Mishra, PhD, Avadh University, Faizabad, India,
Professor D. C. Shukla, PhD, Avadh University, Faizabad India,
Professor Ion Iorga-Simăn, PhD, University of Piteşti,
Professor Ana Jaško, PhD, Faculty of Organizational Sciences, University of Belgrade, Serbia,
Professor Ioan Ştefănescu, PhD, University of Piteşti,
Professor Ondrej Jaško, PhD, Faculty of Organizational Sciences, University of Belgrade, Serbia,
Senior Lecturer Gheorghe Săvoiu, PhD, University of Piteşti,
Senior Lecturer Constantin Manea, PhD, University of Piteşti,
Senior Lecturer Maria-Camelia Manea, PhD, University of Pitesti,
Lecturer Aretina-Magdalena David-Pearson, PhD, Polytechnical University, Bucharest,
Lecturer Daniel Traian Pele, PhD, University of Economics Bucharest,
Lecturer Mladen Čudanov, PhD, Faculty of Organizational Sciences, Belgrade, Serbia,
Research Associate Constantin Andronache, PhD, Boston College, Information Technology, USA,
Associate Professor Mircea Gligor, PhD, National College Roman Vodă, Roman,
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Project manager in 2008: Ion Iorga-Simăn
Project manager in 2009: Gheorghe Săvoiu
Project managers in 2010: Gheorghe Săvoiu and Ion Iorga-Simăn

Editors in chief: Gheorghe Săvoiu &Ion Iorga Simăn

A MULTIVERSE OF DISCIPLINES IN CONTEMPORARY SCIENTIFIC RESEARCH

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Abstract. *The present paper tries to describe not only the contemporary relations between economics and physics, but also between many, many other sciences, or more correctly scientific universes, in a so-called "multiverse" of disciplines in the field of contemporary scientific research. The idea of a multidisciplinarity field, resulting from the reunited universes of Econophysics, Sociophysics, Quantum Physics, Demographysics, sciences of complexity, etc. is a normal consequence of the development of multidisciplinary sciences during this century and especially in the next one. The definitional issues of this new disciplinary multiverse are detailed against a short historical background of teaching and researching physics about the Universe. Two special examples about multiverse as a synthesis, or a reunion of universes of multidisciplinarities, are detailed through the work of two scientific researchers in the field of mathematics and informatics field, Serbia's Petrovitch M. and Romania's Odobleja Ş., and some important ideas from their papers are described in the lines of this paper. The special development of Econophysics, Sociophysics, Quantum Physics in Romania, and the impact of EDEN I, II and III are the final themes of this analysis.*

Keywords: *Universe, Multiverse, Econophysics, Sociophysics, Quantum Physics, Quantum Economics, scientific research.*

1. INTRODUCTION

Many of the contemporary disciplines have developed excessively and quite rapidly, especially in the boundary areas located at the interference with other scientific domains, thus generating the trans-, inter-, and multidisciplinarity of today's scientific research. Thus, ever more interesting sub-universes have appeared, where the contribution of one or another of the scientific disciplines incorporated is increasingly hard to delimit; the result is virtually a new concentrated, densified and coherent manifestation of scientific multidisciplinarity, already become classical.

The name of many of these new intersections is efficiently extracted from the simple adjoining and fusing of easily recognizable components of the original name of the formative sciences: thus, economics and physics have generated econophysics, sociology and physics have given birth to sociophysics, demography and physics have constituted demographysics, economics and quantum physics have eventually led to econoquantics or quantum economics, etc. [1, 2, 3, 4, 5, 6]

Pioneer stage of those new domains is hard to delimit, both thematically and (especially) methodologically. For instance, it is more than difficult to select the first three authors in sociophysics, although some references point especially to Serge Galam (*Sociophysics: a Personal Testimony*), Dietrich Stauffer (*Sociophysics Simulations I: Language Competition*), Paris Arnopoulos (*Sociophysics: Chaos and Cosmos in Nature and Culture*), with a vast list including maybe thousands of contemporary authors, in a multidisciplinary domain that has existed for over two decades. [7, 8, 9]

Gradually, those multidisciplinary subuniverses reunite themselves into increasingly well shaped universes, such as the universe of complexity, or the universe of the sciences of complexity, or else the universe of fundamental scientific research into the theory of neuron networks and of cords, etc.

Beyond these realities, ever more present in the modern academic and research milieux, the appearance becomes visible of a disciplinary universe of contemporary scientific reasearch. The present article is devoted to its birth and development. Three questions, whose answers are like the Fates' ones, dominate this completely new process. Are there any similarities between the cosmos physics, astronomy, modern physics and the universe of knowledge in general? What happens when two theories fail to match in a practical manner within a multidisciplinary domain, or within a newly emerged subuniverse? Can we talk about an identity, be it even a relative one, between the multiverse of scientific research and the real cosmic one, revealed by means of modern physics?

2. ECONOQUANTICS OR QUANTUM ECONOMICS – A RELEVANT EXAMPLE OF A CONTEMPORARY SCIENTIFIC SUBUNIVERSE

The very latest scientific experiments of elementary particle acceleration describe losses of about one percent to the benefit of antimatter. The quantum world, that of the particle-wave indetermination in the mechanics of a quantum type, in a similar manner to the coexistence, in the theory of relativity, of matter and energy, seems much more imbalanced and likely to accelerate thosea imbalances with respect to the classical macro-materialism. Now to make a parenthesis with a major economic impact, we are inclined to believe that at the back of the economic crisis should stand an energy compensation of the future evolution, which we would like to be as spiritualized – in the sense of quantum physics – as possible (so, as close as possible to the particle, the individual, the economic or public entity, etc.). The surprise

provided by quantum physics bordering on the economic phenomenon and the vast domain of the latter's applications imposes a fitting of the quantum support of the particle-wave to the economic processes...

This ebcomes ever more significant under the circumstances of the rapid change in the methods, measuring instruments and units or standards employed in evaluation the general economic result. There is room for quantum physics here to gain recognition, in point of methods and methodology, for several decades to come. [10, 11, 12] The materialism of the economic result of the type profit / loss is both uncertain (principially quantic), and incomplete (its side effects are not usually measured, as in the case of the declared bankruptcy of a company, which subsequently leads, through the circulation of the labour force, to developing new small and medium-sized organizations, proceeding from the energy incorporated and left unmeasured or evaluated of the personnel made redundant for limited periods of time). Another example illustrative for the high degree of incompleteness of measuring comes from the educational system, not yet recognised as a continuous energy transfer between teachers and students, having an unimaginably great economic and social impact.

The materiality of the macroeconomic result cannot obviously escape those influences, being permanently situated also within an unnoticeable area, to a significant extent (from 5 and 35, possibly even 40%), with refrence to the hidden GDP, another undecided form of quantum existence of economic matter, between matter and energy, or oscillating between two states, now a particle, now a wave… Actually, we draw a simple analogy between the famous "Schrődinger's cat, who manages, according to the quantum theory, and its specific uncertainty (or indeterminacy) to posses no less than nine lives" and the economic entity or modern company, we come to be able to easily shape the nine complex, or existenting facets, incompletely researched in the economic space.[13,14] In the paradoxical example of Schrődinger's cat, after it has been for one hour in acage with a disintegrating radioactive atom (while a counter is ticking and activates a hammer that will break a poison phial), it becomes a nearly "coherent" overlapping, i.e. ½ alive, and ½ dead. Any observation will always reveal either a living cat, or a dead cat; similarly, the future of the economic world and of the quantum company will most certainly become, in a few decades, the very image of the nine lives that are described below.

Firstly, the existence of the modern firm or company / commercial enterprise are treated statistically and obviously in an incomplete manner, as part of an ensemble (both Schrődinger's cat and the modern firm or company feel "offended" through their mere omission, as in the resulting economic system the sum total of the parts is always more than the whole, in keeping with the theory of the systems as such, and statistical measurement virtually kills the two elementary particles of the economic phenomenon). Secondly, both Schrődinger's cat and the modern firm or company are standard examples of dichotomies of the type life / death, or profit / loss, and both refuse to yield to that dichotomy, thus trying to survive. Thirdly, both Schrődinger's cat and the modern firm or company are irreversibly "fiscalized" in a world of uncertainty of results, according to the quantum priority of result measuring both in the statistics

of quantum physics, and in macro- or micro-economy. Fourthly, both Schrődinger's cat and the modern firm or company are faced with hidden avriables, i.e with the hidden or "unnoticed" added value, or the hidden or "underground" GDP. Fifthly, both Schrődinger's cat and the modern firm or company are, in the neo-Copenhagen interpretation, both alive and dead, and also both profit-making and bankrupt (coherent overlapping being, as is generally known, a mere abstraction, and nothing more). Sixthly, both Schrődinger's cat and the modern firm or company meet numerous scientific universes or (economic, social, etc.) worlds, being declared now alive and profit-making in some of them, now dead and non-profitable or bankrupt in others. Seventhly and eighthly, both Schrődinger's cat and the modern firm or company either meet Niels Bohr and physical complementarity, being saved by the impossibility of giving a complete answer to the question "what does a correct and complete measurement consist of?", or with the "conscience" in a dual interpretation, yet the neutrality of the interpretation of a different consciousness (of the physicist Eugen Wigner's friend) saves it eventually. The consciousness interprets the result so that its interpreting the result turns into the interpretation of another constant (that of quantum physics or that of economics).

The last of the survival solutions of both Schrődinger's cat's and the modern firm's or company's is represented by the interpretation of idealistic monism (the consciousness through choosing one of the two opposite states, life / death, or profitability / bankruptcy, collapses the wave function, that is to say the economic energy created by the firm).

3. THE SKETCH OF A CONTEMPORARY DISCIPLINARY MULTIVERSE

We used Schrődinger's cat, comparing it to the modern company or firm, precisely to emphasize the importance of the researcher's consciousness within today's universe of knowledge, and also the necessity to amplify the processes of development of the new scientific disciplines, , of combining them into multidisciplinary universes, and, finally, of shaping an original contemporary scientific multiverse, which could cover both the economic environment, where we get close to the the dominant of individual capitalism and of the "virtual" firms, created on the internet and multiplied by the order of 10^{20} or 10^{25}, through products and services, and also the social environment (from education to the health services, from culture to entertainment or leisure activities, etc.).

In the current scientific research, there exist, or more precisely co-exist many other examples of multidisciplinarity, or of cooperating scientific disciplines, and their reunion generatesa relatively limited initial universe, which however has a very high potential. If, as we have partially demosntrated, we combine the methods and methodologies specific to statistical physics, quantum physics, etc. with those of amthematics, statistics, informatics, sociology, psychology, biology, etc. in order to decode the pluridimensional complexity of contemporary (economic, social, political, etc.) reality, we delimit a significant pluridisciplinary universe of scientific research. The ampler the development of that universe gets, the vaguer the actual possibility of defining it, or even of naming it, is; a simple attempt in the case described could be for instance "the universe statistical and quantum of econo-, socio- and

biophysics", but even so all the concurrent adjacent disciplines cannot be covered. If we continually add to that multidisciplinary universe other new universes that are being formed and expanded, such as those of "complexity or of the sciences of complexity", or the multidisciplinary universe of research based on the "theory of neuronal networks and on the theory of cords", we gradually advance into the world of the multiverse of scientific research, the vast scope of which is comparable to the enormity of the cosmic multiverse where we exist. From a graphical point of view, the situation can look like the one described below:
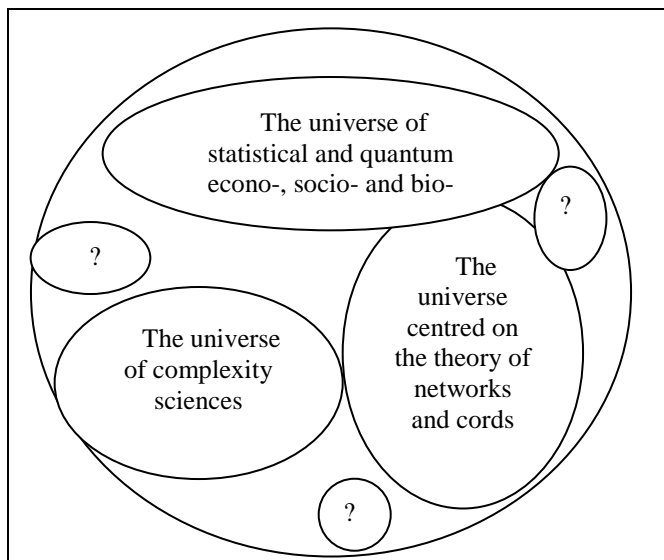

Fig. 1. The disciplinary multiverse of the expanding contemporary scientific research

Very much like the cosmic multiverse, the disciplinary multiverse of contemporary scientific research, as a space of an inimaginable vastness if measured on the scale of human space-time, a space which is also continuously expanding, permanently generates ever new multidisciplinary universes, restructuring itself like Penelope's cloth, waiting for the synthetically formalizing and multi-exprimental thought validated by Ulysses.

The multiverse of the disciplines of contemporary scientific research is a new-born child at the scale of cosmic history, and like any other new-born, is unpredictable in its responses, its metabolism, and its inner structure...

4. THE SCIENTIFIC MULTIDISCIPLINARY THEORY, AND ITS MATHEMATICAL AND SYNTHETICAL LOGICAL FORMALIZATION

A scientific theory is "a model of the universe, or a restricted part of it, and a set of rules that connect the magnitudes in the model to the observations that the researcher makes" [15, 16, 17] in the research activity proper. A classical theory in the unidisciplinary sense meets the conditions of optimization and adequacy to the specific reality, or the object of study of the discipline, if it satisfies at least two requirements:

a) the theory must describe accurately, synthetically and correctly a class of much more extended observations, starting from a "parsimonious", constructed in keeping with William of Ockham's principle, or the principle of "the

minimum simplification through hypotheses", by selecting only a few arbitrary elements and significant variables;

b) the theory must make predictions, in a Popperian philosophical sense, concerning the results of the future observations of an experiment, the time evolutions of a process or phenomenon; (the completeness of a theory is validated precisely by this second requirement, and so Aristotle's theory, who stated that things are made of four elements, i.e. water, air, earth and fire, remains a mere hypothesis, while Newton's theory concerning the attraction of bodies with a force in direct proportion with their mass, and in reverse proportion to the force, through validated predictions, represents a complete theory).

A multidisciplinary theory develops and at the same time relativizes the predictive requirement, supplying not only one alternative, but well-delimited sets of predictions based on alternative methods and scenarios, benefiting by the same "output" parametres (outputs, or impact variables identical in point of level and intensity).

At the same time, the theory of a multidisciplinary universe of scientific research adds a new feature to the classical theory, a feature resulting from its complete validation or invalidation:

c) the theory possesses a temporary validity, in the sense that it is only a hypothesis about the reality of the universe which is itself in expansion.

The disciplinary multiverse of today's scientific research seems to amplify the requirements of acknowledging and validation of a theory, cyclically considered as superannuated, and permanently perfectible (a theory can survive only to the extent to which its predictions are ascertained):

d) the theory of any scientific universe becomes, in the multiverse, a particular case of a theory much vaster in point of applicability, not yet discovered or formulated, while the new theories of the multiverse are inferences, maximized in point of coverage degree and minimized in point of mathematical and logical formulation, of the old theories, extended and selected; this fact is actually acknowledged in the very *principle of complementariness* in physical thought, meaning that the old theories are particular limit cases of the new theories (where the limit, for instance in the theory of general relativity, is the speed of light, and in the theory of quantum physics – Planck's constant).

The final goal of scientific research, or even of science in general, is to provide one only theory (Stephen Hawking), to supply research with a stable support in knowing and anticipating the cosmic multiverse.

The formalization of a theory, as found currently, is done and primarily communicates in two aspects, i.e. the mathematical and/or the logical one. We have chosen two pioneering examples, which can provide light into the matter, in order to be able to understand the history, and the tendency that today's theory of disciplinary multiverse is getting to: that of M. Petrovich's mathematical formulations, and of Ş. Odobleja's logical formulations.

At the turn of the 20th century, M. Petrovitch, professor at the University in Belgrade, proposes the delimitation of a new discipline, synthetical through its method, but also multidisciplinary through its study object and applicability, a new branch of natural philosophy, the object / subject matter of which was to be the study of the mathematical relationships between causes and effects, disburdened of all

the residue of their specific data, methods and instruments, of the peculiarities which could specifically link those interconnection with one of another category of phenomena or processes. The mathematical theory of the equations described in fact various types of phenomena, but each domain of the real studies its specific processes. Such a mathematically formulated law can be defined as:

$$\frac{dy}{dx} + kx = 0$$

and it can represent a synthesis of several disciplines or multidiscdiplinary universes:

- the absorption of an ionizing radiation of intensity y, when passing through a homogeneous medium of thickness x (the law of radiation absorption);
- the variation of barometric pressure y according to the altitude x (Laplace's law);
- the cooling of bodies in media at rest (y is the temperature, and x the time, in keeping with Newton's law);
- radioactive disintegration (y is the quantity of substance, and x the effective time of the process);
- the loss of load through evaporation in electricity-loaded liquids (y is the superficial load density, x the time – Pellat's law);
- the variation of the quantity of a definite compound that gradually transforms under the action of another physical or biological agent (y is the quantity of transformable substance, x is the time, in keeping with the law of monomolecular variations);
- the variation of a population that develops with no restrictions (y is the number of individuals, x is the time, according to the laws of demography), etc.

The essence of M. Petrovitch's exceptional synthetic thought can be reduced to the finding that, in a multiverse of scientific research anticipated in its intersection, or of generalized applicability component, as described by us in the present contribution, the multidisciplinary universes can be simultaneously rendered throgh common major laws. M. Petrovich anticipated by nearly a century the fact that, if in the known universes there exist phenomena different in their nature, they can be rendered through identical mathematical models, and the abstract general study of those mathematical models (to which we could also specifically add the extraction universes: the physical, mathematical, statistical, neuronal biological ones, or those centred on cords and networks, psychological and sociological, economic, demographic, etc.) can be conducted (a model specific to the multiverse, extracted from the universes of scientific research).

Odobleja manages to anticipate, through his logically formulating the so-called consonantist thought, another aspect of the potentiality of today's multiverse. *Consonantics, or the product of thinking a new logic ofresonance or of consonance, is a manner of reuniting logic and psychology, both with physiology, and then of those three taken together with physics, and further on, with technology* [18]. Logic, prior to consonantist psychology, Odobleja would say, seemed completely disoriented. *"Logic has lost the guiding thread, and can no longer find it. Untiredly, logicians ar seeking for it everywhere: in algebra, in superior*

mathematics, in grammar, in metaphysics, in cosmology, in sociology. The only place they won't look for it is psychology of thought…" [19]. Consonantics turns into a logical answer, sought and waited-for, within the context of multidisciplinary developments, and this alternative is not only multidisciplinary through its origin and essence, but also through the method that derives from both its conceptions, and the experience of its own coming into being – the method of the multidisciplinary approach and the collaborative links between sciences.

Odobleja's consonantics is an attempt to incorporate and re-examine the main lines of scientific research, lines that had previously been examined in an isolated manner, becoming the first significant "crossroads" of the larger majority of the sciences, and drawing closer scientific disciplines that used to be virtually disjoined: mathematics, physics, technology – and, respectively, biology, physiology, psychology, linguistics, economics. To conclude, we can assess that Şt. Odobleja reinstates, in both scientific research and thought, the preponderance of the method of logic, but within a new context, of a universal and multidisciplinary type. Another additional clarification that Odobleja brings into the framework of the method of researching a multidisciplinary universe deals with the need for a good classification, accompanied and marked by the logical formulation of its specific system of laws. *"All our science is made up of classes and laws. The latter are the more important: it is the laws that maek the value of any science"*.

5. SOME FINAL OUTLINES OF THE MULTIVERSE OF CONTEMPORARY SCIENTIFIC RESEARCH

In the generalized physics of cosmos, the multiverse appeared in a time point within a black hole, called by Stephen Hawking a singularity (in fact, a point in space-time at which the curve of space-time becomes infinite). Such a birth probably occurred at the level of the first subuniverse of a multidisciplinary type within a space of thematic, methodological and methodical frontier. The expansion then characterized both evolutions.

In the physics of the quantum type, space is never empty, and each particle automatically has an associated anti-particle. Similarly, in contemporary scientific research, there are no "empty spaces" where discoveries come out of nothing, or places not previously searched, be it in a vague manner… As a mere illustration, today's analysis of efficient markets is placed into the spot represented by the E. Fama's doctoral thesis, [21], which in turn did not develop within the same empty space, but in a spce well delimited through L. Bachelierâs contribution. [22]

In the theory of general relativity, any negative particle is attracted into the "Black Hole", whereas in the theory of quantum physics the positive particle attracted into the balck hole emits Hawking radiation (v. Stephen Hawking), very much as the old theories of knowledge are virtually swallowed within the braoder context of the new laws, i.e. only part of them generate the necessary formal or consonant energy also for the furutre researches.

The explosion inside the "Black Hole" gives rise to soups of particles, in modern physics, very much as the invasion of the borderline interdisciplinary space generates new multidisciplinary domains, new methods, new methodologies of scientific research. Any multidisciplinary universe is fused

into the multiverse of research to gradually expand scientific knowledge within the multiverse of all the disciplines.

In the general theoretical physics, the theory of general relativits by no means fits the theory of quantum physics, and their comprehensive reunion becomes possible only in the multiverse, in a theory of "the whole", similar to the common message conveyed by Peter (the peasant, or the experienced pragmatician) and Paul (the intellectual, or the deep theorist), finally detectable in Christianity, or faith.

Any multidisciplinary universe, once made up, enters a process of expansion, and in a parallel movement, aa process of dramatic decrease in gravitation (in the physical universe) or of coherence (in the universe of scientific research) takes place.

Gravitation prevents the universe from collapsing "inside itself" and the multiverse from gradually disappearing, while (thematic, methodical and methodological) coherence concurs towards the survival and expansion, within the ever-changing limits of the disciplinary multiverse, of scientific research.

6. A FINAL REMARK

The periodical meeting of a multidisciplinary group of teachers, academic professors and researchers, capable, during the two workshops EDEN I and II, of making up a first significant nucleus of an academic orientation in Romania towards the new scientific universes of the 21st century (from the universe of "statistical and quantum econo-, socio- and bio-physics" to that of the "sciences of complexity", or to that centred on the theory of the "networks and cords", etc.), has resulted in several potentially significant outcomes; the expansion of the latter is directed, as part of the next workshop, EDEN III, towards the academic scientific research in Serbia, India and, especially, the Belgian school headed and inspired by Professor Marcel Ausloss. That expansion, but from contradicting, confirms the general expansion of the multidisciplinary universes in today's disciplinary multiverse.

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COST AND PROFIT ANALYSIS OF A NON-EMPTY QUEUE

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Abstract: *This paper deals with cost and profit analysis of a non-empty $M/M/1/N$ queuing system. A total cost function and total profit function are constructed and optimized with respect to both arrival and service parameters by using a fast converging Newton-Raphson's (abbreviated as N-R) method. The total optimal cost and profit of the model are computed by solving a system of two non-linear equations which are obtained by applying optimality conditions on the total cost function. Results are tabled and also presented graphically to better realize the performance of the system in different working conditions.*

Keywords: *Cost analysis, profit analysis, total optimal profit, optimal arrival rate, optimal service rate.*

1. INTRODUCTION

The non-empty $M/M/1/N$ queuing model is mostly applied in the field of inventory management, production management, computer and telecommunications, etc. The performance measures of the model can predict the efficiency, applicability, and quality of operating system of the non-empty $M/M/1/N$ queuing model. The applicability of the model depends on the total expected cost and profit of the system. The performance measures of the model can be easily evaluated by using standard results. But the main problem is to optimize these measures in such a way that the total expected cost and profit of the system are optimal with respect to the parameters, arrival and service rates. This problem can be solved only by using a powerful optimization technique with the help of computer and its scientific programming language. Till now, no serious attempt has been made in this direction.

Sharma and Tarabia [6] obtained the transient state probabilities for $M/M/1/N$ queuing system whence all particular cases concerning infinite waiting space and steady-state solutions can be derived straight away. Sharma and Gupta [7] discussed the transient behavior of the queue length of $M/M/1/N$ queue using Chebychev's polynomial. They expressed the transient state probabilities of the system free from Bessel's function which later led to the matrix method by Sharma [8].

Zhang et al. [5] developed a cost model for $M/M/1/N$ queuing system with balking, reneging, and server vacations and determined the optimal service rate. Taha [4] has discussed two queuing decision models namely, an aspiration level model and a cost model. Both models recognize the higher service levels reduce the waiting time in the system. He discussed the two conflicting costs viz. service cost and waiting cost and established a cost model. Mishra and Yadav [13] made an attempt on cost and profit analysis of single server Markovian queuing system with two priority classes. They constructed the functions of total expected cost, revenue, and profit of the system and optimized these functions with respect to service rates of lower and higher priority classes.

Abromovitz and Stegun [1] have introduced the fundamental concepts on cost analysis of various queuing models. Gross and Harris [2] have made an attempt on transient solution of $M/M/1/N$ queue, but the problem tedious when the restriction on waiting capacity is relaxed. Tarabia [10] has introduced an alternative simple approach, based on Laplace transform technique, to the study of transient behavior of non-empty $M/M/1/N$ queue. He has shown that the measures of effectiveness such as the first and second order moments of the queue length can be easily obtained in an elegant closed form. But he made no attempt to analyze the cost and profit of the model as very important aspects of the queuing system.

Takacs [9] obtained the transient solution for $M/M/1/N$ queuing system using eigen-vectors and eigen-values technique. Mishra and Pal [14] have introduced a computational approach to $M/M/1/N$ interdependent queuing system with controllable arrival rate. The computer coding in C programming language on the basis of algorithm have been developed to efficiently carry out the evaluation of performance measures of the model. They have presented the sensitivity analysis for the model in order to make it more efficient and applicable. Pern et al. [15] have considered the management policy of an $M/G/1$ queue with a single removable and non-reliable server. They applied an efficient Mat lab programmer to calculate optimal threshold of management policy and some system characteristics.

Ke [16] has studied the control policy of the N policy $M/G/1$ queue with server vacation, start up, and breakdowns where arrivals form a Poisson process and service times are generally distributed. He developed the total expected cost function per unit time to determine the optimal threshold of N at a minimum cost. Mishra and Yadav [12] analyzed the cost and profit for $M/E_k/1$ queuing model with removable service station under N-policy and steady state conditions. They introduced the notion of total revenue to find the total profit of the system with respect to total cost of the system.

Tarabia [11] obtained a new and simple series form for the transient state probabilities for non-empty $M/M/1/\infty$ queuing model. He has shown that the coefficients in this series satisfy iterative recurrence relations. Xu et al. [17] have discussed an $M/M/1$ queue with single working vacation and set-up times using quasi birth and death process and matrix-geometric solution method. They derived the distributions for the stationary queue length and waiting time of a customer in the system.

In this paper, we obtain various performance measures of the non-empty $M/M/1/N$ queue by programming in C++. We construct a total cost function and total profit function of the model and apply two-variable version of N-R method to

obtain the optimal values of arrival rate λ and optimal service rate μ which optimize the total cost and profit functions. With optimal arrival and service rates, the performance measures like optimal expected number of customers in the system and optimal waiting time in the system are obtained. Finally, the numerical values are tabled and also presented in graphs to better understand the performance, applicability, and cost and profit level of the model.

2. COST ANALYSIS OF THE MODEL

The total cost function for this model is given by,

$$T_C = C_1\mu + C_2 L_s \tag{1}$$

where, T_C is the total cost of the system, C_1 is the service cost per customer per unit time, C_2 is waiting cost per customer per unit time, ρ is the traffic intensity of the system, and L_s is the expected number of customers in the system which is as given by Tarabia (2001),

$$L_s = \begin{cases} \dfrac{\rho\left[1-(N+1)\rho^N + N\rho^{N+1}\right]}{(1-\rho)\left(1-\rho^{N+1}\right)} & \text{if } \lambda \neq \mu \\[4mm] \dfrac{N}{2} & \text{if } \lambda = \mu \end{cases} \tag{2}$$

Where, N is the capacity of the system.

Therefore, from (1) and (2) we have

$$T_C = C_1\mu + C_2 \frac{\left[\rho - (N+1)\rho^{N+1} + N\rho^{N+2}\right]}{\left(1-\rho-\rho^{N+1}+\rho^{N+2}\right)}$$

$$= C_1\mu + C_2 \frac{\left[\dfrac{\lambda}{\mu} - (N+1)\left(\dfrac{\lambda}{\mu}\right)^{N+1} + N\left(\dfrac{\lambda}{\mu}\right)^{N+2}\right]}{\left[1-\dfrac{\lambda}{\mu} - \left(\dfrac{\lambda}{\mu}\right)^{N+1} + \left(\dfrac{\lambda}{\mu}\right)^{N+2}\right]}$$

Let $x = \left[\dfrac{\lambda}{\mu} - (N+1)\left(\dfrac{\lambda}{\mu}\right)^{N+1} + N\left(\dfrac{\lambda}{\mu}\right)^{N+2}\right]$, and

$y = \left[1 - \dfrac{\lambda}{\mu} - \left(\dfrac{\lambda}{\mu}\right)^{N+1} + \left(\dfrac{\lambda}{\mu}\right)^{N+2}\right]$.

Therefore,

$$T_C = C_1\mu + C_2\, x/y \tag{3}$$

Differentiating (3) partially, with respect to λ and μ, we get

$$\frac{\partial T_C}{\partial \lambda} = 0 + C_2 \frac{y\dfrac{\partial x}{\partial \lambda} - x\dfrac{\partial y}{\partial \lambda}}{y^2} \tag{4}$$

$$\frac{\partial T_C}{\partial \mu} = C_1 + C_2 \frac{y\dfrac{\partial x}{\partial \mu} - x\dfrac{\partial y}{\partial \mu}}{y^2} \tag{5}$$

For critical point $(\overline{\lambda}, \overline{\mu})$, we must have $\dfrac{\partial T_C}{\partial \lambda} = \dfrac{\partial T_C}{\partial \lambda} = 0$. Therefore,

$$y\frac{\partial x}{\partial \lambda} - x\frac{\partial y}{\partial \lambda} = 0 \tag{6}$$

$$C_1 y^2 + C_2\left\{y\frac{\partial x}{\partial \mu} - x\frac{\partial y}{\partial \mu}\right\} = 0 \tag{7}$$

Now, to find $\dfrac{\partial x}{\partial \lambda}, \dfrac{\partial x}{\partial \mu}, \dfrac{\partial y}{\partial \lambda}$, and $\dfrac{\partial y}{\partial \mu}$ we proceed as follows:

Since $x = \left[\dfrac{\lambda}{\mu} - (N+1)\left(\dfrac{\lambda}{\mu}\right)^{N+1} + N\left(\dfrac{\lambda}{\mu}\right)^{N+2}\right]$,

$y = \left[1 - \dfrac{\lambda}{\mu} - \left(\dfrac{\lambda}{\mu}\right)^{N+1} + \left(\dfrac{\lambda}{\mu}\right)^{N+2}\right]$ therefore,

$$\frac{\partial x}{\partial \lambda} = \frac{1}{\mu}\left[1 - (N+1)^2\left(\frac{\lambda}{\mu}\right)^N + N(N+2)\left(\frac{\lambda}{\mu}\right)^{N+1}\right] \tag{8}$$

$$\frac{\partial y}{\partial \lambda} = \frac{1}{\mu}\left[-1 - (N+1)\left(\frac{\lambda}{\mu}\right)^N + (N+2)\left(\frac{\lambda}{\mu}\right)^{N+1}\right] \tag{9}$$

$$\frac{\partial x}{\partial \mu} = \left(-\frac{\lambda}{\mu}\right)\frac{1}{\mu}\left[1 - (N+1)^2\left(\frac{\lambda}{\mu}\right)^N + N(N+2)\left(\frac{\lambda}{\mu}\right)^{N+1}\right] \tag{10}$$

$$\frac{\partial y}{\partial \mu} = \left(-\frac{\lambda}{\mu}\right)\frac{1}{\mu}\left[-1 - (N+1)\left(\frac{\lambda}{\mu}\right)^N + (N+2)\left(\frac{\lambda}{\mu}\right)^{N+1}\right] \tag{11}$$

From (8) and (10), we see that

$$\frac{\partial x}{\partial \mu} = \left(-\frac{\lambda}{\mu}\right)\frac{\partial x}{\partial \lambda} \tag{12}$$

From (9) and (11), we observe that

$$\frac{\partial y}{\partial \mu} = \left(-\frac{\lambda}{\mu}\right)\frac{\partial y}{\partial \lambda} \tag{13}$$

Let $W \equiv W(\lambda, \mu) = y\dfrac{\partial x}{\partial \lambda} - x\dfrac{\partial y}{\partial \lambda}$ and

$U \equiv U(\lambda, \mu) = C_1 y^2 + C_2\left\{y\dfrac{\partial x}{\partial \mu} - x\dfrac{\partial y}{\partial \mu}\right\}$.

Therefore from (6) and (7), we have

$$W(\lambda, \mu) = 0 \text{ and } U(\lambda, \mu) = 0 \tag{14}$$

The set of equations (14) represents a system of two non-linear equations in two variables λ and μ. We solve this system by applying a two variable version of N-R method, as discussed by Chapra and Canale [3], and the solution of this system will give critical point $(\overline{\lambda}, \overline{\mu})$. According to this method,

$$\Delta\,(\text{Jacobian}) = \begin{vmatrix} \dfrac{\partial W_i}{\partial \lambda} & \dfrac{\partial W_i}{\partial \mu} \\[3mm] \dfrac{\partial U_i}{\partial \lambda} & \dfrac{\partial U_i}{\partial \mu} \end{vmatrix}, \Delta_1 = \begin{vmatrix} W_i & \dfrac{\partial W_i}{\partial \mu} \\[3mm] U_i & \dfrac{\partial U_i}{\partial \mu} \end{vmatrix}, \Delta_2 = \begin{vmatrix} \dfrac{\partial W_i}{\partial \lambda} & W_i \\[3mm] \dfrac{\partial U_i}{\partial \lambda} & U_i \end{vmatrix}$$

, $\lambda_{i+1} = \lambda_i - \dfrac{\Delta_1}{\Delta}$ and $\mu_{i+1} = \mu_i - \dfrac{\Delta_2}{\Delta}$, where (λ_i, μ_i) is the initial guess for (14), $W_i = W(\lambda_i, \mu_i)$

$$U_i = U(\lambda_i, \mu_i), \quad \frac{\partial W_i}{\partial \lambda} = \left(\frac{\partial W}{\partial \lambda}\right)_{(\lambda_i, \mu_i)}, \quad \frac{\partial W_i}{\partial \mu} = \left(\frac{\partial W}{\partial \mu}\right)_{(\lambda_i, \mu_i)},$$

$$\frac{\partial U_i}{\partial \lambda} = \left(\frac{\partial U}{\partial \lambda}\right)_{(\lambda_i, \mu_i)}, \text{ and } \frac{\partial U_i}{\partial \mu} = \left(\frac{\partial U}{\partial \mu}\right)_{(\lambda_i, \mu_i)}. \text{ Therefore, we}$$

need to find $\frac{\partial W}{\partial \lambda}, \frac{\partial W}{\partial \mu}, \frac{\partial U}{\partial \lambda}$, and $\frac{\partial U}{\partial \mu}$.

Now,

$$\frac{\partial W}{\partial \lambda} = y \frac{\partial^2 x}{\partial \lambda^2} - x \frac{\partial^2 y}{\partial \lambda^2} \tag{15}$$

$$\frac{\partial W}{\partial \mu} = \left(\frac{1}{\lambda}\right)\left\{x\frac{\partial y}{\partial \mu} - y\frac{\partial x}{\partial \mu}\right\} + \left(\frac{\mu}{\lambda}\right)\left\{x\frac{\partial^2 y}{\partial \mu^2} - y\frac{\partial^2 x}{\partial \mu^2}\right\} \tag{16}$$

$$\frac{\partial U}{\partial \mu} = 2C_1 y \frac{\partial y}{\partial \mu} + C_2 \left\{y\frac{\partial^2 x}{\partial \mu^2} - x\frac{\partial^2 y}{\partial \mu^2}\right\} \tag{17}$$

$$\frac{\partial U}{\partial \lambda} = 2C_1 y \frac{\partial y}{\partial \lambda} - \left(\frac{C_2}{\mu}\right)\left\{y\frac{\partial x}{\partial \lambda} - x\frac{\partial y}{\partial \lambda}\right\}$$
$$- C_2\left(\frac{\lambda}{\mu}\right)\left\{y\frac{\partial^2 x}{\partial \lambda^2} - x\frac{\partial^2 y}{\partial \lambda^2}\right\} \tag{18}$$

From (15), (16), (17), and (18), we require

$$\frac{\partial^2 x}{\partial \lambda^2}, \frac{\partial^2 y}{\partial \lambda^2}, \frac{\partial^2 x}{\partial \mu^2}, \text{ and } \frac{\partial^2 y}{\partial \mu^2}$$

Therefore, differentiating (8), (9), (10), and (11) as follows:

$$\frac{\partial^2 x}{\partial \lambda^2} = \left[-N(N+1)^2 \frac{\lambda^{N-1}}{\mu^{N+1}} + N(N+1)(N+2)\frac{\lambda^N}{\mu^{N+2}}\right]$$

$$\frac{\partial^2 y}{\partial \lambda^2} = \left[-N(N+1)\frac{\lambda^{N-1}}{\mu^{N+1}} + (N+2)(N+1)\frac{\lambda^N}{\mu^{N+2}}\right]$$

$$\frac{\partial^2 x}{\partial \mu^2} = \left[2\frac{\lambda}{\mu^3} - (N+2)(N+1)^2\frac{\lambda^{N+1}}{\mu^{N+3}} + N(N+2)(N+3)\frac{\lambda^{N+2}}{\mu^{N+4}}\right]$$

$$\frac{\partial^2 y}{\partial \mu^2} = \left[-2\frac{\lambda}{\mu^3} - (N+1)(N+2)\frac{\lambda^{N+1}}{\mu^{N+3}} + (N+2)(N+3)\frac{\lambda^{N+2}}{\mu^{N+4}}\right]$$

The total cost function T_C will be optimum at the critical point $(\overline{\lambda}, \overline{\mu})$ if (I) $\begin{vmatrix} \dfrac{\partial^2 T_C}{\partial \lambda^2} & \dfrac{\partial^2 T_C}{\partial \lambda \partial \mu} \\ \dfrac{\partial^2 T_C}{\partial \mu \partial \lambda} & \dfrac{\partial^2 T_C}{\partial \mu^2} \end{vmatrix} > 0$, (II) $\dfrac{\partial^2 T_C}{\partial \lambda^2} > 0$.

After calculating the optimal arrival and service rates $\overline{\lambda}$ and $\overline{\mu}$ respectively, we find the performance measures of the system which are optimal expected number of customers in the system $\overline{L_s}$ and optimal waiting time in the system $\overline{W_s}$ by applying Little's law, which states that $\overline{L_s} = \overline{\lambda}\,\overline{W_s}$ and computer programming in C++.

Now, we shall find second order partial derivatives of T_C appeared in (I) and (II). Differentiating equations (4) and (5) partially with respect to λ and μ, we get

$$\frac{\partial^2 T_C}{\partial \lambda^2} = C_2\left[\frac{y\dfrac{\partial^2 x}{\partial \lambda^2} - x\dfrac{\partial^2 y}{\partial \lambda^2}}{y^2} - \frac{2\dfrac{\partial y}{\partial \lambda}\left\{y\dfrac{\partial x}{\partial \lambda} - x\dfrac{\partial y}{\partial \lambda}\right\}}{y^3}\right]$$

$$\frac{\partial^2 T_C}{\partial \mu^2} = C_2\left[\frac{y\dfrac{\partial^2 x}{\partial \mu^2} - x\dfrac{\partial^2 y}{\partial \mu^2}}{y^2} - \frac{2\dfrac{\partial y}{\partial \mu}\left\{y\dfrac{\partial x}{\partial \mu} - x\dfrac{\partial y}{\partial \mu}\right\}}{y^3}\right]$$

Using (12) and (13) in (4), we get

$$\frac{\partial T_C}{\partial \lambda} = C_2\left(-\frac{\mu}{\lambda}\right)\frac{y\dfrac{\partial x}{\partial \mu} - x\dfrac{\partial y}{\partial \mu}}{y^2}$$

Therefore from (5), we have $\dfrac{\partial T_C}{\partial \lambda} = C_2\left(-\dfrac{\mu}{\lambda}\right)\left(\dfrac{\partial T_C}{\partial \mu} - C_1\right)$

$$\frac{\partial^2 T_C}{\partial \mu \partial \lambda} = \left(-\frac{1}{\lambda}\right)\left(\frac{\partial T_C}{\partial \mu} - C_1\right) + \left(-\frac{\mu}{\lambda}\right)\frac{\partial^2 T_C}{\partial \mu^2}$$

Using (12) and (13) in (5), we get

$$\frac{\partial T_C}{\partial \mu} = C_1 + C_2\left(-\frac{\lambda}{\mu}\right)\frac{y\dfrac{\partial x}{\partial \lambda} - x\dfrac{\partial y}{\partial \lambda}}{y^2}$$

Therefore from (4), we have $\dfrac{\partial T_C}{\partial \mu} = C_1 + \left(-\dfrac{\lambda}{\mu}\right)\dfrac{\partial T_C}{\partial \lambda}$

$$\frac{\partial^2 T_C}{\partial \lambda \partial \mu} = \left(-\frac{1}{\mu}\right)\frac{\partial T_C}{\partial \lambda} + \left(-\frac{\lambda}{\mu}\right)\frac{\partial^2 T_C}{\partial \lambda^2}$$

3. PROFIT ANALYSIS OF THE MODEL

We now find the total expected profit (T_P) of the system on the basis of the total revenue earned by the system in rendering its service to the customers.

Suppose that R is the earned revenue for providing the service to each customer then total expected revenue (T_R) of the system is given by, $T_R = R L_s$. From (1), total cost of the system is $T_C = C_1\mu + C_2 L_s$. Therefore total expected profit of the system will be

$$T_P = T_R - T_C = R L_s - (C_1\mu + C_2 L_s) = (R - C_2)L_s - C_1\mu \tag{19}$$

The optimal arrival and service rates $\overline{\lambda}$ and $\overline{\mu}$ respectively optimize the total expected profit of the system given by (19). We evaluate the total optimal profit of the system $\overline{T_P}$ and analyze the effect of variations in parameters on it by developing a computing algorithm in C++.

4. SENSITIVITY ANALYSIS OF THE MODEL

A computing algorithm in C++ is developed to compute the optimal arrival and service rates $\bar{\lambda}$ and $\bar{\mu}$ respectively which optimize the total cost T_C of the system and total expected profit T_P of the system which are given by (1) and (19) respectively. The performance measures of the system $\bar{L}_s$ and $\bar{W}_s$ are also computed with the help of computing algorithm. The changes in these performance measures of the system with respect to variations in the parameters waiting cost, service cost, and capacity of the system are putted in various tables.

The outcomes are also presented in graphs to exhibit the correlation between these parameters and performance measures. Observations are drawn on the basis of existing tables and graphs to better realize the efficiency and performance of the system in different circumstances.

Table no 1: Service Cost vs. various Performance Measures

$N = 40$, $C_2 = 3.80$

(C_1)	$(\bar{\lambda})$	$(\bar{\mu})$	$\bar{L}_s$	$\bar{W}_s$	$\overline{(T_C)}$
3.00	3.86	3.91	18.2	4.72	80.91
4.00	3.84	3.89	18.2	4.74	84.71
5.00	3.82	3.87	18.2	4.76	88.46
6.00	3.81	3.86	18.2	4.78	92.26
7.00	3.80	3.85	18.2	4.79	96.03
8.00	3.80	3.84	18.5	4.87	101.17
9.00	3.80	3.84	18.5	4.87	105.01
10.00	3.79	3.83	18.5	4.88	108.73
11.00	3.78	3.82	18.5	4.89	112.44
12.00	3.78	3.82	18.5	4.89	116.26
13.00	3.77	3.82	18.2	4.83	118.68
14.00	3.77	3.81	18.2	4.91	123.74

Fig. 1.2: Service Cost vs. Total Optimal Cost

Table no 2: Waiting Cost vs. various Performance Measures

$N = 40$, $C_1 = 3.00$

(C_2)	$(\bar{\lambda})$	$(\bar{\mu})$	$\bar{L}_s$	$\bar{W}_s$	$\overline{(T_C)}$
3.80	3.86	3.91	18.2	4.72	80.91
4.80	3.88	3.93	18.2	4.69	99.22
5.80	3.90	3.95	18.2	4.67	117.55
6.80	3.91	3.96	18.2	4.65	135.84
7.80	3.92	3.97	18.2	4.64	154.13
8.80	3.93	3.98	18.2	4.63	172.43
9.80	3.94	3.99	18.2	4.62	190.75
10.80	3.94	4.00	17.9	4.54	205.29
11.80	3.95	4.00	18.2	4.61	227.31
12.80	3.95	4.01	17.9	4.53	241.18
13.80	3.96	4.02	17.9	4.52	259.20
14.80	3.96	4.02	17.9	4.52	277.10

Fig. 1.1: Service Cost vs. Optimal Waiting Time in the System
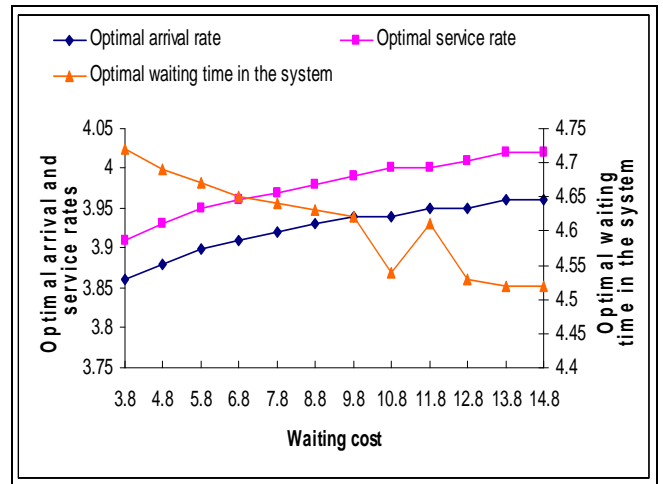
Fig. 2.1: Waiting Cost vs. Optimal Waiting Time in the System
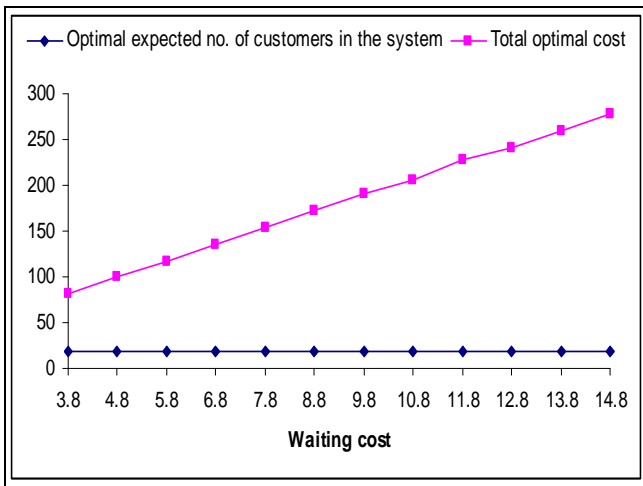
Fig. 2.2: Waiting Cost vs. Total Optimal Cost
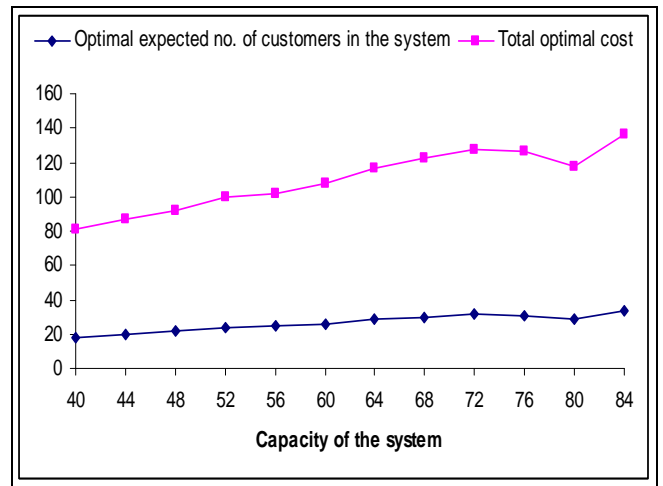
Fig. 3.2: Capacity of the System vs. Total Optimal Cost

Table no 3: Capacity of the System vs. various
Performance Measures
$C_1 = 3.00$, $C_2 = 3.80$

N	$(\bar{\lambda})$	$(\bar{\mu})$	$\bar{L}_s$	$\bar{W}_s$	$(\bar{T}_C)$
40	3.86	3.91	18.2	4.72	80.91
44	3.42	3.46	20.0	4.69	86.56
48	3.21	3.25	21.5	4.67	91.60
52	3.09	3.12	23.7	4.65	99.61
56	3.00	3.04	24.4	4.64	102.02
60	2.94	2.98	25.9	4.63	107.20
64	2.90	2.93	28.4	4.62	116.73
68	2.86	2.89	29.9	4.54	122.28
72	2.83	2.86	31.4	4.61	127.76
76	2.80	2.84	31.1	4.53	126.81
80	2.76	2.82	28.8	4.52	117.90
84	2.76	2.80	33.5	4.52	135.90

Table no 4: Service Cost vs. Total Optimal Profit
$N = 45$, $C_2 = 3.25$

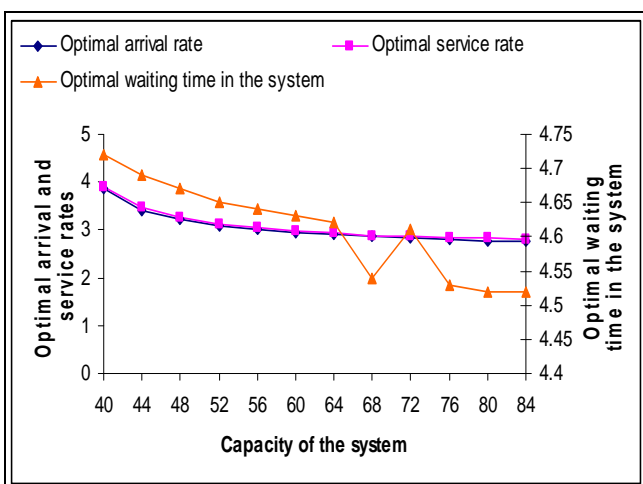| (C_1)	$(\bar{\lambda})$	$(\bar{\mu})$	$(\bar{T}_P)$
6.50	4.32	3.88	768.93
7.50	4.32	3.88	765.05
8.50	4.32	3.88	761.17
9.50	4.32	3.88	757.29
10.50	4.32	3.88	753.41
11.50	4.32	3.88	749.53
12.50	4.32	3.88	745.65
13.50	4.32	3.88	741.77
14.50	4.32	3.88	737.89
15.50	4.32	3.88	734.01
16.50	4.32	3.88	730.13
17.50	4.32	3.88	726.25
18.50	4.32	3.88	722.37
19.50	4.32	3.88	718.49

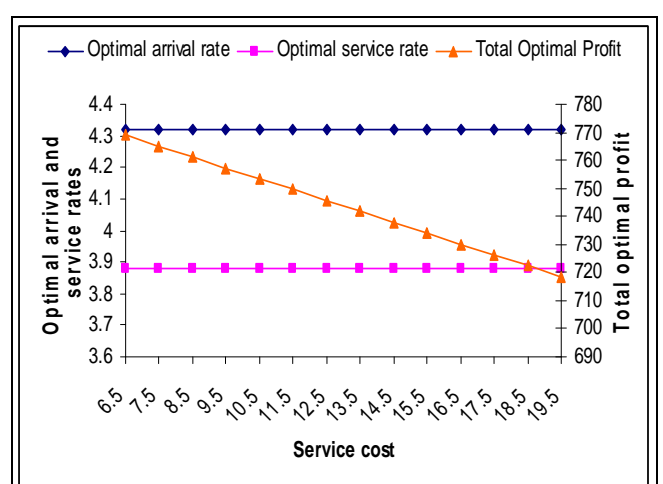Fig. 3.1: Capacity of the System vs. Optimal Waiting Time
in the System

Fig. 4: Service Cost vs. Total Optimal Profit

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Table no 5: Waiting Cost vs. Total Optimal Profit
$N = 45$, $C_1 = 6.50$

(C_2)	$(\bar{\lambda})$	$(\bar{\mu})$	$(\overline{T_P})$
4.50	4.32	3.88	723.20
5.50	4.32	3.88	686.78
6.50	4.32	3.88	650.27
7.50	4.32	3.88	613.75
8.50	4.32	3.88	577.24
9.50	4.32	3.88	540.73
10.50	4.32	3.88	504.22
11.50	4.32	3.89	467.70
12.50	4.32	3.89	431.19
13.50	4.32	3.89	394.68
14.50	4.32	3.89	358.17
15.50	4.32	3.89	321.65
16.50	4.32	3.89	285.14
17.50	4.32	3.89	248.63

Fig. 6: Capacity of the System vs. Total Optimal Profit

Table no 7: Earned Revenue vs. Total Optimal Profit

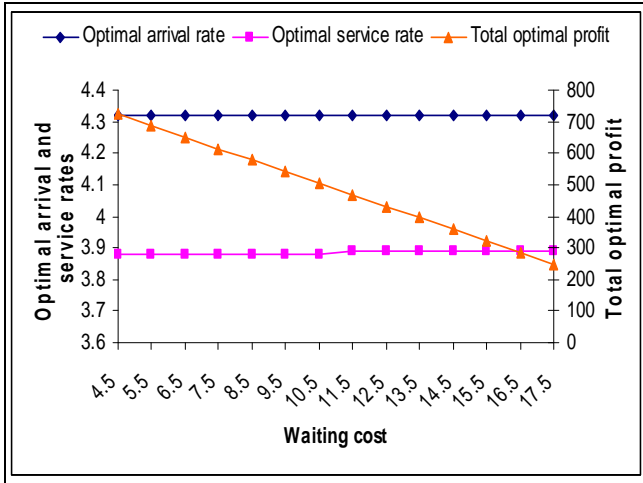| R	N	(C_1)	(C_2)	$(\overline{T_P})$
20.00	75	6.50	3.50	1070.74
22.00	75	6.50	3.50	1203.57
24.00	75	6.50	3.50	1336.41
26.00	75	6.50	3.50	1469.25
28.00	75	6.50	3.50	1602.08
30.00	75	6.50	3.50	1734.92
32.00	75	6.50	3.50	1867.75
34.00	75	6.50	3.50	2000.59
36.00	75	6.50	3.50	2133.42
38.00	75	6.50	3.50	2266.26
40.00	75	6.50	3.50	2399.09
42.00	75	6.50	3.50	2531.93
44.00	75	6.50	3.50	2664.77
46.00	75	6.50	3.50	2797.60

Fig.5: Waiting Cost vs. Total Optimal Profit

Table no 6: Capacity of the System vs. Total Optimal Profit
$C_1 = 6.50$, $C_2 = 3.50$

N	$(\bar{\lambda})$	$(\bar{\mu})$	$(\overline{T_P})$
45	4.32	3.88	759.81
50	4.32	3.88	864.79
55	4.32	3.88	970.63
60	4.32	3.88	1077.06
65	4.32	3.88	1183.87
70	4.32	3.88	1290.93
75	4.32	3.88	1398.15
80	4.32	3.87	1510.18
85	4.32	3.87	1617.59
90	4.32	3.87	1725.03
95	4.32	3.87	1832.50
100	4.32	3.87	1939.98
105	4.32	3.87	2047.46
110	4.32	3.87	2154.96

Fig. 7: Earned Revenue vs. Total Optimal Profit

Observations: In Figure 1.1, we observe that the optimal arrival and service rates decrease very slowly but optimal waiting time in the system shows increasing trend with fluctuations as service cost increases. Therefore service cost and optimal waiting time in the system are in positive correlation. In Figure 1.2 we see that total optimal cost of the

system increases as service cost increases. In fact about 16.6% increase in service cost causes approx. 4.1% increase in the to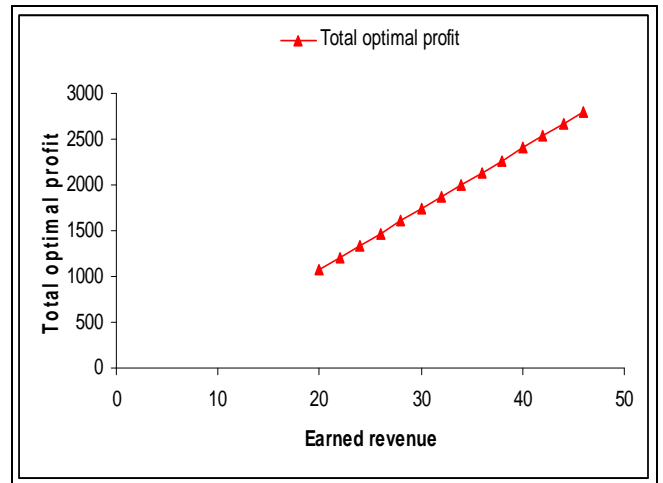tal optimal cost of the system. Thus service cost and total optimal cost of the system are in positive correlation. The optimal expected number of customers in the system remains constant as service cost increases.In Figure 2.1, we see that the optimal arrival and service rates increase gradually as waiting cost increases. The optimal waiting time in the system shows decreasing trend with fluctuations in the end as waiting cost increases. Thus waiting cost and optimal waiting time in the system are in negative correlation. In Figure 2.2, we observe that the total optimal cost of the system increases as waiting cost increases. An increase of 17.2% (approx.) in waiting cost results about 15.6% increase in the total optimal cost of the system. Thus waiting cost and total optimal cost of the system are in positive correlation. The optimal expected number of customers in the system does not vary as waiting cost increases.In Figure 3.1, we observe that the optimal arrival and service rates decreases very slowly as capacity of the system increases. The optimal waiting time in the system shows a decreasing trend with some fluctuations as capacity of the system increases. Thus capacity of the system and optimal waiting time in the system are in negative correlation. In Figure 3.2, we see that the total optimal cost of the system and optimal expected number of customers in the system increase gradually as capacity of the system increases. In fact approx. 7.7% increase in capacity of the system causes approx. 3% increase in optimal expected number of customers in the system and 2.6% increase in total optimal cost of the system.In Figure 4, we observe that the total optimal profit of the system decreases as service cost increases. In fact, about 13.3% increase in service cost causes 0.5% decrease in total optimal profit of the system. Thus a very weak negative correlation between service cost and total optimal profit is seen. The optimal arrival and service rates do not vary as service cost increases.In Figure 5, we see that as waiting cost increases the total optimal profit of the system decreases considerably. In fact, about 5.3% decrease in total optimal profit is observed due to about 18.2% increase in waiting cost. There is a negative correlation between waiting cost and total optimal profit of the system. The optimal arrival and service rates remain constant when waiting cost increases. In Figure 6, we observe that the total optimal profit of the system increases as capacity of the system increases. An increase of 5 units in the capacity of the system results about 12.2% increase in total optimal profit of the system. The optimal arrival and service rates are constant when capacity of the system increases.In Figure 7, we see that as earned revenue increases the total optimal profit of the system increases rapidly. About 7.7% increase in the earned revenue gives approx. 9.1% increase in total optimal profit of the system. Thus earned revenue and total optimal profit of the system are in positive correlation.

5. CONCLUSION

Here, we have succeeded in presenting the cost and profit analysis of non-empty $M/M/1/N$ queuing system. This has led us to efficiently evaluate optimal arrival rate, optimal service rate, and optimal expected number of customers in the system, optimal waiting time in the system, total optimal cost of the system, and total optimal profit of the system as

important performance measures of the system. The problem has good deal of potential to the applications in various fields including inventory management, computer and telecommunications, production management etc.

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MAPPING MACROECONOMIC TIME SERIES INTO WEIGHTED NETWORKS

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Abstract. *The correlations between GDP/capita growth rates of 27 European countries are scanned in various moving time window sizes. The square averaged correlation coefficients are taken as the link weights for a network having the countries as vertices. The network average degree and the weight set variance are found to be monotonic functions on the time window size. The statistics of the weight distributions as well as the adjacency matrix eigensystem are discussed. A new measure of the so called country overlapping is proposed and applied to the network. The ties and clusters are better emphasized through a threshold analysis. The derived clustering structure is found to confirm intuitive or empirical aspects, like the convergence clubs i.e. have a remarkable consistency with the results reported in the actual economic literature.*

Keywords: *fluctuations, correlations, network, clusters*
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1. INTRODUCTION

Modelling the dependences between the macroeconomic (ME) variables has to take into account circumstances that differ substantially from those encountered in the natural sciences. First, experimentation is usually not feasible and is replaced by survey research, implying that the explanatory variables cannot be manipulated and fixed by the researcher. Second, the number of possible explanatory variables is often quite large, unlike the small number of carefully chosen treatment variables frequently found in the natural sciences. Third, the ME time series are short and noisy. Most data have a yearly frequency. When social time series have been produced for a very long period, there is usually strong evidence against stationarity.

Some macroeconomic (ME) indicators are monthly and/or quarterly registered, increasing in this way the number of available data points, but some additional noise is naturally enclosed in the time series so generated (seasonal fluctuations, external and internal short range shocks, etc). This seems to be a solid argument for the fact that the main data sources, at least the ones freely available on the web, tend only to keep the annual averages/rates of growth of the ME indicators.

Let us consider, for example, a time interval of one hundred years, which is mapped onto a graphical plot of 100 data points. From the statistical physics viewpoint, 100 is a quite *small* number of data points, surely too small for speaking about the so called "thermodynamic limit". On the other hand, from a socio-economic point of view, we can justifiably wonder if a growth, say, of 2% of any ME indicator has at the present time the same meaning as it had one century ago. One must take into account that during that time, the social, politic and economic environment was drastically changed. Moreover the methodology of data collecting and processing is today different from what it was two generations ago. Indeed, the economic world is created by people and is substantially changing from a generation to another one (sometimes also during one and the same generation). Thus, this way of statistical data aggregation turns to be controversial.

On the other hand, an increasing interest in network analysis has been registered during the last decade, particularly due to its potential unbounded area of application. Indeed, the inter-disciplinary (or rather trans-disciplinary) concept of "network" is frequently met in all scientific research areas, its covering field spanning from the computer science to the medicine and social psychology. Moreover it proves to be a reliable bridge between the natural and social sciences, so the recent interest in this field is fully justified.

Using the strong methodological arsenal of the mathematical graph theory, the physicists mainly focused on the *dynamical* evolution of networks, *i.e.* on the statistical physics of growing networks. The remarkable extension from the concept of classical random graph [1] to the one of non-equilibrium growing network [2] allows for accounting the structural properties of random complex networks in communications, biology, social sciences and economics [3, 4]. Indeed, the field of the possible applications seems to be unbounded, it spanning from the "classical" WWW and Internet structures [5, 6] to some more sophisticated social networks of scientific collaborations [7-9], paper citations [10] or collective listening habits and music genres [11].

In most approaches, the Euler graph theory legacy was preserved, especially as regards to the "Boolean" character of links: two vertices can only be either tied or not tied, thus the elements of the so-called adjacency matrix only consist of zeros and ones. However, many biological and social networks, and particularly almost all economic networks, must be characterised by *different* strengths of the links between vertices. This aspect led to the concept of "weighted network" as a natural generalisation of the graph-like approaches. Of course, various ways of attaching some weights to the edges of a fully connected network [12-14]. Some ways to relate the weights to the correlations between various properties of nodes have been proposed in the recent literature [15-18].

The correlation coefficients C_{ij} between two ME time series $\{x_i\}$ and $\{y_j\}$, $i, j = 1, …, N$, is calculated in the present work according to the (Pearson's) classical formula:

$$C_{ij}(t,T) = \frac{<x_i y_j> - <x_i><y_j>}{\sqrt{<x_i^2 - <x_i>^2><y_j^2 - <y_j>^2>}} \qquad (1)$$

Each C_{ij} is clearly a function both of the time window size T and of the initial time (*i.e.* the "position" of the constant size time window on the scanned time interval). One has to note (or recall) that the correlation coefficients are *not* additive, *i.e.* an average of correlation coefficients in a number of samples does not represent an "average correlation" in all those samples. In cases when one needs to average correlations, the C_{ij}'s first have to be converted into additive measures. For example, one may square the C_{ij}'s before averaging, to obtain the so called *coefficients of determination* (C_{ij}^2) which are additive, or one can convert the C_{ij}'s into so-called *Fisher z* values, which are also additive [19]. The former approach is used here below, so that the average correlations are calculated as:

$$\hat{C}_{ij}(T) = \left[\frac{1}{\nu} \sum_{t=k}^{k+T} C_{ij}^2(t) \right]^{1/2}, k=0,1,\dots,N-T, \qquad (2)$$

where N is the total number of points (the time span), T is the time window size used for the analysis, $\nu = N - T + 1$, and t is a discrete counter variable.

Let us consider that the M agents (countries) which the ME time series refer to, may be the vertices of a weighted network. The weight of the connection between i and j reflects the strength of correlations between the two agents and can be simply expressed as:

$$w_{ij}(T) = \hat{C}_{ij}(T) \qquad (3)$$

fulfilling the obvious relations: $0 \le w_{ij} \le 1$; $w_{ij} = w_{ji}$ and $w_{ij} = 1$ for $i = j$.

One must stress at this point that the link connecting the vertices i and j does not reflect here either an underlying interaction or a physical/geographical path. Instead, the weight w_{ij} is a measure of the similarity degree between the ME fluctuations in the two countries. The term "fluctuations" refers here to the account of the annual rates of growth of the considered ME indicator. Networks are characterized by various parameters. For instance, the vertex degree is the total number of vertex connections. It may be generalised in a weighted network [13,14] as:

$$k_i = \sum_{\substack{j=1 \\ j \ne i}}^{M} w_{ij} \qquad (4)$$

Thus, the average degree in the network is:

$$<k> = \frac{1}{M} \sum_{i=1}^{M} \sum_{\substack{j=1 \\ j \ne i}}^{M} w_{ij} \qquad (5)$$

Another describes the number of triangles in the network indicating some correlations. In the literature, there have been several ways to evaluate assortative correlations, such as the assortativity coefficient introduced by Newman [4] that is the Pearson correlation coefficient of the degrees at either ends of an edge. Nonetheless, all of them focus on local degree-correlations between two connected nodes. Here below we will introduce an *overlapping coefficient* in order to indicate some hierarchy in clusters on the network. Yet, the first question is to find whether clusters exist. This will be done through a study of the eigenvalues and eigenvectors of the correlation weights matrix defined here above.

A question of great interest in factor analysis is to evaluate how many factors can be extracted from the eigenvalue spectrum *i.e.* how many *common* factors are underlying the correlation matrix. The Kaiser criterion [20] and the Cattell *scree test* [21] are perhaps the most widely used in this question. According to the former, one can retain only factors with eigenvalues greater than 1. In essence this is like saying that, unless a factor extracts at least as much as the equivalent of one original variable, one has to drop it. The latter test suggests finding the "place" where the smooth decrease of the eigenvalue distribution appears to drop significantly before levelling off to the right of the plot. On the left of this point, presumably, one finds the "factorially significant" eigenvalues. Both methods were found remarkably convergent in [22] when the number of common factors is not too large.

The here below investigated ME indicators are the GDP/capita annual growth rates. Indeed, the GDP/capita is expected to reflect to the largest extent what A. Smith called, over two centuries ago, "the wealth of nations". In fact, it is expected to account both for the economic development and for the people well being. The target group of countries is composed of $M = 27$ countries belonging to the European Union in 2008. The countries are abbreviated according to The Roots Web Surname List (RSL) [23] which uses 3 letters standardized abbreviations to designate countries and other regional locations. Given the target country group, the World Bank database [24] is here used instead of the more refereed to Penn World Tables [25] in which some data is missing for several East-European countries. In this way, the investigated time span goes from 1993 to 2008.

A general question facing researchers in many areas of inquiry is how to *organize* observed data into meaningful structures. Having computed the square averaged correlation coefficients from Eq. 2, i.e. the adjacency matrix entries w_{ij} in various time window sizes (Eq. 3), some statistical properties of the $\{w_{ij}\}$ dataset are analysed in Section 2. The cumulative distribution function $F(\{w_{ij}\})$ and the kurtosis $K(\{w_{ij}\})$ indicate a shift from a Gaussian distribution (in small size time windows) to a uniform-like one (in large time window sizes). The variance $\sigma^2(\{w_{ij}\})$ and the network average degree $<k>$ (from Eq. 5), are found to display a smooth behaviour when the time window size increases: σ^2 increases roughly linearly while $<k>$ decreases following an inverse cubic root law. The adjacency matrix eigenvalues spectrum is also studied through a time window perspective. The number of "factorially relevant" eigenvalues is emphasized. The problem of the "optimal" time window for ME correlation investigations is addressed in Appendix A. The "best" time window size is usually considered to be the one corresponding to the minimal variance of the output dataset. However, this criterion is proved not to be universal. From the Kolmogorov-Smirnov test and a chi-square test, we find that a 5-8 years time window has an "optimal" size.

From the eigenvectors corresponding to the two largest eigenvalues, a cluster-like structure of the EU-27 countries is built in Section 3, on the basis of the

eigenvector components. The EU-27 network along a more geographical perspective is also plotted, by emphasizing the relative importance of the link strength (weight) through a display at different threshold values. The threshold values are chosen according to a significance level derived from the *t*-Student statistic test applied to the [w_{ij}] matrix in Appendix B. The clustering scheme and the network structure are in agreement with results reported in the recent economic literature as regards to "convergence clubs". In particular, the so-called "Scandinavian", "Continental", and "East-European" clusters are identified, as well as the particular position of GBR as the single member of any "Anglo" pattern.

In Section 4 the "clustering" structure of the EU-27 countries is measured through a parameter indicating to what extent a country is "connected" to the *whole* system. Using some new coefficient, O_{ij} which takes into account not only the degrees k_i and k_j, but also the number N_{ij} of *common* neighbours of i and j vertices, whence called the "overlapping", we show some hierarchy in countries.

A conclusion is drawn in Section 5 emphasizing the main gains of mapping the GDP/capita (and possibly other ME time series) into the weighted network formalism: an increasing explanatory power, a better intuitive understanding and the possibility of using some new analytical tools, in addition to the ones existing in the actual economic literature.

2. DATA ANALYSIS

Having built the adjacency matrix [w_{ij}] (Eq. 3), the first observation one can make is that its entries are functions of the time window size T from Eq. 2. Thus, the most important characteristics of the weighted network must be seen as depending on T as well. Consider first the cumulative distribution function (CDF) of the weights - elements of the adjacency matrix. The cumulative distribution of the weights is given in Fig. 1 for different time windows, including the minimal (3 years), the maximal (16 years) and two intermediate (5 respectively 10 years). It can be readily seen that the CDF shape is dramatically changing when the time window size

changes. For the small size time windows (3 and 5 years) the CDF is close to a Gaussian, while for the large time windows the CDF approaches the shape expected for a uniform CDF.

These changes of the distribution shape can also be pointed out through the kurtosis (*K*) variation with the time window size (Fig. 2). For the Gaussian distribution $K_G = 0$, while for the discrete uniform distribution of *m* data (*m* = 300 here) it can be calculated [19] as:

$$K_U = -\frac{6}{5}\frac{m^2+1}{m^2-1} \approx -\frac{6}{5} \qquad (6)$$

It is found on Fig. 2 that the *K* value shifts between the limit K_G and K_U indeed.

Taking into account the above results one may conclude that the distribution of the adjacency matrix entries w_{ij} ($i > j$) becomes flatter and flatter when the time window size increases, shifting from the Gaussian-like shape to the uniform-like distribution. Some statistical tests are done in Appendix A.
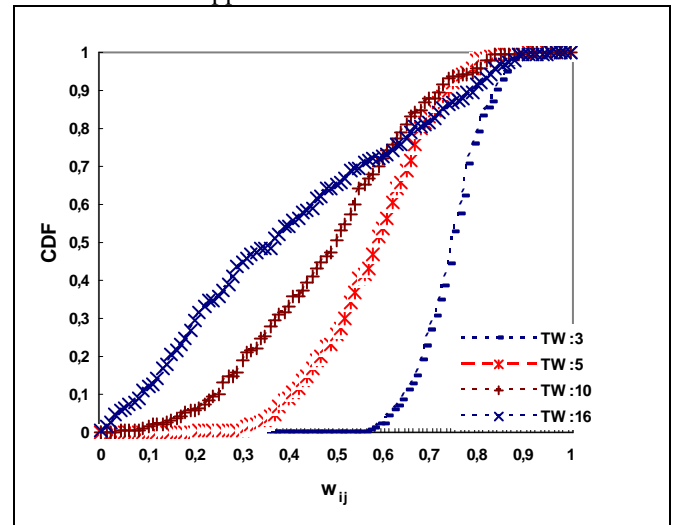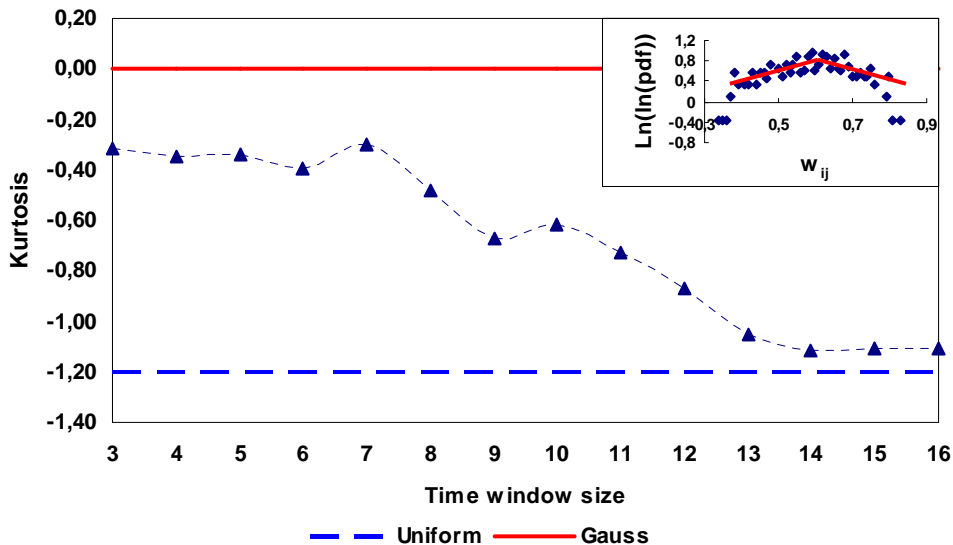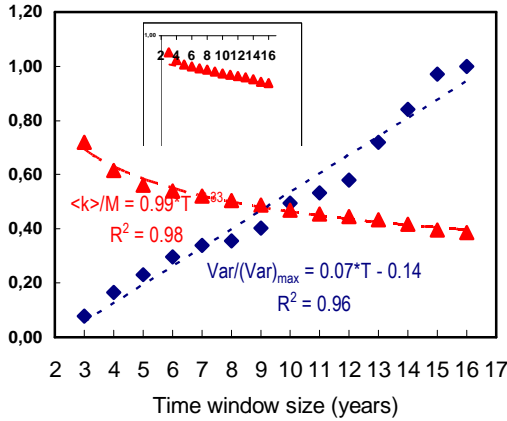

Fig. 1 The CDF of the weights set {w_{ij}} for four different time window sizes

Fig. 2 The kurtosis coefficient of the weights set $\{w_{ij}\}$ versus the time window size. Inset: the double logarithm of the w_{ij}'s probability density function for 5 years time window size. The thick line has a ± 2 slope, corresponding to the Gaussian distribution.

Fig. 3 The average degree $<k>/M$ and the variance of the weights set $\{w_{ij}\}$ in the EU-27 network versus the time window size. Variance is normalised to its maximal value. Inset: $<k>/M$ versus T in log-plot for emphasizing the inverse cubic root law.

The average degree of the EU-27 weighted network is plotted in Fig. 3 for all possible time window sizes with which the time span 1993-2008 can be scanned. One can see that the decreasing of $<k>$ with the time window size T is well fitted by a power law: $<k> \sim 1 / T^{1/3}$.

The somewhat unexpected behaviour, i.e., the monotonic (roughly linear) increase of the variance with the time window size can be understood through the change in CDF shape. A possible explanation of this behaviour is based on the number of common factors underlying the correlation coefficients.

As the adjacency matrix of the EU-27 weighted network is in fact a squared-averaged correlation matrix of the GDP/capita growths, it is natural to ask for the interpretation of its eigensystem.

The six largest eigenvalues are plotted in Fig. 4 for each possible moving time window size scanning the time span 1993-2008. As mentioned in the Introduction, the Kaiser criterion suggests to evaluate the number of common factors taking into account the eigenvalues having a percent contribution to the total variance at least $1/M = 1/27$ (the continuous horizontal line in Fig. 4)

At first sight one can see that the first eigenvalue contribution to the total variance monotonically decreases when the time window size increases, while the other eigenvalues contribution becomes more and more significant. Moreover, the cumulated contribution of the first two largest eigenvalues decreases from 80% for $T = 3$ years, to 64% for $T = 16$ years. Therefore, for the small size time windows (3-5 years) two common factors may be accounted for, while in the largest time windows the number of common factors increases to six.
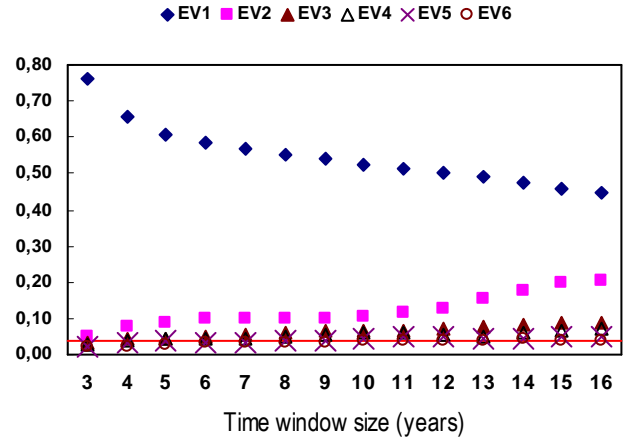
Fig. 4 The six largest eigenvalues (EV) of the adjacency matrix $[w_{ij}]$ for the EU-27 weighted network versus the moving time window size. The eigenvalues are normalized the correlation matrix size ($M = 27$), thus the vertical axis may be read as a fractional contribution to the total variance.

This finding reinforces the results of the previous subsection on the change in shape of the CDF. When the number of common factors is small, the correlation coefficients are grouped around the mean value, leading to the Gaussian-like distribution shape. On the contrary, when many common factors (economic, social, political) are accounted for, the correlations between the GDP/capita rates of growth tend to cover the whole interval between 0 and 1 (in absolute values), and a uniform-like distribution emerges.

3. THE CLUSTERED WEIGHTED NETWORK OF EU-27 COUNTRIES

Since the eigenvectors corresponding to the largest eigenvalues of the correlation matrix are usually expected to be those carrying the most useful information, a cluster-like structure of the EU-27 countries is built in Fig. 5 on the basis of the structure of the first two eigenvectors.

One can easily see (Fig. 5) that a multi-polar structure exists: the "Continental" group (l.h.s., up) and the "Scandinavian" group (l.h.s., middle) are somewhat apart from each other. An extreme position is taken by GBR (r.h.s., down) which appears as the single member of any "Anglo" pattern, since the other OECD representatives of a (supposed to be) anglo-convergence club, *e.g.* U.S.A., Canada and Australia [26, 27]), are missing from our study. Another interesting aspect pointed out by Moran in [27] is also found here, i.e. IRL has a non appartnence to the "Anglo" cluster, but is rather in the "Scandinavian" group and close to the "Continental" one.

For the first time, i.e. as a complementary addition to previous investigations on the subject, we observe an emerging East European convergence club (r.h.s., down), tying to Scandinavian and Continental group through a HUN – POL line. Observe some "Mediterranean" clustering as well.
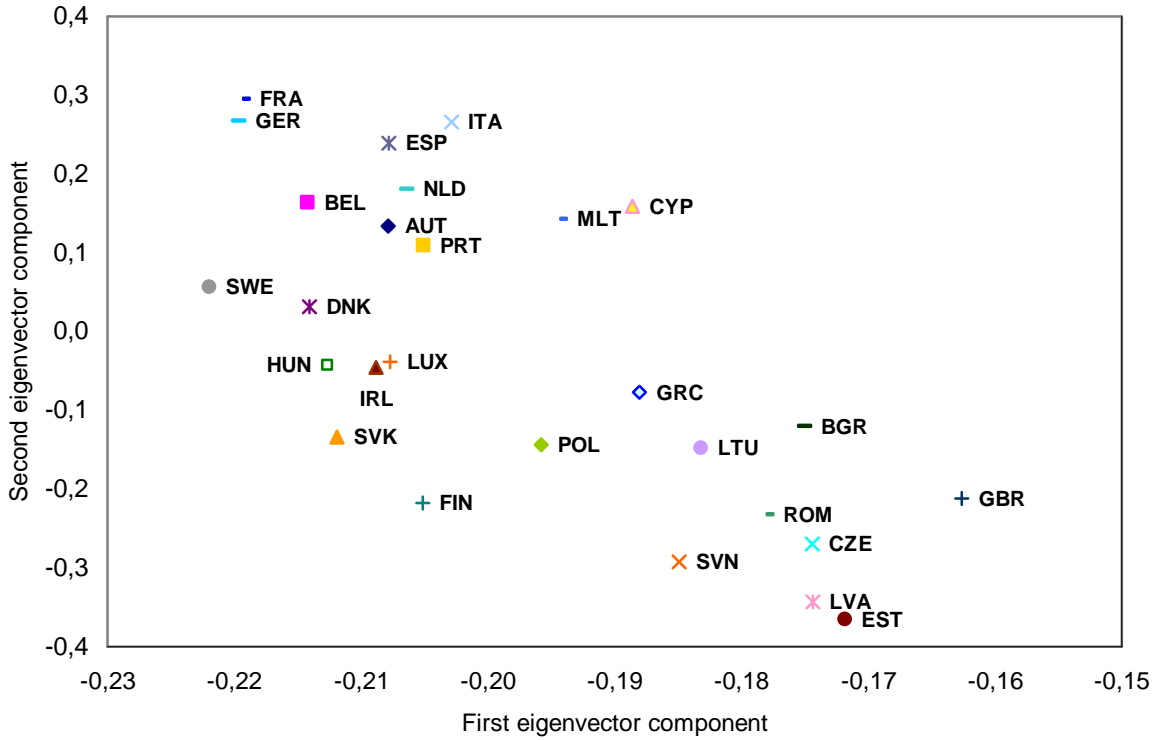
Fig. 5 The cluster-like structure of the EU-27 countries according to the GDP/capita rates of growth. The country coordinates are the corresponding eigenvector components of the EU-27 weighted network adjacency matrix [w_{ij}].

The clustering scheme in Fig. 5 is in agreement with results reported in the recent economic literature as regards the so-called "convergence clubs" across the Western Europe, *i.e.* groups of economies that present a homogeneous pattern and converge towards a common steady state [26-30]. In particular, in [26] it has been showed that Sweden, (Norway) and Denmark, registered a similar level of income mobility while in [27] three distinct patterns of development and income distribution, indeed called "Continental", "Anglo" and "Scandinavian", have been found by examining a group of 17 OECD economies during the two decades before 2000. In the same idea, "a high degree of heterogeneity in preferences for redistribution across four clusters of different systems of social protection of OECD countries" namely Scandinavian, Continental, Anglo-Saxon and Mediterranean has been reported in [30].

Finally, the adjacency matrix [w_{ij}] can be used to plot the EU-27 network along a more geographical perspective. The network is, obviously, fully connected; it is of interest to observe the relative importance of the link strength (weights) through a display at different threshold values. In the subsequent figures, only the links having the corresponding weights greater than a certain threshold value, w_α are taken into account. This threshold value is *a priori* chosen according to a significance level derived from the *t*-Student statistic test applied to the [w_{ij}] matrix (Appendix B). The resulting networks are plotted in Figs. 6a, 6b, 6c for the $T = 5$ years moving time window size.

(a)

$w_{ij} > 0.49$

(b)

$w_{ij} > 0.69$

(c)

w_{ij}**>0.81**
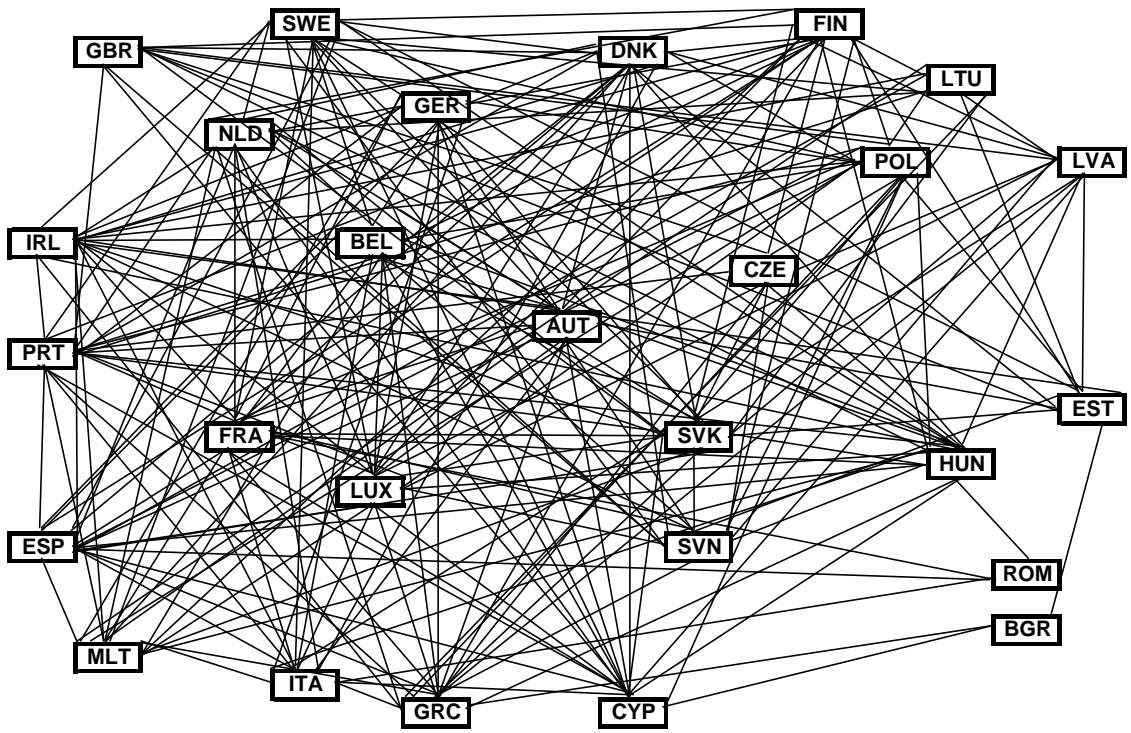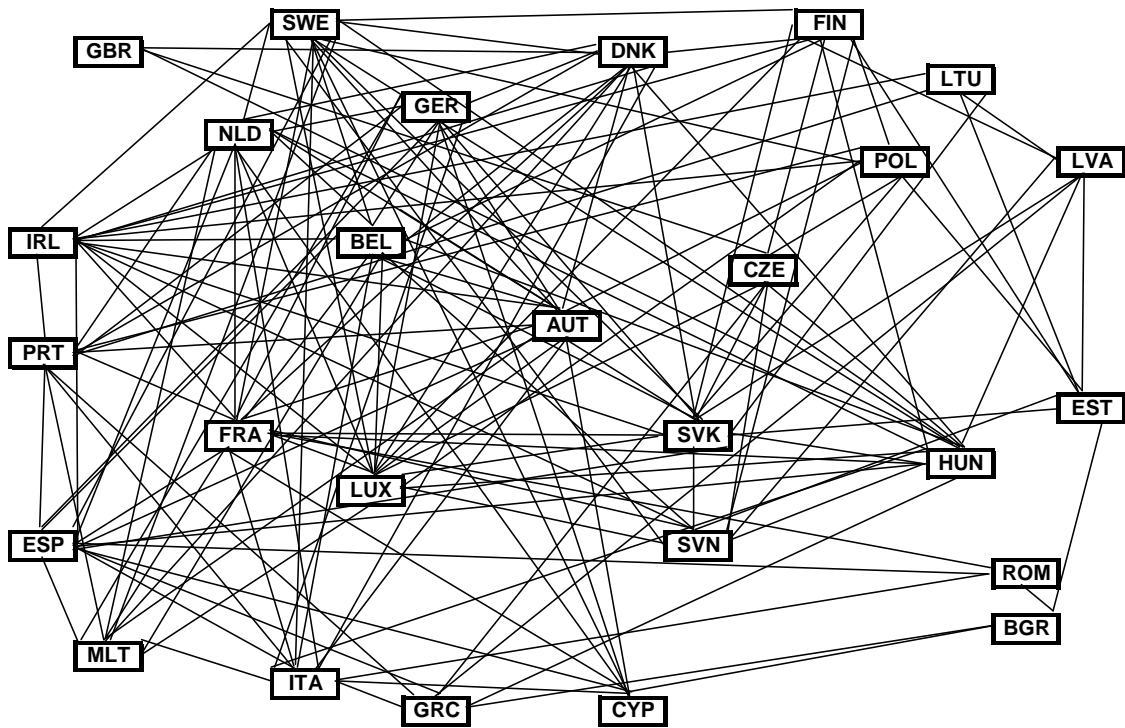
Fig. 6 The EU-27 weighted network for three different weight thresholds: (a) w_T=0.49; (b) w_T=0.69; (a) w_T=0.81.
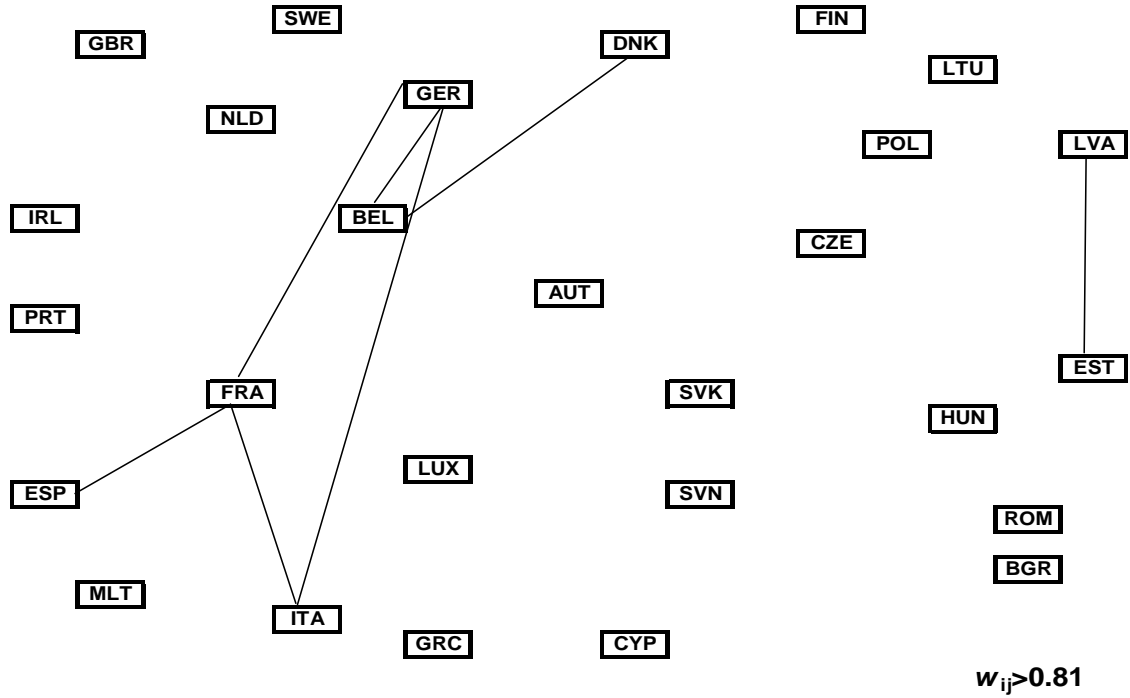Fig. 6a includes all four "convergence clubs" above discussed. The single element "Anglo" club is well isolated, as seen already in Fig. 6b; the "Scandinavian" and "East European" clusters become isolated for a higher threshold, as seen in Fig. 6c. It is also remarkable to observe the decreasing number of long-range links when going from Fig. 6a to Fig. 6b and further to Fig. 6c. Even if the actual geographic, investment and trade inter-country ties are not explicitly considered in our study, the degree of similarity of the country GDP/capita *fluctuations* well supports the evidence of the so-called "regionalization" [28, 29].

4. THE COUNTRY OVERLAPPING HIERARCHY

The previous results lead to consider the hierarchical or "clustering" structure of the EU-27 countries. For the purpose of describing this aspect we introduce a quantity which is able to measure to what extent a country is "connected" to the whole system. The idea, first hereby applied to a non-weighted network, is to construct a country hierarchy using some new coefficient, O_{ij} which takes into account not only the degrees k_i and k_j, but also the number N_{ij} of the *common* neighbours of i and j vertices,. This coefficient O_{ij} is here called "overlapping" of i and j vertices (in spite of the fact that this term has already been assigned various meanings in the network literature).

Firstly, for a non-weighted network consisting of M vertices, O_{ij} must satisfy the following properties:

(1) $O_{ij} = 0 \Leftrightarrow N_{ij} = 0$ (fully disconnected, or "tree-like" network)

(2) $O_{ij} = 1$, $\forall i \neq j$ in a fully connected network, where $N_{ij} = M - 2$; $k_i = k_j = M - 1$;

(3) $0 < O_{ij} < 1$, otherwise;

(4) $O_{ij} \sim N_{ij}$ and $O_{ij} \sim <k_{ij}> \equiv (k_i + k_j)/2$.

A quantity satisfying all these conditions (1)-(4) can be defined as:

$$O_{ij} = \frac{N_{ij}(k_i + k_j)}{2(M-1)(M-2)} \ , i \neq j. \tag{7}$$

For a weighted network, Eq.7 may be generalised as:

$$O_{ij} = \frac{1}{2(M-1)(M-2)} \sum_{\substack{l=1 \\ l \neq i,j}}^{M} (w_{il} + w_{jl}) \left(\sum_{\substack{p=1 \\ p \neq i}}^{M} w_{ip} + \sum_{\substack{q=1 \\ q \neq j}}^{M} w_{jq} \right), i \neq j. \tag{8}$$

One can easily see that $0 < O_{ij} < 1$, and $O_{ij} = 1$ only for all $w_{ij} = 1$, *i.e.* fully connected non-weighted network. However, for a weighted network, O_{ij} can never be zero.

Each overlapping coefficient is thus computed for each EU-27 country using the adjacency matrix defined in Eq. 3. A country average overlapping index $<O_i>$ can be next assigned to each country, dividing the sum of its overlapping coefficients by the number of neighbours:

$$< O_i > = \frac{1}{M-1} \sum_{j=1}^{M} O_{ij} \tag{9}$$

The results are shown in Table 1.

Table 1 The country average overlapping index of each EU-27 country

SWE	0.38	NLD	0.35	CYP	0.32
DNK	0.37	AUT	0.35	SVN	0.32
GER	0.37	FIN	0.35	CZE	0.31
FRA	0.37	POL	0.35	ROM	0.31
HUN	0.37	ESP	0.35	BGR	0.31
SVK	0.37	PRT	0.35	LTU	0.31
BEL	0.36	ITA	0.34	LVA	0.31
IRL	0.36	MLT	0.33	EST	0.30
LUX	0.36	GRC	0.33	GBR	0.29

The highest values of the average overlapping index correspond to the countries belonging to the "Continental" and "Scandinavian" groups, while the lowest values correspond to several countries forming an East European cluster. Again, the separate position of GBR as a single representative of the "Anglo" pattern, with respect to European economies is emphasized, the former being in fact a cluster by itself.

One has to note a remarkable similarity between the country ranking over the first eigenvector component (Fig.5) and the ranking over the country average overlapping index (Table 1). This similarity proves the ability of the hereby introduced $<O_i>$ index to supply a correct description of the country weighted network.

5. CONCLUSIONS

The present paper has shown the possibility of mapping a macroeconomic time series, namely the GDP/capita rates of growth into a weighted network. The considered vertices are the 27 countries belonging to the EU community in 2008 and the weights assigned to the links are the correlation coefficients. An averaging has been performed over the squared values obtained when a constant size time window is moved with a constant time step over the scanned time interval (1993-2008).

Usually, the correlation coefficients are computed in various time windows, with a given size; the first problem brought into discussion here above and outlined in Appendix A has been the role played by the time window size. In particular, the variance of the weights dataset has been found to be a monotonically increasing function of the time window size. This unusual result reflects the weight distribution shifting from a Gaussian to a uniform-like shape when the time window size used for data analysis increases. This transition has been explained when analysing the eigenvalue spectrum of the adjacency matrix in various time windows: as the time windows size increases, more and more common factors must be taken into account as underlying the adjacency matrix, so that the correlation coefficients (absolute) values cover almost uniformly the interval between 0 and 1.

Finally, we have to point out that the mapping of the GDP/capita and other macroeconomic time series into a weighted network structure allows a direct visualisation of the inter-country connections from at least three different viewpoints: (a) as relative distances in the bi- or multi-dimensional space of the adjacency matrix eigenvalues; (b) as statistical significant edges in the graph plot; (c) as relative positions in the country averaged overlapping coefficients based hierarchy. In all these three ways, the derived clustering structure is found to have a remarkable consistency with the results reported in the actual economic literature. In the future, other network multi-vertex characteristics (clustering, minimal path, centrality, etc.) may be expected to be studied in order to show whether they play an important role in a better understanding of economic connections.

APPENDIX A: IS THERE AN OPTIMAL TIME WINDOW?

A Kolmogorov-Smirnov test has been performed over the CDF (Fig.1) corresponding to every time window size [31]. The p-values are found to be small (0.12 – 0.16) for 3 and 4 years as well as for 9, 10 and 11 years time window sizes; some large p-values are obtained for the range 5 – 8 years (0.34-0.48) and drop to 0.01 and 0.00 for 12-16 time window size. As generally accepted ([31], [32]), the null hypothesis is rejected when p-values are smaller than 0.10. Thus, one can conclude that the hypothesis of Gaussian distribution is rejected for the time windows larger than 11 years.

The χ^2 statistical test has been performed in contrast against the hypothesis of a uniform distribution. The standard confidence intervals are found to be less than 1% for the 3 and 5 years time window sizes, while for the 10 and 16 years time window sizes they are found to be at 85% and 90% respectively.

As regards the problem of the "optimal" time window, one must firstly recall that usually, the "best" time window size is considered to be the one corresponding to the minimal variance of the output dataset. However, this criterion is not universal. From the Kolmogorov-Smirnov test we have derived that for the 5-8 years time window sizes the corresponding distributions are "more Gaussian" than for the small time windows of 3 and 4 years. Moreover, in the 3 and 4 years window sizes the same statistical test points out to a relatively large number of "outliers" which may be seen as spurious correlations.

In view of the above considerations, we conclude that the "optimal" time window sizes are situated in the interval 5-8 years. That is why some particular results in the Sections 3-5 are derived from a constant size time window of 5 years, for which the distribution of $\{w_{ij}\}$ set is Gaussian, at least in its central part (see Fig. 3, inset).

APPENDIX B: THE T-STUDENT'S TEST APPLIED TO THE $[w_{ij}]$ MATRIX

The linear relationship between two variables can be tested using t-statistics [32] by computing:

$$t = w_{ij} \sqrt{\frac{n-2}{1-w_{ij}^2}}, \tag{10}$$

where $n - 2$ is the number of degrees of freedom. The correlation (weight) w_{ij} is considered to be statistically

significant if the computed t value is greater than a critical value t_α read from the t-Student's distribution table for the α level of significance.

From Eq. (6), if $w_{ij} = w_\alpha$ and $t = t_\alpha$ one gets:

$$w_\alpha = \frac{t_\alpha}{\sqrt{t_\alpha^2 + n - 2}} \tag{11}$$

Taking $n = 5$ (the number of statistical data used for computing each correlation coefficient in the 5 years time window size), from the t-Student distribution tables we find the critical values $t_{\alpha1} = 0.98$; $t_{\alpha2} = 1.64$ and $t_{\alpha3} = 2.35$ for the levels of significance $\alpha_1 = 0.4$; $\alpha_2 = 0.2$ and $\alpha_3 = 0.1$; (or, equivalently, 60%, 80% and, respectively, 90% confidence intervals). The corresponding threshold values are $w_{\alpha1} = 0.49$; $w_{\alpha2} = 0.69$ and $w_{\alpha3} = 0.81$, they are therefore used as threshold for the display (Fig. 6a, 6b, 6c).

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REVISITING STOCK MARKET ASSUMPTIONS.
APPLICATION FOR ROMANIAN STOCK EXCHANGE

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Abstract. *The last century was marked by a prodigious development of modeling phenomena of capital markets. During the basic process, a number of assumptions that were made proved to have more or less validity in tests confronting or conforming to reality. In this paper we propose to question some of those assumptions in the case of the capital market of Romania.*
Keywords: *Efficient Market Hypothesis, stable distribution, predictability.*

1. INTRODUCTION

Understanding the phenomena that take place within the capital markets or those connected to it, requires the use of quantitative methods and techniques.

In particular, the statistical methodology provides efficient tools for the analysis of the processes taking place in close connection with capital markets activity.

After centuries of studies in which statistics was used to investigate a wide variety of phenomena in economic or social areas, medical sciences etc., a useful conclusion can be drawn for the understanding of these classes of events: unlike sciences terminology, such as logic, statistics does not operate with concepts of true or false. A statistical conclusion will almost never be true or false, but only probable or less probable, the accuracy test of this conclusion being comparison with reality.

This requires a special relationship with reality: to understand a phenomen of this nature, usually we seek to obtain a law, i.e. a general rule of governing the intrinsic life of that phenomenon; and we discover this by building models of reality, being more or less abstract ones, trying to surprise the essence of the event.

In general, a model is a simplified representation of reality, taken in order to understand its essential aspects.

In economics, a model is a theoretical construct explaining the economic process through a set of variables and some qualitative and quantitative relationships between them.

The model simplifies, being a key to understanding reality, not at a true reflection of it.

The way in which we use models to represent and have a deep knowledge of reality allows us to form an analogy with Plato's theory of ideas.

According to this theory, there is a perfect world, the world of ideas, of forms, which is the true reality, the sensory world being a pale reflection of the world ideas. Thus, having an idea of a perfectly round circle cannot be false as is relating to and describing an aspect of perfection. However, this idea does not prove the existence of anything, but merely demonstrates that it is possible for an imperfect being to hold a concept of perfection. If it is possible to hold an idea of a perfect circle, but still be imperfect, surely it is possible to hold a concept of a perfect being whilst being imperfect.

This happens generally with geometric models, which operates with perfect concepts and notions that are not to be found in inherent reality.

In general, a model is in intrinsic connection with the reality that it describes; starting from the actual data of reality, we are building models, schemes of understanding of reality. These models can be studied independently, at the abstract level (which it makes it particularly applicable to modern mathematics), have a life of their own, in the ideal world of models, but ultimately there is a return to real world models with valid conclusions from the reality's level that gave rise to the model.
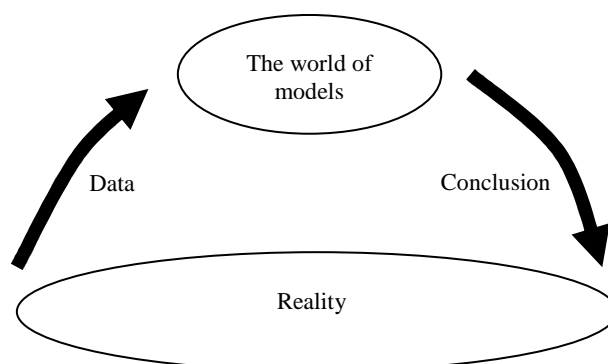
Fig. 1. Scheme of understanding reality through a model

We distinguish between two classes of models: deterministic models and probabilistic models.

Deterministic models are models in which parameters and variables are not subject to some random fluctuations. An example is the model associated with Newtonian mechanics. According to the second principle of mechanics, the force is proportional to the body's mass in motion and it's accceleration: $\vec{F} = m\vec{a}$. Then whenever we know the values of mass and acceleration of a body in motion, we know with certainty the amount of force developed by it. In this case the only errors that can interfere are errors of measurement.

Probabilistic models are models that take into account the random component. In our attempt to include in a mathematical model the surrounding reality, a special requirement is the prediction of the future states of reality with the help of the build model. Since the use of

deterministic models to capture essential aspects of reality seems to be an approach inevitably doomed to failure[1], a reasonable solution would be to use stochastic models, in which the random factor is given a proper role.

Modeling capital markets has a long history, which can not be separated from the historical development of modern methods and techniques of quantitative investigation.

As it will be seen from this work, modeling capital market is in a close relationship with the hypothesis of capital market efficiency, a concept also correlated with the rationality of the participants's behavior in the market's activities.

In the following analysis we make an overview of the main authors who have approached this piece of reality in their work, but also the most important results that have marked in a definitive way the understanding of phenomena that occur in the capital markets.

In the year 1565, the famous Renaissance mathematician Girolamo Cardano published the book *Liber de ludo aleae (The book of gambling)*, in which he proposes the concept of equality of chances, which can be found in modern literature of game theory under the name of the correct game (fair game): „the fundamental principle in all gambling is the equality of chances, whether it is about opponents, money, etc.".

In the year 1828, the Scottish botanist Robert Brown observed in an experiment that pollen particles in suspension have a random oscillatory movement, which rapidly change the trajectory. This observation leads to the concept of the Brownian motion.

In 1863 a French broker, Jules Regnault noted a fundamental property of Brownian motion: the variability (measured by standard deviation) of Brownian motion is proportional to the square root of time.

It is already the moment when it begins to crystallize the main notions and concepts that will mark the effort of modeling financial phenomena.

Thus, British physicist Rayleigh discovered in 1880 the processes of random walk (walking at random) during his studies on sound waves.

In the year 1888, logician and philosopher John Venn formulated a coherent concept of random walk and Brownian motion.

The crucial point in modeling financial market phenomena came in the year 1900, when the young French mathematician Louis Bachelier published his doctoral thesis *Théorie de la speculation*[2]. Using statistical methods, he deduced that the mathematical expectation of the speculator is zero; also, it formalized the Brownian motion, being calculated the

probability that a certain return to be achieved in a given period of time.

In 1905, the statistician Karl Pearson introduced the term of *random walk* in his article in the journal *Nature*[3] where he define the random walk proccess: „in an open space, the most likely place where to find a drunken man, who can not stand up, is somewhere in the neighborhood of its initial position".

That same year, independent of previous research by Bachelier, Einstein developed the equations that are describing Brownian motion.

Much later, in the 70's, appears the article that will definitely mark the theory of financial markets: *Efficient Capital Markets: A Review of Theory and Empirical Work*, written by Fama. This paper provides a summary of previous research on the issue of predictability in equity markets and it provides clearly formalism for notions like fair game and random walk.

Also, it is given the classic definition of efficient markets: a market is efficient if stock prices always fully reflects all available information[4].

There is made the distinction between three forms of efficiency: strong, semi-strong and weak form efficiency. To discuss capital market efficiency hypothesis to be considered common (*joint hypothesis*): in addition to studying how a stock price fully reflects available information should be considered an investor's attitude towards risk. As will be shown later Campbell, Lo and MacKinlay (1997) [5] „any test of efficiency is based on the assumption that there is an equilibrium model that defines the normal gains. If efficiency is rejected, this may mean that the market is truly inefficient or may be a sign that an inappropriate model of market equilibrium was chosen".

It is interesting to note that these papers, as many others, are based on several assumptions that are more or more or less explicitly formulated: hypothesis of rational behavior of investors, independence of economic agents, hypothesis of existing a normal distribution of returns, assuming the existence of market equilibrium.It may be questioned whether these assumptions are originating from economic reality or all of the past decade of research has modified the reality according to the theory. In the following we discuss in a critical way some of these assumptions.

2. NORMAL DISTRIBUTION ASSUMPTION

In 1915, Wesley Mitchell argued[6] that the distribution of financial asset price changes is „too stretched" to come from a normal distribution.

[1] See in this respect also the aroused controversy in the XVIIth and XIXth centuries on the deterministic models of the Universe built by Laplace which is assigned the following phrase:" No place for God in the world build by me" (i.e., no error would have belong in such a purely, deterministic Universe!).

[2] Bachelier, L.,1900, "Théorie de la speculation", *AnnalesScientifique de l'E.N.S.,*3[e]serie, tome 17,pp.21-86,http://www.numadam.org/item ?id=ASENS_1900_3_17_21_0

[3] Pearson, K. , 1905, "The Problem of Random Walk", *Nature*, No.1865, Vol. **72**, August.

[4] A market in which prices always "fully reflect" available information is called "efficient".

[5] Campbell, J.Y., LO, W., MacKinlay, C., 1997, *The Econometrics of Financial Markets*, Princeton University, pp. 24.

[6] Mitchell, W. C., 1915 and 1921, "The Making and Using of Index Numbers," Introduction to *Index Numbers and Wholesale Prices in the United States and Foreign Countries*, published in 1915 as Bulletin No. 173 of the U.S. Bureau of Labor Statistics, reprinted in 1921 as Bulletin No. 284.

In 1923 Keynes[7] emits the hypothesize that investors in financial markets obtain profits not due their ability to predict better than the overall market's future price developments, but because of an appetite for risk, an idea that is consistent with the efficient market hypothesis.

In 1926 the French mathematician Maurice Olivier[8] provided a clear demonstration that the return distribution on the capital market is a leptokurtic distribution, which deviates from the normal distribution curve, being more elongated than that.

In an article from 1960[9], Larson shows that the return distribution is very closed to the normal for the 80% of observations in the middle of the original distribution, but there are a large number of extreme values that creates a departure from normality.

One of the researchers who decisively influenced financial modeling, Benoit Mandelbrot, rediscovers in an article in 1962 (but published a year later[10]) the ideas of Louis Bachelier and proposes the so-called stable distributions, of Pareto-Levy type, for price behavior of a financial asset, which explains better than normal distribution the occurrence of extreme values.

A confirmation that stock's return (calculated as the difference of logarithms of prices) follows a stable Pareto distribution is obtained by Fama in 1963[11]: thus, the logarithm of the characteristic function of a stable Pareto distribution has the form:

$$\ln \varphi(t) = \ln \int_{-\infty}^{+\infty} \exp(uit)dP(\tilde{u} < u) = i\delta t - \gamma|t|^{\alpha}\left[1 + i\beta\frac{t}{|t|}\tan\left(\frac{\alpha\pi}{2}\right)\right].$$

Mandelbrot demonstrated that the parameter α is controlling the length of „tails" of such a distribution and takes values in the range $[0,2]$. In particular, if $\alpha = 2$, the stable Pareto distribution becomes a normal distribution.

Using daily differences of logarithms share prices of 30 companies from the Dow Jones Industrial Average, Fama estimates the α parameter and obtains in all the cases values smaller than 2, an important argument in the favour of the fact that the return is not following a normal distribution, but a stable Pareto one.

Fama's calculation on the distribution of returns indicates that they are following a stable Pareto distribution, with

coefficient $\alpha < 2$, a strong argument against the hypothesis of normal distribution.

An important consequence arising from this conclusion: since the Pareto distribution with $\alpha < 2$ has the second-order infinite, therefore infinite dispersion, using classical methods of estimation, such as ordinary least squares method, becomes unnecessary. Fama suggests using mean absolute deviation[12] instead of variance as a measure of variation.

More recents works (Rachev, etc.) rediscover the theory of stable distributions in financial modeling theory and shows that there are much better approaches than classical distributions. The fact that the observed distribution of the returns is heavy-tailed can not be explained through a normal distribution. Further, the frequency of extreme events such as the financial crisis is much bigger than it actually allowing for Gaussian distribution.

3. EFFICIENT MARKET HYPOTHESIS

Efficient market idea, as it is understood in modern literature, has its origins from Bachelier Cowles and Samuelson's works. In 1970, in his famous study13, Fama gives the following definition:"A market in which prices always fully reflect the available information is called an efficient market".

A more recent definition is made by Malkiel (1992): „A capital market is called efficient if it correctly and fully reflects all relevant information in determining asset prices. Formally, the market is assumed to be efficient relative to a particular set of information, if asset prices would not be affected by revealing that information to all agents on the capital market. Furthermore, efficiency relative to a lot of information implies that it is impossible to get profits act upon that information crowds".

The first part of this latter definition is similar to Fama's classic definition, the second one involves a way to test the efficiency of capital markets: if prices do not change when a certain set of information is disclosed, then the market is efficient compared with that set of information (this test is impossible to achieve in real terms).

The third part of the definition suggests another way to measure efficiency: by measuring the profits from transactions based on a set of information, we can decide whether the efficient market hypothesis is confirmed or not. And this way is difficult to implement since the information available to the the agents in capital market as incomplete known.

One way to avoid these difficulties in testing the efficiency of capital market is to develop a classification according to the multitude of information available, so we can distinguish between three types of efficiency:

[7] Keynes, J. M., 1923, "Some Aspects of Commodities Markets", *Manchester Guardian Commercial*, March 29, reprinted in *The Collected Writings of John Maynard Keynes*, *Volume XII*, London: Macmillan, 1983.

[8] Olivier, M., 1926, "Les Nombres indices de la variation des prix", Paris doctoral dissertation.

[9] Larson, A. B., 1960, "Measurement of a Random Process in Futures Prices", *Food Research Institute Studies*, Vol. **1**, No. 3, pp. 313-24.

[10] Mandelbrot, B., 1963, "The Variation of Certain Speculative Prices", *The Journal of Business*, Volume **36**, Issue 4, October, pp. 394-419.

[11] Fama, E. F., 1963, "Mandelbrot and the Stable Paretian Hypothesis", *The Journal of Business*, Volume **36**, Issue 4, October, pp. 420-429.

[12] *Mean absolute deviation* (MAD) for a set of values $x_1, \ldots, x_n$ is

defined as: $MAD = \sum_{i=1}^{n} \frac{|x_i - \bar{x}|}{n}$

[13] Fama E. F., 1970. "Efficient Capital Markets: A Review of Theory and Empirical Work", *Journal of Finance*, **25**(2), pp. 383–417.

- **weak form efficiency**—the set of information includes only the transaction history (information on prices or financial return on assets);
- **semi-strong form efficiency**—the set of information includes, besides the transaction history, all public information known by all participants in the transaction;
- **strong form efficiency**—sets of information including all information known to any of the capital market actors (including private information).

One way to test the efficiency of capital market is to study the behavior of stock returns: if these are unpredictable it is an indication that the market is efficient.

A reverse argument is offered by so-called *law of iterated averages*. Allowing in this sense two sets of information I_t and J_t, so that $I_t \subset J_t$, namely the second set is superior in information to the first one.

The law of iterated averages says this: if X is a random variable, then $\mathbf{E}[X \mid I_t] = \mathbf{E}[\mathbf{E}[X \mid J_t] \mid I_t]$.

Interpretation of this law is the following: prediction based on the information contained in the set I_t is identical to the prediction that we get it if we have the additional information contained in the set J_t.

Applying this law in equity markets leads to an interesting conclusion: if a market is efficient, fluctuations in financial asset prices are not predictable.

Indeed, suppose that at some point we have the set of information I_t, information that is completely and correctly reflected in the price P_t (formalizing, this means that there is a random variable V, so that $P_t = \mathbf{E}[V \mid I_t]$).

Similarly, the price of the next moment $t+1$, is determined by a set of information $I_{t+1} \supset I_t : P_{t+1} = \mathbf{E}[V \mid I_{t+1}]$.

Then the expected value of price change between the two moments of time is:

$$\mathbf{E}[P_{t+1} - P_t \mid I_t] = \mathbf{E}\{[\mathbf{E}[V \mid I_{t+1}] - \mathbf{E}[V \mid I_t]] \mid I_t\}$$
$$= \mathbf{E}\{[\mathbf{E}[V \mid I_{t+1}] \mid I_t\} - \mathbf{E}[V \mid I_t] = 0$$

In conclusion, price change cannot be predicted, based on the information contained in the set I_t.

From a theoretically view point, if the issue of the capital market efficiency is well devised, we question in what way it can be extented to achieve a practically efficient market hypothesis testing. A useful approach to achieve this is the concept of relative efficiency, i.e. testing the efficiency of a market in relation to another market.

The possibility to model the behaviour of financial assets in order to achive predictions of their future returns is a concern of researchers in this field. In the following we consider the problem of predictability of financial asset price fluctuations, considering that they are influenced by past values.

3.1.RW1 hypothesis: independent and identically distributed increments (i.i.d)

The most natural expression of random walk hypothesis is that the price of financial assets is a stohastic process with internal dependence, with the following form:

$$P_t = \mu + P_{t-1} + \varepsilon_t , \tag{3.1}$$

where $(\varepsilon_t)_t \quad \mathbf{WN}(0, \sigma^2)$ is a white noise, i.e. a series of random variables independent, identically distributed:

$E[\varepsilon_t] = 0, \forall t$

$Var[\varepsilon_t] = \sigma^2, \forall t$

$\varepsilon_t, \varepsilon_{t+k} independents\ for\ every\ k$

Moreover, if the last condition is satisfied, then we have.

$$\mathbf{Cov}[\varepsilon_t, \varepsilon_{t+k}] = 0 \text{ și } \mathbf{Cov}[\varepsilon_t^2, \varepsilon_{t+k}^2] = 0, \forall k \neq 0 .$$

In equation (3.1), P_t, P_{t-1} are the price value at two consecutive moments, and μ is the expected price change, so-called *drift*.

Independence of innovations $(\varepsilon_t)_t$ implies that random walk is also a fair game, but in a sense stronger than the Martingale hypothesis: increments are not only non-correlated, but also independent, hence results that any linear combinations thereof are non-correlated.

The functional form of the RW1 model induces non-stationarity conditions of the process

$$(P_t)_t : \begin{cases} \mathbf{E}[P_t \mid P_0] = P_0 + \mu t \\ \mathbf{Var}[P_t \mid P_0] = \sigma^2 t \end{cases} .$$

The most encountered condition that is imposed to innovations $(\varepsilon_t)_t$ is the one of the normality, beside the white noise's character, a condition which induces a certain convenience in formal terms. But it appears inconsistent with the actual situation, because the normal distribution covers the entire real line, so there is a nonzero probability that an asset price is negative. One way to avoid this difficulty is to use instead of financial asset price series, time series of natural logarithms of these prices: $p_t = \log P_t$.

RW1 model becomes then a lognormal:

$$p_t = \mu + p_{t-1} + \varepsilon_t ,$$

where $(\varepsilon_t)_t \quad \mathbf{WN}(0, \sigma^2)$ (i.e. white noise) and $\varepsilon_t \quad \mathbf{N}(0, \sigma^2)$.

3.2. RW2 Hypothesis: independent increments

Although simplicity and elegance RW1 model is appealing, assuming the existence of independent identically distributed growth is just natural.

Factors that determine the evolution of financial asset prices in a market are not the same and do not have the same intensity for different periods of time. Also, economic conditions differ greatly over time, making the identical distributions assumption over the entire time horizon to be unnatural.

When the RW2 model is derived from RW1 model, renouncing to the hypothesis of the existence of a joint distribution of innovations $(\varepsilon_t)_t : P_t = \mu + P_{t-1} + \varepsilon_t$, where is a sequence of independent random variables such that

$$\begin{cases} \mathbf{E}[\varepsilon_t] = 0, \forall t \\ \mathbf{Var}[\varepsilon_t] = \sigma_t^2, \forall t \\ \mathbf{Cov}[\varepsilon_t, \varepsilon_{t+k}] = 0, \forall k \neq 0 \\ \mathbf{Cov}[\varepsilon_t^2, \varepsilon_{t+k}^2] = 0, \forall k \neq 0 \end{cases}.$$

Although the RW2 model is weaker than RW1, retains its essence: any future change in the price of financial assets is unpredictibil using past price changes.

3.3.RW3 hypothesis: non-correlated increments

Relaxing the assumptions of previous models, we obtain a more general form of the random walk hypothesis, the innovations are dependent but non-correlated.

$$P_t = \mu + P_{t-1} + \varepsilon_t$$

where $(\varepsilon_t)_t$ is a sequence of random variables such that

$$\begin{cases} \mathbf{E}[\varepsilon_t] = 0, \forall t \\ \mathbf{Var}[\varepsilon_t] = \sigma_t^2, \forall t \\ \mathbf{Cov}[\varepsilon_t, \varepsilon_{t+k}] = 0, \forall k \neq 0 \end{cases}.$$

An immediate consequence of the efficient market hypothesis in weak form is that price changes (i.e., yields) are not predictable.

One of the most commonly used statistical test to verify the hypothesis of random walks is variance ratio test. An important property of all random walk hypothesis is that the variable residual variance to be a linear function of time.

Considering the RW1 model $r_t = \mu + \varepsilon_t$, since yields r_t are independent and follows the same distribution, we have that $\mathbf{Var}[r_t + r_{t-1}] = 2\mathbf{Var}[r_t]$. Therefore, we can determine whether the random walk hypothesis is plausible verifying report variances: $VR(2) = \dfrac{\mathbf{Var}[r_t + r_{t-1}]}{2\mathbf{Var}[r_t]}$. If RW1 hypothesis is true, then this report should be substantially equal to one.

Variances ratio can be written according to first-order autocorrelation coefficient, if it is assuming that the return series is stationary (this is necessary to define the autocorrelation function):

$$VR(2) = \frac{\mathbf{Var}[r_t + r_{t-1}]}{2\mathbf{Var}[r_t]} = \frac{2\mathbf{Var}[r_t] + 2\mathbf{Cov}[r_t, r_{t-1}]}{2\mathbf{Var}[r_t]} = 1 + 2\rho(1) \cdot$$

If RW1 is met, then a first-order autocorrelation coefficient is zero, so $VR(2) = 1$. If the series has positive autocorrelation of first-order, then $VR(2) > 1$, and if the series has negative autocorrelation of first-order, then $VR(2) < 1$.

For lags bigger than 1, variances ratio is a linear combination of coefficients's autocorrelation:

$$VR(q) = \frac{\mathbf{Var}[r_t + r_{t-1} + ... + r_{t-q+1}]}{q\mathbf{Var}[r_t]} = 1 + 2\sum_{k=1}^{q-1}\left(1 - \frac{k}{q}\right)\rho(k) \cdot$$

To infer the distribution of $VR(2)$, we assume that profitability r_t follows a pattern RW1: $H_0 : r_t = \mu + \varepsilon_t$, where $(\varepsilon_t)_t$ is a sequence of independent random variables indentically distributed $\varepsilon_t \sim \mathbf{N}(0, \sigma^2)$. Assuming that we work with a sample of $2n+1$ observations over time $p_0, ..., p_{2n}$, we will consider the following estimators for the parameters's distribution, μ and σ^2:

- $\hat{\mu} = \dfrac{1}{2n}\sum_{k=1}^{2n}(p_k - p_{k-1}) = \dfrac{1}{2n}(p_{2n} - p_0)$

- $\hat{\sigma}_a^2 = \dfrac{1}{2n}\sum_{k=1}^{2n}(p_k - p_{k-1} - \hat{\mu})^2$

- $\hat{\sigma}_b^2 = \dfrac{1}{2n}\sum_{k=1}^{n}(p_{2k} - p_{2k-2} - 2\hat{\mu})^2$.

Estimators $\hat{\mu}$ and $\hat{\sigma}_a^2$ are exactly the estimators of maximum verosimility of the two parameters, and $\hat{\sigma}_b^2$ is an estimator constructed so that is taking into account the random behavior of time series $(p_t)_t$; variance is a linear function of time, so σ^2 can be estimated by half of the variance even-terms of the series.

Then in contions of RW1 hypothesis, we can inferre the asymptotic distribution of the variances ratio $VR(2) = \dfrac{\sigma_b^2}{\sigma_a^2} : \sqrt{2n}(VR(2) - 1) \to \mathbf{N}(0, 2)$ [14].

We reject the random walk hypothesis at significance level α if the value of statistics $z = \dfrac{\sqrt{2n}(VR(2) - 1)}{\sqrt{2}}$ is outside the interval $[-z_{\alpha/2}, z_{\alpha/2}]$.

Variances ratio test can be easily extended to the case of several time periods. If the initial sample consists of $nq+1$ observations, $\{ p_0, ..., p_{nq} \}$, we have:

- $\hat{\mu} = \dfrac{1}{nq}\sum_{k=1}^{nq}(p_k - p_{k-1}) = \dfrac{1}{nq}(p_{nq} - p_0)$

- $\hat{\sigma}_a^2 = \dfrac{1}{nq}\sum_{k=1}^{nq}(p_k - p_{k-1} - \hat{\mu})^2$

- $\hat{\sigma}_b^2(q) = \dfrac{1}{nq}\sum_{k=1}^{nq}(p_{kq} - p_{kq-q} - q\hat{\mu})^2$

- $VR(q) = \dfrac{\hat{\sigma}_b^2(q)}{\hat{\sigma}_a^2}$.

In RW1 hypothesis's conditions, we have:

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[14] Haussman, J. 1978, "Specification Tests in Econometrics", *Econometrica*, Vol. **46**.

$$\sqrt{nq}\,(VR(q)-1)\rightarrow \mathbf{N}(0,2(q-1)).$$

We can refine the asymptotic distribution of the variances ratio, building better estimators for the parameters from above. A better estimator for the model's dispersion can be obtained using returns for q periods:

$$\hat{\sigma}_c^2(q)=\frac{1}{nq^2}\sum_{k=q}^{nq}(p_k-p_{k-q}-q\hat{\mu})^2 .$$

Also, we will correct dispersions $\hat{\sigma}_a^2$ and $\hat{\sigma}_b^2$:

$$-\,\overline{\sigma}_a^2=\frac{1}{nq-1}\sum_{k=1}^{nq}(p_k-p_{k-1}-\hat{\mu})^2$$

$$-\,\overline{\sigma}_b^2(q)=\frac{1}{m}\sum_{k=1}^{nq}(p_{kq}-p_{kq-q}-q\hat{\mu})^2 ,$$

where $m=q(nq-q+1)\left(1-\dfrac{1}{n}\right)$.

The new ratio of the variances will be: $\overline{VR}(q)=\dfrac{\overline{\sigma}_c^2(q)}{\overline{\sigma}_a^2}$.

Then we define a new statistics by which we test the hypothesis of random walk:

$$\psi(q)=\sqrt{nq}\,(\overline{VR}(q)-1)\left(\frac{2(2q-1)(q-1)}{3q}\right)^{-1/2}\rightarrow \mathbf{N}(0,1).$$

This test can be used to verify the RW1 hypothesis, assuming homoscedasticity and returns independence.

A variant of this test, for the RW3 hypothesis, in which we presume the heteroscedasticity hypothesis, is presented below.

The two versions of the ratio-variance test follows the methodology used by Lo and MacKinlay (1988) and Campbell, Lo, and MacKinlay (1997).

To test RW3, assuming innovation's non-correlation and heteroscedasticity, one can use the following statistics:

$$\psi^*(q)=\frac{\sqrt{nq}\,(VR(q)-1)}{\sqrt{\hat{\theta}(q)}}\approx N(0,1).$$

- Variance ratio is computed using its asymptotic expression:
$$VR(q)\rightarrow 1+2\sum_{k=1}^{q-1}\left(1-\frac{k}{q}\right)\hat{\rho}(k),\quad\text{where}\quad \hat{\rho}(k)\quad\text{is the}$$

coefficient's estimator of autocrelation of order k for r_t;

- $\hat{\theta}(q)$ is an heteroscedasticity-consistent estimator of $\theta(q)$, the asymptotic dispersion of VR(q), calculated such as:

$$\hat{\theta}(q)=4\sum_{k=1}^{q-1}\left(1-\frac{k}{q}\right)^2\hat{\delta}_k ;$$

- $\hat{\delta}_k$ is a heteroscedasticity-consistent estimator of δ_k, the asymptotic dispersion of $\rho(k)$, r_t's autocorrelation coefficient of order k:

$$\hat{\delta}_k=\frac{nq\sum_{j=k+1}^{nq}(p_j-p_{j-1}-\hat{\mu})^2(p_{j-k}-p_{j-k-1}-\hat{\mu})^2}{\left[\sum_{j=1}^{nq}(p_j-p_{j-1}-\hat{\mu})^2\right]^2}=$$

$$=\frac{nq\sum_{j=k+1}^{nq}(r_j-\hat{\mu})^2(r_{j-k}-\hat{\mu})^2}{\left[\sum_{j=1}^{nq}(r_j-\hat{\mu})^2\right]^2}.$$

Typically, to test one of the two forms of the random walk hypothesis, we compute the variance ratios $VR(q)$ for m periods, $\{q_1,q_2,...,q_m\}$, then determine appropriate statistics $\psi(q)$ or $\psi^*(q)$ and finally compare the statistics with a critical value of normal or Student distribution, $z_{\alpha/2}$ or $t_{\alpha/2;nq}$.

4. APPLICATION FOR BET INDEX

To check the assumptions from above, we used daily data values of BET, the index of the Bucharest Stock Exchange. The time period studied is 19th September 1997 to 15th June 2010(3164 observations). We used logreturn, defined as $r_t=\ln P_t-\ln P_{t-1}$, where P_t is the index value at time t.

4.1 Normal distribution assumption

To check the hypothesis of normal distribution for daily return of BET index, we applied the battery of tests for normal distribution available in SAS 9.2: Kolmogorov-Smirnov test, Anderson-Darling test and Cramer-von Mises test. In all three cases, the normal distribution hypothesis was rejected with a probability of at least 99%.
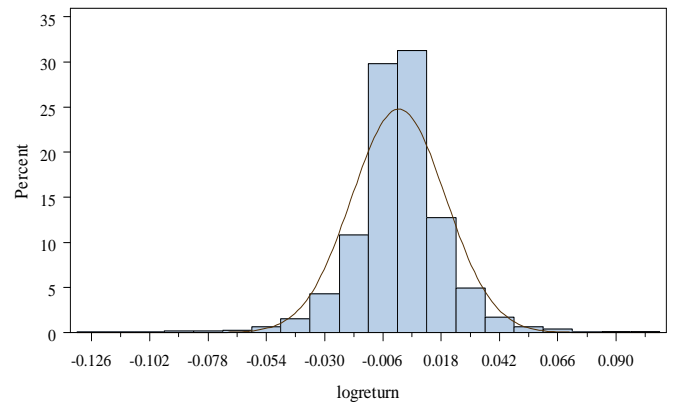
Fig. 2. Histogram of logreturn for BET

Table 1. Parameters of normal distribution

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Parameter	Estimate
Mean	0.000506
Std Dev	0.019321

Table 2. Goodness-of-Fit Tests for Normal Distribution

Test	Statistic		p Value	
Kolmogorov-Smirnov	**D**	0.085	**Pr >D**	<0.010
Cramer-von Mises	**W-Sq**	8.062	**Pr>W-Sq**	<0.005
Anderson-Darling	**A-Sq**	45.963	**Pr>A-Sq**	<0.005

Moreover, the normal distribution cannot explain the presence of large deviations in stock price evolution.

The table below shows the probability that returns are lower than a certain value, computed form the estimated normal distribution and from the real data

Table 3. Distribution of extrem returns

	$\Pr(r_t > c)$	
Cut point(c)	Real data	Normal distribution
-0.05	0.013906	0.0044738
-0.1	0.001264	9.863E-08
-0.11	0.000948	5.343E-09
-0.13	0.000316	7.161E-12

A strong research direction studied in later years, although it has its origins in the works of Mandelbrot in the ‚60s, is the use of stable distributions (Pareto-Levy) for modeling stocks's returns.

As noted, the return's distribution has tails of much higher return than would be expected under normal distribution, and stable distributions resolves the problem of such extreme events. Stable distributions have a remarquable property: they allow for skewness and heavy tails and more, any linear combination of stable independent variables is also stable. In other words, the shape of distribution is preserved under linear transformation.

In general, the stable distributions do not present an explicit form of probability density function, being only the known characteristic function. Normal distribution is a special case of stable distribution: any linear combination of dependent Gaussian is also Gaussian.

In literature there are several parametrizations of stable distributions. We chosed for this paper the parametrisation S0, in Nolan (2001)'s variant.

Thus, a variable X follow a stable distribution $S(\alpha, \beta, \gamma, \delta; 0)$ if its characteristic function has the form:

$$\phi(t) = \mathbf{E}[e^{itX}] = \begin{cases} \exp(-\gamma^{\alpha}|t|^{\alpha}[1+i\beta\tan(\frac{\pi\alpha}{2})sign(t)(|\gamma t|^{1-\alpha}-1)]+i\delta t, \alpha \neq 1 \\ \exp(-\gamma|t|[1+i\beta t\frac{2}{\pi}sign(t)(\ln(\gamma|t|))]+i\delta t, \alpha = 1 \end{cases}.$$

In the above notation $\alpha \in (0.2]$ is the characteristic parmeter(for normal distribution $\alpha = 2$), $\beta \in [-1,1]$ is the skewness parameter, $\gamma \in (0,\infty)$ is the scale parameter and $\delta \in \mathbf{R}$ is the location parameter.For our daily return series of BET index, the following results have been obtained, using the software STABLE (Nolan, 2001).

Table 4. Parameters of the stable distribution

Parameter	Estimate	Lower 95%	Upper 95%
α	1.476234	1.421034	1.531434
β	-0.01872	-0.138416	0.100984
γ	0.009246	0.0088915	0.0096011
δ	0.000551	-0.00005	0.0011552

Maximum likelihood estimators of stable distribution under S0 parametrization shows that we can reject the normal distribution hypothesis, since the characteristic parameter α is significantlly lower than 2, the value of the gaussian distribution.

4.2. Random walk hypothesis

Based on the methodolgy descried above, we have computed variance ratios for daily returns. Also a confidence interval with 95% probability was computed, using homoskedasticity or heteroskedascicity assumption for model innovations.
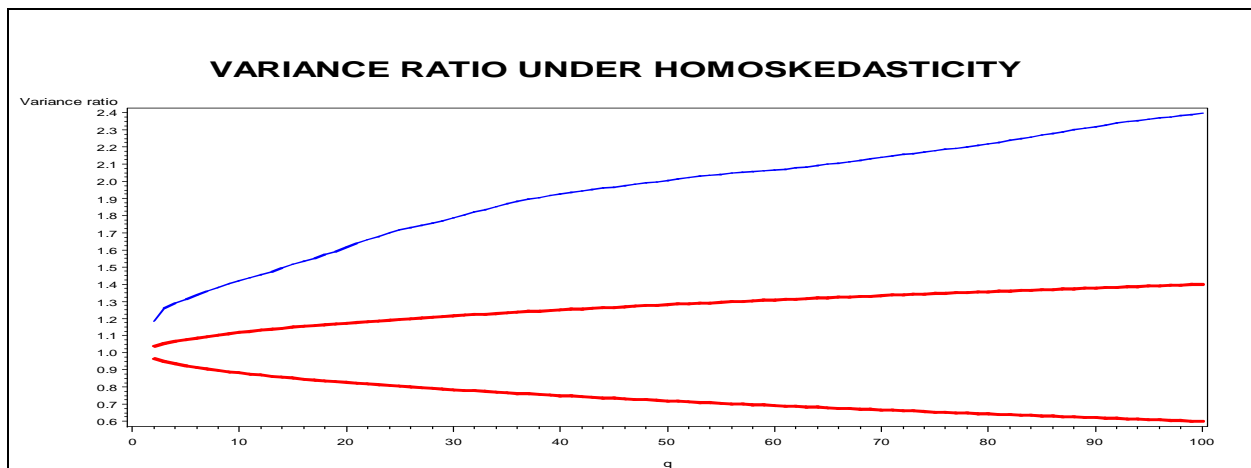
VARIANCE RATIO UNDER HETEROSKEDASTICITY
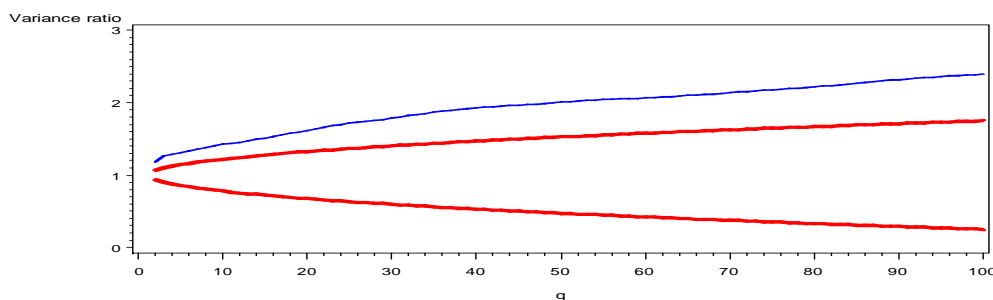
Fig. 3. Confidence intervals for VR(q)

In the above graphs, the red lines represent the limits of 95% confidence interval, while the blue line represents the values of variance ratio. Based on the Variance Ratio Test, we can reject the random walk hypothesis for daily series of BET.

5. CONCLUSIONS

Altough the normal distribution has been widely used for a lot of applications in the financial world we still need appropriate distribution in order to take account for large variability and heavy tails. Stable distributions are a good approach for these problems even they are not easy to define analytically and also easy to estimate.

Also the Efficient Market Hypothesis (and consequently the Random Walk Hypothesis) needs to be reconsidered, since they cannot explain large fluctuations in stock price and stock market crisis.

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CALCULATING CREDIT RISK FOR A PORTFOLIO OF FIXED-RATE BONDS

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Abstract. *Credit risk is defined and explained, as well as the two models of credit risk measurement. The used 60 credit risk factors that are used are presented, together with the credit worthiness index model according to which they are used. After data description and analysis, the models used in the scenarios generation are described in detail. A portfolio of fixed rate bonds has been taken and its credit risk has been calculated.*

Keywords: *calculating credit risk, fixed rate bonds portfolio.*

1.INTRODUCTION

Credit risk is defined, in its strong version, as the risk that an obligor will not be able to meet its financial obligations towards its creditors. Under this definition default is the only credit event. The weaker definition of credit risk is based on market perception. This definition implies that obligors will face credit risk even if they do not fail their financial obligations yet but the market perceives they might fail in the future. This is known as the *mark-to-market* definition of credit risk and gives rise to migration as well as default as possible credit events. Perception of financial distress gives rise to credit downgrade.

There are two categories of credit risk measurement models: Counterparty Credit Exposure models and Portfolio Credit Risk models. Counterparty exposure is the economic loss that will be incurred on all outstanding transactions if a counterparty defaults, unadjusted by possible future recoveries. Counterparty exposure models measure and aggregate the exposures of all transactions with a given counterparty. Although simple to implement, the model has been widely criticized because it does not accurately account for stochastic exposures. Since exposures of derivatives such as swaps depend on the level of the market when default occurs, models must capture not only the actual exposure to counterparty at the time of the analysis but also its potential future changes. By simulating counterparty portfolios through time over a wide range of scenarios, these models explicitly capture the contingency of the market on derivative portfolios and credit risk.

In contrast, Portfolio Credit Risk (*PCR*) models measure credit capital and are specifically designed to capture portfolio effects, *specifically obligor correlations*. It accounts for the benefits of diversification. With diversification, the risk of the portfolio is different from the sum of risk across counterparties. Correlations allow a financial institution to diversify their portfolios and manage credit risk in an optimal way. However, empirical work shows generally that all *PCR* models yield similar results if the input data is consistent. A major limitation of all current *PCR* models is the assumption that market risk factors, such as interest rates, are deterministic. Hence,

they do not account for stochastic exposures. One of the objectives of *PCR* is to measure *economic* capital.

Credit risk is the risk of losses caused by counterparty or an issuer defaulting on their payment obligations. It focuses on the calculations of credit exposures and capital allocation based on estimated economic losses. A portfolio of Fixed Rate bonds of Depfa Bank Plc (www.depfa.com) has been taken. The total exposure of all the instruments for this portfolio is approximately 635 billion USD.

2.THE CREDIT WORTHINESS INDEX MODEL

Credit Worthiness Index (*CWI*) comprises systemic credit risk arising from movements in the credit drivers that are common to the counterparties in the portfolio, and idiosyncratic (un-systemic) risk that is specific to a particular counterparty in the portfolio.

The correlation infrastructure and data consist of credit drivers that we have identified to be relevant for measuring credit risk for any credit portfolio with global coverage, the idiosyncratic risk, and the sensitivities of representative counterparties for any given global region and industry sector.

For a portfolio of *J* obligors, the credit quality of an obligor is modelled through a multi-factor Credit Worthiness Index Y_j and is described in following equation

$$Y_j(t) = \sum_{i=1}^{I} \beta_{ij} Z_i(t) + \alpha_j \varepsilon_j \quad (1)$$

In the above equation, the systemic credit risk component of the *CWI* for each obligor *j*, *j*=1,2,...*J* , is assumed to be driven by credit drivers Z_i , *i*=1,2..., *I* . Each credit driver Z_i represents the country and industry sector affiliation of obligor *j* . The sensitivities vector can then be written as $(\beta_{1j}, \beta_{2j}, ..., \beta_{ij}, ..., \beta_{Ij})$ where β_{ij} is the sensitivity of obligor *j* to credit driver *i*. The second term in equation above represents the obligor-specific, idiosyncratic risk component. The higher the sensitivities of an obligor to a credit driver or a set of them, the higher its systemic risk and the lower its idiosyncratic risk will be.

$$\alpha_j = \sqrt{1 - \sum_{i=1}^{I} \beta_{ij}^2} = \sqrt{1 - R^2_j} \quad (2)$$

R^2_j is the proportion of variance of Y_j explained by the credit drivers, and ε_j in equation (1) are independent standard normal variables. Also, in equation (1) the index Y_j is standard normal in view of equation (2); it has zero mean and unit variance. One refers to α_j as the specific weight for counterparty *j*.

In the above framework, correlation between any two obligors' credit quality is governed by the correlations among the risk drivers in their *CWI*s. This is represented by the joint Variance – Covariance matrix in this paper.

The covariance between the *CWIs* Y_l and Y_k of any two obligors can be written as:

$$cov(Y_l, Y_j) = \sum_{i=1}^{I} \beta_{il}\beta_{kj}Cov(Z_i, Z_k) + \sum \beta_{il}\beta_{ij}Var(Z_i) \quad (3)$$

Under a multi-factor *CWI* model, the sensitivity β_{ij} must be estimated for a set of credit drivers appropriate for a given counterparty.

We have also assumed that when all except one of the sensitivities to the credit drivers equal zero, the sensitivities vector for obligor *j* is with systemic impact of only one credit driver, namely, Z_i. In this case, although the systemic risk in each obligor *CWI* is determined by one single index, the model still captures the diversification effect across different region-industry sector pairs through the different indexes serving as proxies for such pairs. At the same time, correlated defaults are captured to the extent that the indexes themselves are correlated.

Once we estimate the *CWI* for each counter party in the credit portfolio, the occurrence of default or migration in each one of a set of Monte Carlo scenarios on the credit drivers can be simulated. Also, given other information such as counterparty exposures, recovery rates, length of planning horizon, etc., the portfolio loss distribution is computed where the losses now incorporate the impact of correlated defaults and migrations. A pre-specified loss percentile, e.g., 99.90th, of the loss distribution then signifies the credit risk economic capital for the portfolio.

In theory, the above process requires prior knowledge of the specific counterparty names in the credit portfolio in order to compute the credit loss distribution. But in the above infrastructure and framework, however, one eliminates this requirement of prior knowledge of specific names. Instead, one estimate CWIs for *representative counterparties* on to which specific counterparties in any given portfolio may be mapped, based on a set of well-defined criteria.

3. DATA DESCRIPTION AND ANALYSIS

A portfolio of Fixed Rate bonds comprising of approximately 1,700 counterparties and 140 portfolios denominated in different currencies with different credit ratings assigned to each one of them has been taken, with USD as the base currency.

A sample of market and credit risk factors has been considered. Some risk factors may influence both market and credit risk. Interest rates, for example, are market prices determining the values of various fixed income instruments, but they also have an influence on default probabilities, and they are in turn influenced by idiosyncratic properties of individual obligors.

Scenarios have been generated on market risk factors like Treasury interest rates and Credit risk factors like the systemic credit drivers. In this portfolio 50,000 scenarios have been generated on each market and credit state drivers for 2 time steps of 89 days and 365 days.

The credit risk has been measured with respect to credit drivers' indices which are the systemic macroeconomic factors that have an impact on the credit risk of the bond instruments for each counter party.

One has to make a distinction between regulatory and economic capital since regulatory capital does not take into account correlations among obligors that form a portfolio and so, depending on the credit quality of the obligors to which a financial institution is exposed to, it might over- or under-estimate economic capital requirements.

As we have seen above, we assume a multi-factor *CWI* model wherein a given counterparty has a single credit driver associated to it. Given our objective of arriving at an infrastructure whereby credit losses can be computed for an arbitrary credit portfolio that may contain counterparties from any part of the globe, we have first identified a comprehensive set of credit drivers with global coverage. In addition to providing comprehensive coverage, the selected credit drivers also capture the characteristics of the economic and credit environment of a given region as well as the characteristics of the particular industry within which a given counterparty is operating.

Accordingly, we have divided the globe into three regions to start with: Americas, Asia-Pacific, and Europe. We have taken a dominant economy in each region like Japan in Asia-Pacific, and U.K. in Europe but for Americas we have taken a combination of other ten globally diversified Indices. We have divided the globe in to five regions.

Further, within each region, we have utilized the GICS system for 10 industry sectors in order to account for their distinct credit risk characteristics. Thus, we have a total of 50 region-sector combinations to cover a global credit portfolio or a portfolio covering one or more of the five regions.

Regions	Sectors
1. Americas	1. Energy
2. UK	2. Basic Materials
3. Europe (ex UK)	3. Industrials
4. Japan	4. Consumer Cyclical
5. Asia-Pacific (ex Japan)	5. Consumer Non-Cyclical
	6. HealthCare
	7. Financials
	8. Information Technology
	9. Telecommunication Services
	10. Utilities

We have also taken the following 10 Indexes to represent additional Credit Drivers to capture the macroeconomic impact of the overseas countries

1. FTSE/ASE 20 (FTASE) Index – The FTASE Index consists of 20 of the largest and most liquid stocks that trade on the Athens Stock Exchange. It was developed in September 1997 out of a partnership between the Athens Stock Exchange and FTSE International.
2. BRAZIL BOVESPA STOCK Index (IBOV) - The Bovespa Index is a total return index weighted by traded volume and is comprised of the most liquid stocks traded on the Sao Paulo Stock Exchange.
3. CAC Index – The CAC-40 Index is a narrow-based, modified capitalization-weighted index of 40 companies listed on the Paris Bourse.

4. DAX Index – The German Stock Index is a total return index of 30 selected German blue chip stocks traded on the Frankfurt Stock Exchange.
5. KOSPI Index – The KOSPI Index is a capitalization-weighted index of all common shares on the Korean Stock Exchanges.
6. MEXICO BOLSA Index (MEXBOL) – The Mexican Bolsa Index is a capitalization-weighted index of the leading stocks traded on the Mexican Stock Exchange.
7. NIKKIE 225 (NKY) Index – The Nikkei-225 Stock Average is a price-weighted average of 225 top-rated Japanese companies listed in the First Section of the Tokyo Stock Exchange.
8. S&P/TSX COMPOSITE Index (SPTSX) – The S&P/Toronto Stock Exchange Composite Index is a capitalization-weighted index designed to measure market activity of stocks listed on the TSX.
9. S&P 500 Index (SPX) – Standard and Poor's 500 Index is a capitalization-weighted index of 500 stocks. The index is designed to measure performance of the broad domestic economy through changes in the aggregate market value of 500 stocks representing all major industries.
10. MSCI TAIWAN Index (TWY) – The MSCI Taiwan Index is a market capitalization-weighted index of stocks listed on the Taiwan Stock Exchange.

For each region-sector combination, we designate the corresponding Dow Jones Region-Sector Index as the credit driver for counterparty affiliated to that region and sector. In order to estimate the sensitivity of a representative counterparty for a given region-sector combination to the Region-Sector Index as the credit driver, we have carried out the following steps. First, there have been collected the time series data on all fixed rate corporate bonds in a given region and sector and the time series data on the corresponding Region-Sector indexes.

Next, one uses the average of the estimated R-Squares for the bonds in the given region-sector combination obtained when the individual fixed income returns are regressed on the Index returns, which are then available for use as the R-Square for a representative counterparty in a given region-sector combination.

Once R-Square estimates are available for a representative counterparty for every region-sector combination, equation (2) above can be used to estimate the sensitivity and the specific risk for any counterparty in a given region and sector therein.

4. INTEREST RATE RISK FACTORS MODELLED WITH BLACK-KARASINSKI MODEL

The Black-Karasinski simulation model is a normal, mean-reverting model that is applied on the log of the risk factors. This model is used for simulations over a large time horizon that uses arbitrary length time steps. I have applied the Black-Karasinski Model for Interest Rate Treasury risk factor block.

At each step, a mean-reverting process takes a small step toward a target mean before taking a random step up or down. The long-term range or bounds on the values of the mean-reverting process depend on the values of both the rate of mean reversion and the volatility.

The reasons why the Black Karasinski mean reversion simulation model has been used for the interest rate risk factors include the following:

- Each country has an ideal or equilibrium interest rate term structure
- When the term structure is out of equilibrium, a variety of market, economic, and political forces act to bring interest rates back to this equilibrium
- These forces become stronger as the term structure deviates further from equilibrium

Theoretical Model:

$$Y(t) = \log X(t)$$

$$dY(t) = a(\overline{Y} - Y(t))dt + \sigma dW(t)$$

Simulation Equation:

$$Y(t+\Delta t) = \overline{Y} + (Y(t) - \overline{Y})e^{-a\Delta t} + \sigma\sqrt{\frac{(1-e^{-2a\Delta t})}{2a}}\eta$$

Calibration Equation

$$Y(t_t) = \log(X(t_t))$$

$$V(t_t) = Y(t_t) - Y(t_t - 1) - (1 - e^{-a/N})(\overline{Y} - Y(t_t - 1))$$

In the Interest rate block one has the time series data for Zero Coupon Treasury Interest Rate curves for monthly data from 31/01/1997 until 31/01/2007 for major currencies of AUD, CHF, DKK, EUR, GBP, and USD. We have the data for the above time series in the form of treasury interest rates for one week, month, quarter, half year, three quarter, one year, two years, four years, five years, seven years, ten years, fifteen years, twenty years, twenty five years and thirty years. We can observe the mean reverting level under the lognormal model and the rate of mean reversion for all the interest rate risk factors in the figure given below. The average mean reverting level is 4.3337% and average rate of mean reversion is 8.7883

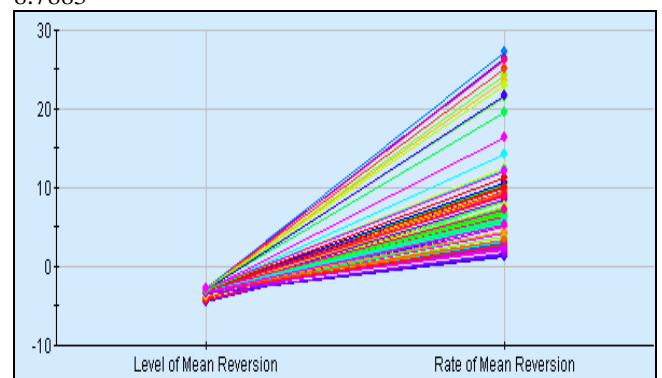**Fig.1.** Mean Reverting Level of Interest Rate Risk Factors

5. CREDIT RISK FACTORS MODELLED WITH GEOMETRIC BROWNIAN MOTION MODEL

The Geometric Brownian Motion Model, also known as the Black-Scholes Model with zero drift, is used to generate multi-step Monte Carlo scenarios. It is a stochastic process that is similar to the Brownian Motion Model, but is pictured as a geometric random walk in

continuous time. The distribution of these continuously compounded returns at the end of any finite time interval will be a *LogNormal distribution*. It also includes an adjustment based on Ito's Lemma. This process generates scenarios whose dispersion increases without bound as simulated time elapses. Stochastic Process:

$$dX(t) = \sigma X(t)dW(t)$$

Simulation Equation:

$$X(t) = X(t - \Delta t).\exp\left\{-\frac{1}{2}\sigma^2\Delta t + \eta\sqrt{\Delta t}\right\}$$

Calibration Equation:
The increments have a normal distribution.

$$V(t_{t_i}) = \ln\left(\frac{X(t_t)}{X(t_{t-1})}\right) + \frac{1}{2}\sigma^2\Delta t$$

The Geometric Brownian Motion Model has been applied for Credit Drivers risk factor block. In this block we have the time series data for independent credit drivers in the form of market indexes for monthly data from 31/05/2000 until 31/05/2007 for major indexes regions across the globe etc and for different sectors within these regions like Energy, Basic Materials, Industrials, Consumer Cyclical, Consumer Non-Cyclical, Health Care, Financials, Information Technology, Telecommunication Services and Utilities. In total we have 60 credit drivers comprising of combination of different worldwide indexes with one of these sectors above.
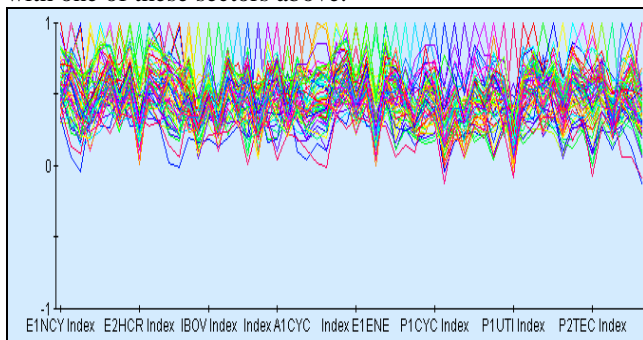

Fig. 2. Correlation movements of the credit drivers

The correlation behaviour between the 60 credit risk factors observed in observed in *Figure 2* has all the 60 credit risk factors on the *x*-axis and their correlation with the other indexes on the *y*-axis. The correlation ranges between 0 and 1.
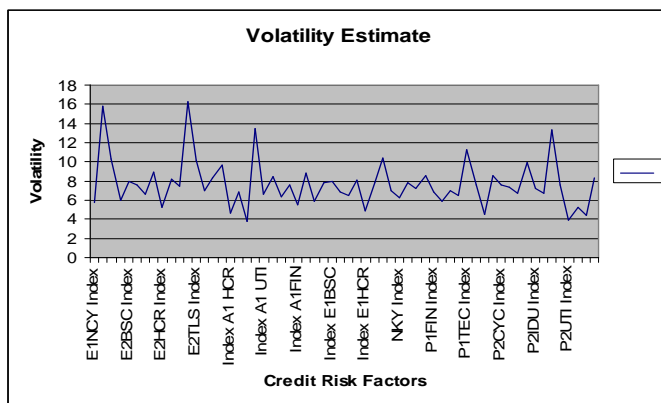

Fig.3. Credit risk factors' volatility

6.RESULTS

We have calculated the measures for Expected Shortfall and Credit VaR at 99.95 percentile level of confidence for both time steps 89 days and 365 days. The result of a Value at Risk (*VaR*) calculation for a portfolio indicates the amount of money that can be lost over a given time horizon at a specific confidence interval.

The results for the Credit risk estimates can be observed in the below table:

Credit Risk	89 days	365 days
ExpectedShortfall@99.95	183,943,506.80	237,456,252.20
Credit VaR @99.95	137,898,249.00	198,598,398.50
Mean Loss	1,101,751.04	8,101,601.48
MeanExposure	1,889,172,428.00	1,470,622,964.00

The other results estimates for Credit Risk are

• Mean Exposure – This is the average exposure per counterparty for the given portfolio of fixed rate bonds

• Mean Loss – This is the average expected loss and can be arrived as per the following calculations: (Mean Exposure * Expected Probability of Default * Assumed deterministic rate or recovery)

• Expected Shortfall (ES) - Expected Shortfall is the average of all losses that meet or exceed the VaR. For this reason, it is also known as "conditional VaR" or "tail conditional expectation."

The expected shortfall for Credit risk has been calculated, which is 184 million for 89 days and 237 million for 365 days.

We can observe that the credit VaR at 99.95 percentile for 89 days is approximately 138 million, which is 0.02% of the overall portfolio exposure and 199 million for 365 days which is 0.03% of the overall portfolio exposure.

On one side, this might be due to the portfolio consisting of counterparties with very less stochastic probability to default in spite of having all sorts of credit ratings. On the other side, the inputs for the credit sensitivity used for this analysis are coming from an analysis in progress.

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SOCIOPHYSICS AND QUANTUM ECONOMICS

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Abstract. *The contemporary economic reality could be more adequate for new sociophysics and quantum economics' models and methods. These new multi – disciplinary sciences are able to perform economical analysis, better than contemporary econometrics or economic statistics, in general. Other aspects of this article are related to the significance of time concept in the contemporary economics through physics way of thinking and to the integration of the multi-disciplines thought into the statistical evaluation of the economic results. This could be also a consequence of the experience generated by the global crisis in the economic world. The authors believe that new multi – disciplinary sciences can solve the problem of a better coverage of economic realities, through more adequate and comprehensive methods and models. In addition to this main purpose, the paper could be a good explanation for a better understanding of the crisis and recessions.*

Keywords: *sociophysics, quantum economics, macrorealism, particle, multi – disciplinary sciences.*

1. INTRODUCTION

The models are either a modality of representing a simplifying empirical objects from reality or parts of reality, phenomena, and physical processes (either models of phenomena or models of data), or an alternative in which the human way of thinking's processes can be amplified (for the scientist's thought, the construction and the manipulation of models are vehicles for learning and understanding), and, probably most of all, a substitute for direct measurement, experimentation and simulation of reality). Simulations are used only for the dynamic models, i.e. models that involve time (the simulation's aim means understanding, solving and projecting the equations of motion of such a model).

Researchers are acknowledging the importance of models with increasing attention and are probing the assorted roles that models play in scientific practice. Interpretation "in simulacra" of a special reality through the model means to simplify reflections of this reality, but despite their inherent and relative falsity, model remains extremely useful (in fact, there is no complete and entire true model, able to describe the reality).

2. NEW MULTIDISCIPLINARY SCIENCES, MODELS AND METHODS DERIVED FROM PHYSICS

The physics models used in (macro) economics generate the multidisciplinary models and do not analyze only economic or social processes and phenomena, but rather their continuity in evolution or involution. At the pragmatic and challenging crossroads of (macro) economics (i.e. econometric research) and sociology (sociological research), or, more recently, even of politology with physics (that is, the thought based on physical, quantum statistic, or the theory of relativity), completely new sciences have been generated over the last three decades, e.g. sociophysics and quantum economics, etc., which vie, through their seeming originality and simplicity, with the impact of other new modern research methods that emerge and take firmer shape, such as the science of complexity, the science of the neural net systems, of the genetic algorithms, of fractals, of chaos theory, of fuzzy and neutrosophic logic. Their historical evolution is an occasion for us to acknowledge the pace of the development of the border disciplines. The physics' model can contribute, through its sociophysics, quantum-economic, science of complexity, science of the neural net systems, genetic algorithms, fractals, chaos theory, fuzzy and neutrosophic logic, etc. forms, in an unexpected manner, to a better understanding of the economic problems, of the processes or decisions of an economic-social type.

Contemporary humanistic sciences are nowadays more and more distinctive, from psychology to the cognitive sciences, from sociology to economics, from the political sciences to anthropology, etc. The special humanistic sciences were previously known by the name of moral sciences, and, at the same time, were marked by the tradition of generating analogies with the ideas in the natural world and in the natural sciences. There exists a great diversity of the schools of thought of an economic type: that of the Austrian economists, that of the institutionalists, the Marxist one, that of the social economists, of the behaviouralist economists, of the theorists of chaos, of the Keynesians and post-Keynesians, of the neo-Ricardians, of the Chicago school theorists, of the constitutional political economists, of the supporters of the theory of public choice (the theory of rational choice already represents the focus of the economic discipline, in the balance of the neo-classical microeconomic, and the macroeconomic one).

Physics was born as a fundamental science, in demonstrative or reductive a manner of thinking, only to assume a manner of thinking of a universal type, with Newton. What is a fundamental science? Can unity exist without fundamentality? The form the unity takes, or should take, especially in physics, is a controversial question, which has led to plurality within the broad community of the whole discipline of physics. Physics has developed a genuine universe of the activities, between the theoretical and the experimental approaches and trends. That process has led to a lack of unity in the terms of any classical discipline, as well as a greater complexity of the sets of interactions within the usual term of *physics*, as it gradually became a great science, alongside of other disciplines, such as engineering, economics and

management. A distinctive feature of the econometric model has to do with the fact that, whereas it shares with the physical model the application of mathematics and statistics, inductively or deductively, descriptively or explanatorily – with respect to the population, and the probabilistic interpretations – it seems that it still lacks the strict and accurate, correct approach to the universal laws in as "recognizable" a manner as in the physical model.

The economic model is a scientific model oriented towards the possibility of choosing, of managing risks, and making decisions with respect to some genuine, often serious problems, but it also involves a number of general aspects that are of special interest in understanding the phenomena or processes. Thus, after two decades of existence, it can be found that:

- the economic model only refers to certain aspects of the reality, where the man is concerned with limited resources, it is true more often than not in an optimal manner;

- the economic model always encourages the enforcement of the quantitative and formal methods, it confers intellectual legitimacy, associated with virtues of accuracy and precision, somehow relative, and of objectivity, sometimes only apparent;

- the subjects of the economic aggregates are made of the same simple material, as elements, atoms of the activities, units that are also physical entities: husbandries, households, corporations and financial or non-financial agencies, the labour market and other markets, but the economic laws, as formulated or invalidated through the econometric models, do not have the same type of viability as the models and laws of physics;

- the economic systems modelled in the econometric manner reveal they are on the increase, day after day, in natural or human environments, just like the other types of physical, biological and social systems.

All the above aspects show serious grounds for competition in knowing and quantifying, in modelling and forecasting the real world, simultaneously economic, physical, sociological, etc. The physical model can make a real contribution, through its sociophysics, quantum economics, etc. Forms, and in an unexpected manner, to understanding the economic problems, the processes or the decisions of an economic and social nature:

- through its methodology, which can be described as dual: of an analytical and experimental type at once;

- through its solutions of decomposing, coherently and very close to the reality, a system into its constitutive pieces, and its manner of final understanding, known through the formula "the whole is larger than the sum of its parts" (the *Gestalt* phenomenon);

- through its measuring scale, or it quantitative, relevant standpoint, where it describes the qualities of an economic system or its constituent and determinative phenomena, without however omitting the simplicity of the physical universe, assimilable to any other universe;

- through its specific vision and its manner of making references, always in terms of parts of the universe that must be studied within the great structural hierarchy of reality: from a micro-scale to a macro-perspective, which it deals with through its two main extreme disciplines (nuclear physics at the sub-level of the atomic particles,

and astrophysics, at the aggregate level of the cosmic and universal type), connecting a great variety of disciplines, from chemistry, molecular biology, organic biology, psychology, up to economics, political sciences and sociology, ecology, geology and climatology and, to end with, astrophysics);

- through its contribution to establishing the equations that simplify, and the methods that describe phenomena with much more accuracy and precision, as compared with any other models, such as production, markets, migration, traffic or transportation, the financial world, etc.

The physics' laws, mathematically express the conservation of a quantity, as well as the conservation of symmetries or the homogeneousness of space and time (the object space–time).

The physicists' interest in the fields of the financial and economic systems has comparatively old roots, and a brief history of the appearance of sociophysics can be illuminating in that respect. Sociophysics has become also an attractive research domain in the last two or three decades, despite the controversies between sociologists and sociophysicists; it is all due to its extraordinary potential to allow the understanding of a simple principle in keeping with which social phenomena will always be victorious, unlike the scientific theories that explain them. By using statistical physics on a large scale, by modelling the relevant social phenomena, such as those of the making up of the cultural, economic or political opinions, the dynamics and dissemination of the opinions, the origin and evolution of language, competition, conflict, the behaviour of the masses, the spreading of the rumours, social contagion, the net systems of the Internet and the World Wide Web, scientific cooperation and research, the appearance and evolution of the terrorist networks, etc., sociophysics tries to supply new solutions in modelling such phenomena as the inter connexion between the dynamics of a number of social or demographic indicators (life expectancy, birthrates, fertility, etc.), and the distribution of wealth and well-being, religion, the ecosystems, friendship, the social and traffic networks, etc.

The origins of sociophysics can be detected as belonging to the '70s and '80s. One of the most frequently cited authors is Serge Galam, who published his papers in *Journal of Mathematical Sociology* and in *European Journal of Social Psychology*. The apparently conflictive nature of the new discipline, called sociophysics, in relation with the scientific communities of the classical physicists, is best described in his book *Sociophysics: A Personal Testimony (2004)*. Physicist Elliott Montroll was the co-author of the first book that anticipated the evolution of this new science called sociophysics, alongside W.W. Badger, in 1974; the title of the book was *Introduction to Quantitative Aspects of Social Phenomena*. Sociophysics was defined, by association with econophysics, as the specific phenomenon of using the models of physics in sociology, as the first objective of the new science was to deal, in its models, with the human individual as statistical physics and the quantum physics or mechanics treat particles. Physics concentrates up to this day on the scientific and technological aspects of human society, and accepts ideas of Alfred Lotka, concerning the human populations as the owners of genuine solutions of

transforming their own energies into specific dynamics (demographic migrations, cultural, educational, religious, behavioural changes). The sociophysical models can change the possibilities of the human population to know themselves, and physics itself dynamizes the investigation effort through its traditional analysis models based on quantum thinking, through the method of statistical physics, together with fuzzy logic, through the science of complexity, or through the methods specific to sociology; it thus enriches the methodological supply of sociophysics, the initial name of which was intended to be *psychophysics*. Starting with the 21st century, sociophysics is really a new science, and not only a mere multidisciplinary or trans-disciplinary slogan. Among the most important pioneers of the new science, we could mention, in addition to Serge Galam (*Sociophysics: A Personal Testimony*), Dietrich Stauffer (*Sociophysics Simulations I: Language Competition)*, Paris Arnopoulos (*Sociophysics: Chaos and Cosmos in Nature and Culture*), etc.

The contemporary debate about the limits of the economic realism and the future of economics must defence the importance of the new alliance with quantum physics. Quantum physics can approximately be considered as a generalization of Newtonian physics and mechanics. The probability of finding a particle is given by a function having conformity with the principles of wave mechanics. Thus, the particle is dissipated in space, and it is only the probability of finding it in a certain location can be calculated, until it is noticed in a practical way. The thinking of quantum physics leads to the conclusion that using the probabilistic scenario with alternative state variants (very much as the particle–wave, in the quantum model), stands the best chances of coming near the description of the macroscopic, macroeconomic, macro-financial world of the companies. First, it becomes necessary to define the specificity of quantum physics' way of thinking.

Quantum physics remains a powerful science for studying subatomic particles. Very small particles at very high velocities behave differently from billiard balls and solar system planets and there are some non-intuitive effects of trying to observe and pinpoint features of individual particles. Quantum physics emerge from classical statistical physics or classical statistics. A typical quantum system describes an isolated subsystem of a classical statistical ensemble with infinitely many classical states. The state of this subsystem can be characterized by only a few probabilistic variables. Their expectation values define a density matrix if they obey a "purity constraint". Then all the usual laws of quantum follow, including Heisenberg's uncertainty relation, entanglement and a violation of inequalities. No concepts beyond classical statistics are needed for quantum physics - the differences are only apparent and result from the particularities of those classical statistical systems which admit a quantum mechanical description. The rule for quantum probabilities follows from the probability concept for a classical statistical ensemble. In particular, the non-commuting properties of quantum operators are associated to the use of conditional probabilities within the classical system, and a unitary time evolution reflects the isolation of the subsystem. But first of all, despite the scientific character of quantum physics, this incredible way of thinking offers and takes a spiritual perspective in which there are no separate parts, in which everything is fluid and always changing, from particle or atom to wave or energy, from material to spiritual, from realism to idealism, etc.

It is through our thoughts that we transform this ever-changing energy into observable reality. Therefore, we can create our reality with our thoughts. With quantum physics, science is leaving behind the notion that human beings are powerless victims and moving toward an understanding that we are fully empowered creators of our lives and of our world. Quantum physics shows that what's happening on the inside determines what's happening on the outside. It says that our world is shaped by our thoughts. Quantum physics' way of thinking is the nearest thought to the universe, and even beyond universe. The original connection between quantum physics and thought was made by David Bohm in 1951. The human brain is no Turing Machine. Roger Penrose tries to prove that our consciousness is non-algorithmic, and that we seem - to our conscious selves - able to make decisions in a flash. He finds that this could be explained only by quantum physical thought processes that proceed in sub-graviton parallelism until they reach graviton level, when they collapse and produce a conscious thought. Both Roger Penrose and Amit Goswami note that where quantum physics seems mystical, it is because it is not complete, stable, or a finished theory. Since quantum theory cannot explain the collapse of wave functions adequately we should not try to use to explain more complex phenomena either. We need better tools. Obviously, the brain is composed of particles obeying quantum laws (a notable case is that the retina accepts photons, which are small enough to behave strangely in terms of classical physics). Quantum physics is strange. So is consciousness. Maybe there is something in common between the two. The indeterminism in quantum physics is commonly modelled in a wave function - which is a combination function of possible outcomes, and determining the outcome is commonly termed "collapse of a wave function". Penrose says that consciousness as a side effect of running an algorithm is not possible. Amit Goswami completes this idea, and reconciling macro realism with micro idealism is possible in quantum physics' way of thinking because of six main reasons: a) the quantum state of a system is determined by the Schrodinger equation, but the solution of Schrodinger equation, the wave function is not directly related to anything that can be seen by someone; b) quantum objects are governed by the Heisenberg uncertainty principle: it is impossible to measure simultaneously and with certainty pairs of conjugate variables such as position and momentum; c) the paradox of wave-particle duality consist of quantum objects, needing for a solution which involves interpretation and philosophy; d) the discontinuity and quantum leaps are truly fundamental features of quantum systems behaviour; e) the physics' reality could be or not a coherent superposition; f) under certain conditions (for example, when energy levels of atoms are separated by very small spaces), quantum mechanical predictions could be reduced to those of classical mechanics. Macro realism arises

whenever economics appear, but difficulties are more and more significant because of the quantum nature of reality. Very much as the measuring process gets us acquainted with quantum thinking, the concepts of statistical collective and ensemble, being tantamount to a number of sequences of probabilities and mean values of the variables of quantum physics, allow the mental associations among molecules or particles, and economic agents, or subjects. The world of physics thinking can impose to economical thought the probabilistic character of its forecasts, even in the case of a pure statistical collective, gradually eliminating the exclusively deterministic models of prognosis specific to classical economics. Probabilistic density will thus generate models for previsions s based on the probabilistic thinking structured in distinct scenarios. The merit of the quantum physics is that of acknowledging its limits in foreseeing future events, centred on the principle of uncertainty, and becoming familiar to future economics, as well. Economical thinking will also take over, in future, the simultaneity of the states of particle or wave, from quantum statistics, in an alternative approach to the various specific units defined through binary states. Finally, the quantum economics is the scientific compromise between the economic vision and quantum physics' thought. Quantum economics means also the coalition and the equilibrium between the two sciences. This coalition has three steps: a) the coalition must have "positive measure" (the coalition "matters", in the general sense); b) the both sciences (economics and quantum physics) prefer the new allocations of the common sense of thinking; c) the total endowment of the coalition must be sufficient for them to conduct to a better understanding of the economic world (more atomized and thus continuum). In his relative recently finished book, entitled "*Physical Modeling of Economic Systems. Classical and Quantum Economics*" (published in 2005), Anatoly V Kondratenko underlines that if compare quantum economics with other most known economic theories (neoclassical economic theory, institutional economics, evolutionary economics) it can be said, that quantum economics does not contradict them. Generally speaking, for the beginning, quantum economics has been considered a method for *ab initio* or *non-empirical calculations of demand and supply functions* and their dynamics or evolution in time due to all interactions in economic systems. Moreover quantum economics combines or/and unifies most important of mainstream theories and gives fruitful theoretical and computational tools for further development of them. As a matter of fact, quantum economics can be regarded as the first step in developing the 'grand unified economics' in a multidisciplinary theory, using multidisciplinary methods and models, etc. Really, on the one hand, quantum economics makes it possible to simultaneously consider influence exerted by the interaction of the economic agents (a major subject in neoclassical economic theory) and interaction of the government, society and other institutions with economic agents (subject of investigation by means of institutional economics) on the economy agents' behaviour, and on the other hand, to offer equations of motion of the economics phenomena that describe evolution of the economy in time (paradigm of evolutionary economics).

3. A FINAL REMARK

To conclude the presentation of the new model of sociophysics and quantum economics, the application of sociology and quantum theory in economics implies the fact that new systemical vision of sociology is alwazs a good option and the sum total of the information concerning a certain particle or an economic entity must be contained in the wave function or in the energy function of the economic activity which is associated to it, as the formalism of the wave functions is considered adequate, because their predictions are in keeping with the experiments and economic evolutions. The basic laws of quantum physics and mechanics describe the physics of the sub atom world, but the macroscopic world is itself a final case of that science of the greatest generality as we can see from economic point of view. In the thinking of quantum physics and mechanics, an entity of a sub atom particle, such as the electron, could behave not only as a particle, but also as a wave. This is the major change for economics' thought. Even economics' entity is not a particle, sometimes it is activity and results during the same time, like in quantum physics. That odd quantum effect is supposed to disappear, in accordance with the thinking of quantum physics, when the entities become bigger.

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CORRUPTION FROM ANTIQUE ASTRONOMY TO CONTEMPORARY EVERYDAY LIFE

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Abstract: *Physics may offer powerful tools to model social, political and economic phenomena, among them corruption. The word corruption was used in Physics and Philosophy, in Antiquity, to describe an alteration of the actual motion (behavior) of a body, with respect to that expected (due to the physical law applicable) to be, but the Physics meaning of corruption is not even mentioned in contemporary dictionaries. By analyzing the evolution of corruption in Physics the authors draw some conclusions, useful in applying Physics models to every day life.The authors give some examples starting from Physics models of the law of action-reaction, dimensional homogeneity, the use of errors besides the use of average values in Physics and apply them to economy and politics to identify, characterize and suggest how fight some types of corruption.The models fit, also, the actual situation in dealing with the State Budget deficit in 2010 Romania.*
Keywords: Corruption, fraud on law, fiscal evasion, physics models, econophysics, action and reaction, dimensional calculus, dimensional homogeneity, error estimation.

1. INTRODUCTION

The authors have been lead to this research by being interested to explain how it was possible to accumulate huge private wealth during world war and post-war time and more recently, after the breakdown of communist regimes in the early 1990', in Romania, Russia, Albania a. s. o., by people with low initial wealth.The media and politicians have explained this "achievements" by infringement of law, by "corruption", probably some of their members knowing it from the source. But many of the newly wealthy people, their accountants, allegate that they acted within the existing law, not infringing law. In such a case, there is being implied not the simple infringement of law but "fraud on law".

How it is defined, the term "corruption" (in French *corruption*, from Latin *corruptio*)?

In contemporary dictionaries, **"corrupt"** means : 1250–1300; ME (< AF) < L corruptus broken in pieces, destroyed; corrupted (ptp. of corrumpere), equiv. to cor- cor- + rup- (var. s. of rumpere to break) + -tus ptp. Suffix; when used as an adverb literally means "utterly broken"

In modern English usage, the words **corruption** and **corrupt** have many meanings [1]:

• Political corruption: the abuse of public power, office, or resources by government officials or employees for personal or group gain, e.g. by extortion, soliciting or offering bribes.

• Bribery in politics, business, or sport (including match fixing).

• Police corruption

• Corporate corruption: corporate criminality and the abuse of power by corporation officials, either internally or externally.

• Putrefaction: the natural process of decomposition in the human and animal body following death.

• Linguistic corruption: the change in meaning to a language or a text introduced by cumulative errors in transcription as changes in the language speakers' comprehension.

• Data corruption: an unintended change to data in storage or in transit.

Legally, corruption is an occult disregard of the law, the violation of legal provisions in their meaning and spirit [4]. This disregard of the law may be or may be not relying upon an the other law.

Frequently, in legal courts, the corruption is connected with fraud on law.

There is reckoned fraud in law, when certain legal rules are not used for the purpose for which they were enacted, but to circumvent other mandatory legal rules, that meaning when there is an infringement of a mandatory law by using an the other law.

The contemporary corruption is so important that, there are frequently mentioned institutions dealing with political corruption, from world to local levels:

• Transparency International, which since 1995, has published an annual Corruption Perceptions Index (CPI) listing and ordering the countries of the world according to "the degree to which corruption is perceived to exist among public officials and politicians". The organization defines corruption as "the abuse of entrusted power for private gain".

• Group of States Against Corruption (French: *Groupe d'Etats contre la Corruption*), a body established under the Council of Europe to monitor the implementation of instruments adopted by member states to combat political corruption.

• Independent Commission against Corruption, **ICAC,** of Hong Kong (1974). Its main aim has been to clean up endemic corruption in the many departments of the Hong Kong Government through law enforcement, prevention and community education. The ICAC is independent of the Hong Kong Civil Service.

• Anti-Corruption Trust of Southern Africa (ACT-Southern Africa)

• D.N.A. National Anti-corruption Directorate (a prosecution entity) in Romania, with national headquarters and 15+3 local branches.

In dictionaries and in media, there is not even an allusion about the Physics' origin of the word „corruption" and how Physics has been dealing with corruption along History, in spite of the fact that Physics: has being using the word corruption for 25 centuries, has explained corruption, has modeled corruption and has found ways to master, to reduce or sometimes to eliminate corruption.

The word corruption was used in Physics and Philosophy, in Antiquity, to describe an alteration of the actual motion (behavior) of a body, with respect to that expected (due to the physical law applicable) to be.

Aristotle (384–322 b.Ch.) located a gap between terrestrial and heavenly Physics. The first had laws valid in the terrestrial (corruptible and mortal) region; the second had proper laws valid only in the ethereal (incorruptible, celestial, heavens' and eternal) region.

This duality remained unquestioned until Galileo Galilei (1564 - 1642) attempted to demonstrate the mobility of the Earth. However, Galileo hypothesized that only one Physics could exist, but he did not actually apply terrestrial physics to the ethereal region.

Tycho Brache (1546 – 1601) established theoretically the super-Lunar position of transient phenomena such as new stars and comets. This meant that he undermined the Aristotelian conception of the immutability and incorruptibility of the heavens.

More, Tycho Brache and his assistant Christen Sorensen Longberg (~1562-1647), discovered and computed the main anomalies of Lunar motion. That has meant that corruption of a motion expected to observe a physical law may be explained and forecasted by an other law.

Later on, the tendency was to find general laws to include both basic laws and laws considered responsible for corruption.

Isaac Newton (1642 – 1727) established new general physical laws which were at the same time a result and a demonstration of the existence of a single terrestrial and ethereal World. Newton included the law of gravitation in his "Mathematical Principles of Natural Philosophy" (1687), together with the three principles of dynamics. He proved that such principles, valid in terrestrial regions, when joining the theory of gravitation could explain perfectly why planets followed Johann Kepler (1571-1630)'s laws. As a result, Newton's "Mathematical Principles" completely obliterated the Aristotelian gap between the terrestrial and celestial worlds and apparently eliminated astronomical corruption.

Joint consideration of the theory of universal gravitation and the three principles of dynamics became extremely fruitful. The pairing could be applied to a study of a single body revolving around a larger body, for instance, a planet or a comet around the Sun. For example, in 1684, Newton demonstrated that the path of a planet, acted upon by a force related to the inverse-square of distance, was an ellipse. Newton also concluded that comets' paths were parabolas, or extremely elongated ellipses, as in the case of "Halley's Comet".

The coupling could be also applied to the study of the influence that a third body could produce on the elliptical path of a body orbiting around a major body.

This second direction of studies became extremely productive in the 18th and 19th centuries. The discovery of an eighth planet, Neptune, in 1846, made independently by John Couch Adams (1819-1892) and Urbain Jean Joseph Le Verrier (1811-1877), established that Newton's Physics definitely applied to planetary motion. The discovery originated from a reverse application of Newton's analysis of a three-body system. Since it was observed that Uranus (fortuitously discovered in 1781) did not follow its predicted path, the planet's course probably had to be influenced ("corrupted") by the gravitational attraction of an as-yet unknown eighth planet. The new Physics was the conceptual instrument which became indispensable for solving many astronomical problems and fight astronomical corruption. Sometimes, these problems of eliminating corruption led to unsuspected results: for example, the discovery of the planets Neptune (1846) and Pluto (1930). The path was opened for a new perception of the structure and future evolution of the Universe.

From this historical approach of corruption in Physics, the authors have drawn a few conclusions:

- corruption has cosmic origins and the term designating it have been continous used in Physics since its origins (Antiquity);

- corruption means alteration of a lawful behavior because of an external influence;

- corruption may be generated by an external individual influence, a tandem or a group influence;

- the external influence at the origin of corruption is also subject to a law;

- corruption has its laws;

- the laws governing corruption may be discovered, by refining, extending or diversifying the research;

- an approach at a higher level of understanding might describe simultaneously both the basic law and the laws given rise to previously „corrupted" behavior as regards the basic law;

- the new more general law may describe „corrupted" behavior until a new kind of corruption (or a refined one, or an inter-disciplinary one or a far range one) is discovered and the cycle experimental corruption, theoretical explanation, unification of corruption laws and basic laws restarts!

- corruption laws generate system structures organized and acting (at least, partially) subject to corruption laws;

- corruption propagates from universal to local levels.

2. SOME MODELS OF CONTEMPORARY EVERYDAY LIFE'S CORRUPTION

Because Physics has large spectra of models able to describe social, political, economic, human, psychical, biological phenomena, not only physical, chemical and engineering ones, by analogy with Physics models, Econophysics seems convenient to be applied to generally deal with corruption.

By such opportunities, Econophysics is called to suggest and/or develop models, laws, principles, methods, structures and ways to control or fight corruption.

Econophysics may suggest how, where, when, in connection with what, to find corruption depending of the type of the law to be broken by corruption, identify

corruption which breaks laws, how to find the corruption laws, which kind of laws are contributing to infringe the main law, what is the mechanism and the hierarchy of the laws and of the structures implied in facilitating visible corruption.

In opposition to Physics, where laws are objective ones, natural ones, independent of humans, the social laws are subjective, being generating by human groups or individuals on behalf of the whole society referred.

The social corruption may be more versatile, refined, deep, extended, interdisciplinary, than the physical corruption.

Corruption is facilitated by such law provisions and such an institutional frame permitting incompetent or corrupt people to regulate corruption, starting from the highest level of the world society.

But there is the reversed opportunity, too, that because the social laws, are being done by humans, the laws and the human law-generators, might be under the control of the society, not independent of it (like physics laws which observe the principle of objectivity and are socially independent).

This means that social corruption could be differently mastered by society, than physical corruption is, by physicists, who can't change physics laws).

The result on human control of social laws may be not only a decrease of corruption but, also, an increase, a flourishing, an enlargement, a deepening, a diversification of corruption if those groups or individuals subjectively generating social or economic laws and regulations are corrupted themselves as individuals or as a group or incompetent or obeying orders from persons or groups interested in generating a given kind of corruption, for a given period of time, in a given region, concerning a given activity.

As regards corruption in society, where the laws are subjective, generated by groups of individuals or even individuals in front of some powerful institutions:

- corruption frame, legal and institutional, may be voluntarily created by groups or individuals interested in promoting their private interests against general interests;

- corruption is making profit of the incompetence and/or corruption or subordination to corruption interested groups or individuals of those normally in charge of fighting corruption;

- corruption is facilitated by a superior law and/or higher level structural frame permitting corrupts to regulate or promote corruption at lower levels.

Some time ago, one of the authors has explained the infringement of some financial rules in spite of stiff supervision [2] applying to a Quantum Mechanics tunnel effect model. Such a model might explain the normally unexplained capture of wealth by some individuals or groups in a not wealthy society. That model fits one of the approaches of Econophysics foreseen by the authors in dealing with corruption: to find a Physics model to explain a chosen type of social, politic or economic corruption.

Another possible approach is a reverse application of the first approach: Econophysics, is not to start from a social, political or economic phenomenon and to find a model in Physics for it, but to start from an existing Physics model,

or law or method and to find social, political or economic, a.s.o. phenomena where this Physics model, law, method fit successfully.

To this approach, there is devoted the rest of the paper, based on a few examples.

A first example of this suggested approach is to apply the Newton's, **action-reaction,** third, **law** of Mechanics:

„The mutual forces of action and reaction between two bodies are equal, opposite and collinear. This means that whenever a first body exerts a force **F** (action) on a second body, the second body exerts a force **−F** (reaction) on the first body. **F** and **−F** are equal in magnitude and opposite in direction".

It is essential to understand that the reaction applies to another body that the one on which the action itself applies, at the same instant.

Simultaneity of action and reaction with the implied time constant is to be understood within the time constant corresponding to the preservation of the stability of the concerned system.

The same is valid for the momenta of forces with respect to a point and for other interactions.

The action-reaction laws are the result of conservation laws, to ensure the stability of a system in its stationary evolution within an inertial frame, not subjected to external forces or momenta or other actions, during which evolution a certain quantity characteristic to the whole system is preserved. Stability is ensured by action-reaction law for the different kinds of actions, not only for mechanical type ones.

The physical nature of the reaction force is identical to that of the action itself: if the action is due to gravity, the reaction is also due to gravity. This has correspondence in other domains, f. e.: if the action means expenses (money) the reaction would mean income (money), if the action means more rights, the reaction would mean more obligations, if the action means larger immunity for smaller responsibility, reaction would mean less immunity for larger responsibility.

To Physics action-reaction law do correspond many non physical phenomena. They might have some characteristics a little different from those of the physics law of action - reaction.

To Physics action – reaction law might correspond causality. **Causality** is the relationship between an event (the *cause*) and a second event (the *effect*), where the second event is a consequence of the first, in the special situation when antecedence (which usually postulates that the cause must be prior to, or at least simultaneous with, the effect) is reduced to simultaneity, understood as before.

Though cause and effect are typically related to events, candidates quantities in Econophysics include objects, resources, processes, properties, variables, facts, rights, states of affairs. The characterizing of the causal relationship may be the subject of much debate in each case.

Contiguity in causality, postulating that cause and effect must be in spatial contact or connected by a chain of intermediate things in contact (Born, 1949), is always implied.

Karma in Indian religions treated in Hindu, Jain, Buddhist and Sikh philosophies, means "deed" or "act" and more broadly names the universal principle of cause and effect, action and reaction that governs all life. The effects experienced are also able to be mitigated by actions and are not necessarily fated. A particular action now is not binding to some particular, pre-determined future experience or reaction; it is not a simple, one-to-one correspondence of reward or of punishment.

Karma is the belief that a person's actions cause certain effects in the current life and/or in future life, positively or negatively.

According to the Vedas, if one sows goodness, one will reap goodness; if one sows evil, one will reap evil. Karma refers to the totality of our actions and their concomitant reactions in this and previous lives, all of which determines our future.

The conquest of karma lies in intelligent action and dispassionate response.

In Theosophy, karma is affiliated with the Neopagan *law of return* or *Threefold Law,* the idea that the beneficial or harmful effects one has on the world will return to oneself. Colloquially this may be summed up as 'what goes around comes around.'

Hegel's dialectic principle of unity and conflict of opposites (contraries) stated in his "Science of Logic" is an other example of the validity of Physics action-reaction law in the world at large, not restricted to physical world.

This law was seen by Hegel as the central feature of a dialectical understanding of things and originates from the ancient Ionian philosopher Heraclitus from Efes.

The general Hegelian principle of philosophy of history, that is the development of the thesis into its antithesis which, by the *Aufhebung* ("synthesis"), may be also connected with Physics action-reaction law. The *Aufhebung* conserves the thesis and the antithesis and transcends them both. The demand and supply and the demand and offer laws in economics [3] are example of action-reaction type laws.

In the theories on Law, the rights are always accompanied and conditioned by obligations [4]. The reverse allegation is also valid.

The fraud on law is a standard doctrine in most jurisdictions: in France, it is termed, *fraude à la loi*, in Spain, *fraude de ley*, in Italy, *violazione di norme di legge*, in Germany, *Rechtswidrige Umgehung eines Gesetzes, in Romania Frauda la lege.* It reflects the need for governments to prevent their citizens from intentionally and improperly manipulating their behavior (using other law provisions) to prevent mandatory provisions in the law from applying to them, that means for using their rights to elude their obligations, that means to infringe the action-reaction law.

As the translated names necessarily imply, the key is an intention to displace the normal operation of the legal system, from a balance between rights and obligations, towards predominance of rights used to elude normally corresponding obligations. Sometimes, this intention will be express. On other occasions, it will be for the courts to decide whether a sufficient intention can be imputed. Once the intention is established, the evasive maneuver

will be void and the normal legal provisions will apply to the parties.

The observation of the action-reaction law is evident in the major part of provisions of the Constitution of Romania [5], for example, Art. 57: „Romanian citizens, foreign citizens, and stateless persons shall exercise their constitutional rights and freedoms in good faith, without any infringement of the rights and liberties of others".

Another example: in the Article 138 (5) there is provided that „No budget expenditure shall be approved unless its financing source has been established" [5].

But, in spite of this constitutional provision, the State Budget Deficit has continuously increased in the last years, including the first trimester of 2010 year, the Government being obliged not to infringe existing, previously passed laws which regulate unsustainable social expenses and salaries. Therefore, the Art. 138(5) have been infringed by other laws, previously passed by Parliament, by „fraud on law".

The solution for the Government would be to amend those laws generating corruption, through the infringement of the provisions of Art. 138(5) of the Constitution of Romania.

This is regarding the reduction of opportunities for corruption created in the past.

For the future, there seems necessary, as regards legislation procedures, to improve the legislation regulations leading to the passage of laws in Parliament or of adopting Ordinances by the Government or of issuing institutional advices and reports and to increase the responsibility of all legislators, including the Parliament members which, must decide in the favor of public interest (Art. 69(1) "In the exercise of their mandate Deputies and Senators shall be in the service of the people"), but not in the private interests of some individuals or groups, deeply interested to be favored, as have been accused sometimes.

The legislators are protected when taken their decisions by the provision of Art. 72(1) „No Deputy or Senator shall be held judicially accountable for the votes cast or the political opinions expressed while exercising their office" but they are under the political control of the people, at poles, once in 4 years.

As regards the Government, it is under the continuous control of the Parliament: Art. 109 (1) „The Government is politically responsible for its entire activity only before Parliament. Each member of the Government is politically and jointly liable with the other members for the activity and acts of the Government".

An analysis of the Constitutional content, at its next Revision, from the point of view of action-reaction law (balance of rights and obligations) seems necessary.

An other typical example of breaking action-reaction law is offered by the requests of the representatives of some groups on behalf of those groups to gain financial and other gains without offering society nothing in return for their demands or at least by indicating where from to take the supplementary required resources,. One could mention, f. e., trade unions, which ask increased salaries without indicating the source of the new demanded funds (where to diminish spending) or what they offer to increase revenues of the patronage (including the State) –

for example, the unions do not ensure the upgrading of the training of their union members with regards the use of IT technologies or of the contemporary standards of quality, or of international languages. The same is valid for political parties which, during electoral extended campaigns,to gain votes, do demand uncovered budgetary future expenses, which lead to future chronic State Budget Deficits.

Another example of a useful Physics tool in modeling some aspects of politico-economical life is **Dimensional Calculus.**

The authors shall apply Dimensional Calculus in this paper to appreciate the fairness of the formulae currently used for calculating State Budget Deficit, showing a few possible frequent errors introduced to corrupt public opinion perception about the state of the Budget Deficit.

In defining of the State Budget Deficit, **D**, there are being used the following quantities: government revenues, **R** and government spending, **E,** but, frequently and the gross domestic product, GDP, here, shortly denoted by **P**.

Defined as an absolute quantity, D_a, the absolute deficit is equal to:

$$D_a = E - R, \qquad (1)$$

The quantities **R, E, D_a** are expressed as absolute (not relative) quantities, having the identical dimensional expressions:

$$[R] = [E] = [D_a] = V/T, \qquad (2)$$

where **V** and **T** the symbols of the dimensions of the chosen monetary unit and of time, respectively.

The Principle of Equality requires keeping the reference unchanged. The condition of dimensional homogeneity has to be observed for each equation and for each term. The mentioned quantities have the same dimensional equation, the revenue, spending and the deficit, are referring to the same State Budget components. Therefore, they must be expressed in the same currency unit, per the same time interval, for the same economic system, f.e. in Euro/year, RON/trimester, including the same components, for whole Romania. Generally, there must be valid the equations:

$$\{R\} = \{E\} = \{D_a\}, \qquad (3)$$

A frequent error may be not to keep the unit {**V**} of the monetary dimension **V** as a constant and to compare values of each one of these quantities **R** or **E** or D_a, for different equal periods of time, but by using different, currencies, at different instants, f. e Euro/y at the end of 2010 compared with RON/y at the end of 2009, without mentioning the chosen currencies and the evolution of their exchange rate (i. e. Euro/RON), during the interval of time implied.

Another dimensional error would be to compare each one of these quantities **R** or **E** or D_a, as absolute values but for different time intervals, in spite of using the same currencies.

For example there is compared the absolute State Budget Deficit on the first semester of 2010 with D_a for the whole 2009, with an false optimistic conclusion for politicians and media, unaware of the trick.

Another possible dimensional error is to compare the quantities **R, E, D_a,** at different instants, by using different methodology of computing them, not the same one.

The State Budget Deficit may be defined, besides absolutely, as a relative quantity, **D_R,** expressed as the percentage from the revenue, **R**:

$$D_R = D_a / R . \qquad (4)$$

More frequently, the relative deficit is expressed as **D_P ,** a percentage **D_a** of the gross domestic product, **P** :

$$D_P = D_a / P. \qquad (5)$$

An other dimensional error in operating with relative Budget deficit is that referring the absolute budget deficit for a trimester to the gross domestic product, **P,** for the whole year, **D_{tPa}** , in which case the relative deficit seems to be, relatively, 4 times smaller than the actual correct figure relative to **P** when observing the condition of homogeneity in Dimensional Calculus.

The definition of the relative state budget deficit with respect to Gross Domestic Product, **D_P**, is preferred by politicians and international institutions like International Monetary Fund, World Bank a. s. o., but, from a dimensional point of view, it is a rather unhappy definition and practice because the quantities: government revenue, **R,** government spending **E,** on one side and respectively the gross domestic product **P**, on the other side, dimensionally represent different types of economical quantities. Simply speaking, the whole revenue **R** may be spent by the government, but not the whole domestic product, **P**.

To better realize this essential dimensional distinction between the definitions (4) and respectively (5) of the relative deficit, let exemplify by the situation in Romania reported for the whole year 2009.

The „Budget State Deficit" was reported and largely used as being equal to ~ 8.3 %.

Looking at the detailed economical figures one may see that the report was about:
- a relative deficit, not about the absolute deficit

$$D_a = E - R \ (1);$$

- a relative deficit computed by dividing the absolute deficit $D_a = E - R$, to **P** , that means as percentage of the gross domestic product, **P:**

$$D_P = D_a / P. \qquad (5)$$

From this definition it would result that there is enough to splash state spending with 8.3 % to escape of the State Budget Deficit.

The correct dimensional approach had would been to use **D_R** , the relative State Budget Deficit, as a percentage of **D_a** from the government revenue, **R**, quantities which have the same dimension and may be divided to offer a correct percentage:

$$D_R = D_a / R, \qquad (4)$$

D_R is larger than **D_P**, as much as **P** is larger than **R.**

- The figures for the **R/P** vary between 31% and 32% (with or respectively, without progressive taxes). Considering as acceptable for the computations done here a **R/P** value of approximately 1/3 (the revenue **R** being approximately only one third of the gross domestic product, **P**), the relative State Budget Deficit expressed as percentage of **R, D_R** , is equal to:

$$D_R = \sim 3 * 8.3 \% = \sim 25 \%.$$

Therefore, D_P, the relative state budget deficit expressed as percentage of P, seems 3 times smaller than D_R and possibly, that is why D_P is preferred by politicians, because D_P is not so impressive for the laymen.

This figure of 25% of the relative deficit being equal approximately to a quarter of the revenue is the significant one by itself and exactly it has been used by the Romanian Government and the I. M. F., World Bank and E. U. when actualizing the loan agreement for the second semester of 2010.

The payments are to be done on condition that Romania slashes public spending and boosts tax revenue to reach a $D_R = \sim 25 \%$

Firstly, it was convened to slash Government spending by diminishing all salaries of the public employees, paid from the State Budget, by a quarter, 25% , and a part of the social expenses, the pensions, with only 15 %.

Clearly, this had not been enough as shown by our econophysical dimensional reasoning. It would had been necessary to reduce all kinds of expenses with 25 %, including all pensions, all social aid, all bouses, all spending on goods and services and all investment spending of the Government. This has not been advertised, may be, because of possible political consequences of the social unhappiness generated by such information.

More, the Constitutional Court of Romania invalidated the law providing for reducing pensions.

Therefore, to comply with the law of action-reaction, the Government has had to increase, on the spot, its revenues to cover the failed proposed slash of expenses by equally reducing with 15% all pensions.

As a consequence, the Government has decided to increase revenues, by increasing the Value Added Tax from 19 % to 24 % from the added value in economy. That means, again by increasing VAT relatively with itself, with approximately a quarter (with 5%, from 19% of the added value, that meaning 5/19 = 26.3% of the initial value of 19%).

Again, this increase of revenue is not enough as required by the action-reaction law. It is possible that there would be necessary to: further drastically reduce expenses on goods and services and the number of state employees but these reductions are not enough, because social expenses are ~ 46 % of the revenue.

There seems necessary to more boost revenues, by: generalizing and eventually increasing the general tax on every kind of income from the present 16%, increase and add many other taxes. Austerity measures might include rising the retirement age, cracking down on tax evasion and ending public sector bonuses.

The exact steps are to be chosen following numerical simulations of different possible measures too be taken, by modeling their correlations, too. There is to be avoided that the harsh measures trigger series of solutions of public sector strikes and eventually violence on the streets (like it has happened in Greece), by taking gradual measures to allow social acceptance.

By its success in getting the IMF loan, Romania has gained a vote of confidence for the measures taken by the government. Romania has an open window to exit crisis, which may influence financial markets and this has to be honored. Payments are to be done on condition that Romania slashes public spending and boosts tax revenue.

Measures to encourage development by attracting investment local and foreign and E. U. Funds, accessible to Romania (insufficiently applied for until now) are to be taken. An other example of a possible application of an other Physics tool in socio-economic life are **Physics common procedures in processing the errors on experimental data.**

Such procedures might be used in improving the control of public expenditures when selecting a winner of a public auction for services or goods or for public-private partnership investments, by changing the current regulations, to observe common procedures in processing the errors on experimental data.

Let us suppose that the price offered by a company X is P_X and the price offered by the next ranked competing company Y, is P_Y , for the same package of goods and services in their offer, in the bid concerned. If

$$P_X < P_Y \tag{6}$$

and

$$P_Y - P_X = \Delta P_{YX} \tag{7}$$

the selected company would be X and the agreed price P_X.

The corruption in the public authorities allotting and implementing contracts is possible because there is legally permitted a later increase in the price invoiced to be paid, without a new auction, just by agreement of the implied parties. This increase might be not only a few percentages from the settled price but even a few times the initial price (media examples of 10 times larger are quoted!).

Knowing that possibility and based on relatively frequent leakage of information during offer time, the favored company X may offer a slightly diminished price than Y company, to be sure that it „legally" gains the auction. Later on, the price P_X is increased much more over P_Y , by corrupted bilateral agreement only, not being compulsory that the increase of price be subjected to third party control.

The possible actions to reduce corruption when auctioning pubic expenses would be:

- to provide for, in the public auctions law or in the auction rules on the bid, that the price is firm (for the engaged services or supplies), could not be increased and the risks belong to the company or less tight, at least:

- to provide for in the auction law that following a public auction, the final price invoiced and paid could not be increased by a supplementary agreement between the parties, at an amount larger than ΔP_{YX}, the difference between the prices demanded by firstly and the secondly ranked competitors.

The solution proposed by the Government to impose a limit on the relative increase of the price, during implementation of the contract, limited to 50%:

$$\Delta P_{YX} / P_X < 50 \% , \tag{8}$$

marks a progress, but also keeps encouraging corruption and supposes that the estimated profit of the winner, hidden in its offer be ~50%.

By referring to public perception of the high level of corruption in allotting public expenses on goods and services, a 25% reduction on public spending at auctions,

by legally introducing the above proposed limitation seems quite possible.

3. CONCLUSIONS

The examples of applying Physics tools and emphasizing corruption on socio-economic laws similar to the action-reaction principle, dimensional calculus and processing of errors methodology in Physics, are based upon middle school and bachelor compulsory curriculum and the application of the Physics models implied could be done by every manager, politician or media man.

Physics may guide them to think about their own concept of the phenomenon considered and then challenge it, measure it and see if it connects. „Sometimes your physical intuition may not be exactly right…It teaches you to think beyond 'the normal' …and ask what does the physics tell you?" [Feynman].

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