

# **Book of Abstracts**

**2nd Polish Symposium on Econo- and  
Sociophysics (FENS 2006/04/21-22, Cracow)**

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# **Book of Abstracts: 2nd Polish Symposium on Econo- and Sociophysics (FENS 2006/04/21-22, Cracow)**

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# Preface

Welcome on behalf of the physicists who look for bridges between methods used in physics and problems encountered in economic and social sciences. We are motivated by the belief that our methods can be useful also outside physics. Another formulation of the same belief would be that physics is applicable almost everywhere.

The aim of this symposium is to confront this self-confident optimism with the point of view of the scientists working in economic and social sciences. We are sure that such an encounter will be advantageous to the physicists. We hope that it will prove profitable for our Guests as well.

*Krzysztof Kułakowski*

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- SAS Poland



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# Frame programme

Topics of the Symposium include:

- Time series analysis
- Markets modelling
- Game theory applications
- Modelling of the public opinion dynamics
- Social systems modelling

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# Part I. Symposia

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# Plenary session

## Programme

### Friday, 21 April

#### Opening Ceremony

WFiIS AGH, D-10/A

Friday morning, 21 April, 8:45

Chair: Krzysztof Kulakowski

#### Plenary Session 1

WFiIS AGH, D-10/A

Friday morning, 21 April, 9:00

Chair: Janusz A. Holyst

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9:00 Oral

#### **Bivariate financial time-series models: Bayesian comparison and inference**

Jacek Osiewalski

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Most of discrete stochastic processes used in financial econometrics belong to one of the two leading classes: the GARCH (Generalised AutoRegressive Conditionally Heteroskedastic) class or the SV (Stochastic Volatility or Stochastic Variance) class. In both, the parametric distributional assumptions (like conditional normality or the conditional Student t distribution) are usually made. However, despite the large number of observations that are often available, classical statistical inference is not easy for any of these classes, because either the (asymptotic) theory is not well established or the computations are very time-consuming, especially when the latent variables are present in the model (as it is in the SV case). The Bayesian approach to statistical inference, equipped with the numerical tools based on the Markov Chain Monte Carlo (MCMC) methods, is an interesting alternative. It provides the researcher with fully probabilistic, non-asymptotic and very intuitive inference procedures.

The paper reviews the Bayesian statistical approach to parameter inference and forecasting as well as to model comparison and pooling (averaging). The aim is to show how Bayesian techniques are used to compare different non-nested multivariate specifications proposed in financial econometrics. Since some of the models are very unparsimonious, the actual comparison is restricted to bivariate cases. The review of some recent empirical work is presented, which shows that

the SV class (based on latent processes describing volatility), can fit the data much better. But the most flexible SV models use at least as many latent processes as there is financial time series to be modelled, which makes them of little practical interest in really multivariate settings. Also, the best GARCH models involve too many parameters to be of practical interest in such cases. Thus, a hybrid GARCH-SV specification based on just one latent process and a relatively parsimonious GARCH-type model is proposed.

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9:45 Oral

#### **The development of science as the factor of economic growth**

Marek Szydłowski

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We study the connection between the development of science and economic growth. We show that there is a strict dependence of the rate of economic growth on the rate of growth of knowledge. To study this problem we use the methods of dynamical systems theory. If we use the new variables defined as original variables over effective labour, the economy reaches the stationary state. This long-term evolution of the economic system is represented by a global attractor in the phase space where the rate of economic growth is equal to the rate of growth of knowledge and the rate of growth of population.

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10:10 Oral

#### **Dynamics of the Warsaw Stock Exchange index as analysed by the fractional relaxation equation**

Marzena Kozłowska, Ryszard Kutner

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We studied the historical Warsaw Stock Exchange (WSE) index (WIG) at a daily time horizon; we expect that its dynamics is a typical for an emerging financial market of moderate size. We found that the well developed local maxima of the index (except the left side of the first one) can be fitted (up to its fluctuations) by an intermediate part of the Mittag-Leffler (ML) function which is a natural generalisation of the exponential one. In our case we obtained the exponent  $\alpha$  defining the ML function as  $\alpha < 0.5$  for WIG's maxima; the left side of the first maximum is well fitted by the exponential function. Note that the ML function has two characteristic limits: (i) for the initial time the stretched exponential form or Kohlrausch-Williams-Watts (KWW) and (ii) for the asymptotic time the power-law or the Nuttig law. These decays are typical for the

relaxation of disordered systems, e.g. viscoelastic materials, and lead to the Cole-Cole behaviour for the complex susceptibility which is broadly used to describe empirical data. The ML function can be applied to describe dynamics in both time directions. In other words, the relaxation of the WIG local maxima can be described by the fractional (non-Debye) relaxation equation which has indeed the solution in the form of the ML function. Since we found that most of empirical WIG maxima are well covered by the intermediate part of the ML function, this means that the WSE is a complex system lying between two different types of disordered ones created by stock market investors and described, correspondingly, by two types of relaxation functions (i) and (ii). Unfortunately, this observation does not uniquely define the microeconomic (or microscopic) model which constitutes its basis.

10:35

Oral

### Free random variables and financial correlations

Maciej A. Nowak

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We apply free random variables to derive statistical properties of empirical covariance matrices, which play a central role in the problem of portfolio selection.

### Coffee Break

*WFiIS AGH, D-10*

Friday morning, 21 April, 11:00

### Plenary Session 2

*WFiIS AGH, D-10/A*

Friday morning, 21 April, 11:30

*Chair: Ryszard Kutner*

11:30

Oral

### Classification of Polish provinces according to their competitiveness using the cluster and neuron network methods.

Krzysztof Karpio<sup>1</sup>, Piotr J. Łukasiewicz<sup>1</sup>, Arkadiusz J. Orłowski<sup>1,2</sup>, Arkadiusz Gralak<sup>1</sup>

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This paper presents the procedure and results of a classification of Poland's 16 provinces according to their level of competitiveness described by the indexes published by GUS (Poland's Chief Statistical Office).

The potential set of the properties underwent two-step verification in terms of their diagnostic properties. The first one was performed based on an analysis of variability, whereas the latter involved studying a matrix of correlations. The final set of variables, comprises of seven substantive groups, reflecting such aspects of the regions' competitiveness as economic potential, progressiveness of the economic structure, the level of sophistication of technical infrastructure and transport accessibility, competitiveness of labour resources, social development level, extent of progress in free-market transformation as well as the general state and level of the protection of the natural environment.

The classification of Polish provinces was carried out by Helwig's standard method as well as six selected taxonomical methods of cluster analysis: the single linkage method, complete linkage method, un-weighted pair-group method using arithmetic averages, Ward's method, k-means method and the Wrocław taxonomy method. The results were compared to those obtained using the neural network approach. The differences of the results were observed, discussed and 3-stage method was applied to further understand their origin. However we found the distinguished clusters of provinces which form the separate class for most of the methods used. Exclusion of the distinguished cluster changed the results for remaining provinces - the results became more uniform across methods used.

11:55

Oral

### Quantitative and sociological analysis of blog networks

Wiktor Bachnik<sup>1</sup>, Stanisław Szymczyk<sup>1</sup>, Piotr Leszczyński<sup>1</sup>, Rafał Podsiadło<sup>1</sup>, Ewa Rymaszewicz<sup>1</sup>, Łukasz Kuryło<sup>1</sup>, Danuta Makowiec<sup>1</sup>, Beata Bykowska<sup>2</sup>

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This paper examines the emerging phenomenon of blogging, using three different Polish blogging services as the base of the research. Authors show that blog networks are sharing their characteristics with complex networks ( $\gamma$ -coefficients, small worlds, cliques, etc.). Elements of sociometric analysis were used to prove existence of different social structures in the blog networks.

12:20

Oral

### Transition to Coherent Oscillatory Behaviour in a Route Choice Game

Dirk Helbing<sup>1</sup>, Martin Schonhof<sup>1</sup>, Hans-Ulrich Stark<sup>1</sup>, Janusz A. Holyst<sup>2</sup>

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Selfish routing of traffic over alternative routes wastes available street capacities, as individuals tend to generate an equilibrium state (a 'Wardrop' or 'Nash equilibrium') with higher overall travel times than in the optimal state. This 'Pareto optimum' is characterized by coherent oscillatory patterns rather than a stationary behaviour. Here, we study the time-dependent decision behaviour in a day-to-day route choice setting by means of experimental and simulation results. While there is a tendency towards establishing the Nash equilibrium in the beginning, we often find a transition to coherent oscillatory behaviour after a long transient time period. In spite of the complex dynamics leading to co-ordinated oscillations, we have identified mathematical relationships quantifying the observed transition process.

13:05

Oral

### Porównanie narzędzi SAS Forecast Server, SAS Time Series Forecasting System, SAS/ETS oraz SAS Enterprise Miner do analizy i prognozowania szeregów czasowych

Łukasz Kociuba

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SAS rozwinął i zaimplementował wiele metod do analizy szeregów czasowych. Narzędzia służące do analizy i prognozowania szeregów czasowych to SAS/ETS, SAS Time Series Forecasting System, węzeł szeregów czasowych w SAS Enterprise Miner, SAS HPF (high-performance forecasting) i aplikacja SAS Forecast Server. Celem referatu jest porównanie narzędzi i różnych metod w nich zawartych oraz demonstracja ich zastosowań. Celem metod jest stworzenie dokładnych prognoz, które można wykorzystać w nauce, przemyśle, handlu i usługach oraz innych dziedzinach życia gospodarczego.

### Lunch

Friday afternoon, 21 April, 13:30

### Plenary session 3

WFiIS AGH, D-10/A

Friday afternoon, 21 April, 15:30

Chair: Dariusz Grech

15:30

Oral

### Theory of Capital in Relation to the Laws of Thermodynamics

Mieczysław Dobija

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At the beginning of time, Prime Energy began Her labour creating Universes - matters and spirits and laws of their evolution towards societies of human beings. Therefore all creatures are energetic by nature and must maintain an adequate level of energy's concentration to continue their life in their existing shape. Energy is a fundamental concept of contemporary sciences. Economics have to follow this way in order to join to other sciences in creating intellectual capital indispensable for successful development of economy.

In economic language, capital is an economic power, although academics have not been fully aware of this connection. Much trouble with real economies, and economic theories as well, has its roots in the lack of reconciliation of the energy concept in physics and economics. Capital, in the sense of being used to "do something", is analogous to the property in physical science that is labelled as "energy". Energy is often defined as "the capacity to do work" and thermodynamics is the field, in which the applications of energy and heat are thoroughly studied. Therefore thermodynamics provides us with a useful premises for understanding capital.

Both thermodynamics laws apply in economics. The first law is a fundamental of the duality principle and "double-entry" concept used in accounting systems. The second law of thermodynamics is a key to understanding the properties of energy taking into regard its unavoidable diffusion. Dispersion of capital in the context of economic activities produces risk that manifests itself in reality as the cost of risk. Human capital as ability of doing work is transformed into value of products by labour, but a serious part of it disperses by heat. This is the reason of using concepts of present and future value in economic considerations and estimations.

Free, dynamic market assigns for successful workers, entrepreneurs and investors a premium for risk in order they could maintain their capital intact at least. Thus the rate of diffusion of capital influences the size of the risk premium because it must be sufficient to cover the rate of dispersion. Therefore the second law of thermodynamics predetermines an existen-

ce and a size of the risk premium. The risk premium is an essential economic constant, which shapes interest and discount rates, wages and salaries, prices of goods, and rate of returns under conditions of free market exchanges. Preventing the random dispersion of capital by well arranged management system an economic unit can create profit by limiting costs of risk and saving partly the market risk premium. The risk premium is a benchmark for fair, just prices. An estimated size of the risk premium is 8% of initial capital assuming an average risk level.

16:15 Oral

### On Value at Risk for foreign exchange rates - the copula approach

Piotr Jaworski

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In my talk I am going to present some numerical methods for determining the Value at Risk of portfolio consisting of long positions in foreign currencies. My approach is based on the fact that the copula  $C$  describing the joint probability of the daily logarithmic returns can be approximated, near the lower corner, by a homogeneous function  $L$  of degree 1. Since  $L$  must be concave, it is enough to estimate its values and the values of its first derivatives at one or two points to obtain quite reasonable approximation of the Value at Risk of the portfolio. I will illustrate the practical usefulness of these approximations by the analysis of the exchange rates of EUR and CHF at the Polish forex market.

16:40 Oral

### Levy matrices

Jerzy Jurkiewicz

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We present properties of symmetric real matrices with elements drawn from the Levy heavy-tail distribution. We determine the eigenvalue spectrum of such matrices. We also illustrate the relation between Levy matrices and the free Levy matrices, which satisfy the property of freeness.

### Coffee Break

*WFiIS AGH, D-10*

Friday afternoon, 21 April, 17:00

### Plenary session 4

*WFiIS AGH, D-10/A*

Friday afternoon, 21 April, 17:30

*Chair: Stanisław Drożdż*

17:30 Oral

### Dogadamy się czy nie? - o modelowaniu ewolucji opinii w socjofizyce.

Katarzyna Sznajd-Weron

*Wroclaw University, Institute of Theoretical Physics (IFT UWr), pl. Maksa Borna 9, Wroclaw 50-205, Poland*

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Dlaczego PiS nie dogadał się z PO? Dlaczego możliwy był sojusz LPR i Samoobrony z PiS - em ? Kiedy w społeczeństwie możliwy jest konsensus, a kiedy następuje polaryzacja opinii? Jakiego typu zmienną jest opinia i jakiej podlega dynamice? Co różni "sferę osobistą" od "sfery ekonomicznej"? Na tego typu pytania będę próbowała odpowiedzieć w trakcie wykładu przywołując zarówno znane już, jak i nowe modele socjofizyki oraz obserwacje zaczerpnięte z nauk społecznych.

17:55 Oral

### Scaling Range for Power Laws in Time Series

Dariusz Grech, Zygmunt Mazur

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The DFA (Detrended Fluctuation Analysis) and DMA (Detrended Moving Average Analysis) are crucial in determination of autocorrelation in time series giving a nice and useful tool to determine the Hurst-Hausdorff scaling factor. Not a lot is known however on the scaling regime (range) where both methods can be used. It is in particular the case of short and medium length series ( $L \leq 10^4$ ) one often meets in practical analysis. We present a way to solve this problem and discuss preliminary results. Then comparison with real financial time series is done.

18:20 Oral

### Automatic Trading Agent. RMT based Portfolio Theory and Portfolio Selection

Malgorzata M. Snarska

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Portfolio theory is a very powerful tool in the modern invest-

ment theory. It is helpful in estimating risk of an investor's portfolio, which arises from our lack of information, uncertainty and incomplete knowledge of reality, which forbids a perfect prediction of future price changes. Despite of many advantages this tool is not known and is not widely used among investors on Warsaw Stock Exchange. They treat it as a strictly academic tool. The main reason for abandoning this method is a high level of complexity and immense calculations, which one has to impose in order to use the methods of portfolio analysis.

The aim of this paper is to introduce an automatic decision - making system, which allows a single investor to use such complex methods of Modern Portfolio Theory (MPT) as Markowitz's algorithm or Capital Assets Pricing Model (CAPM). The key tool in MPT is an analysis of an empirical covariance matrix. This matrix, obtained from historical data is biased by such a high amount of statistical uncertainty, that it can be seen as random. By bringing into practice the ideas of Random Matrix Theory (RMT), the noise is removed. This concepts are applied to the Warsaw Stock Exchange Simulator <http://gra.onet.pl>. The result of the simulation is 18% level of gains in comparison for respective 10% loss of the Warsaw Stock Exchange main index WIG.

18:45

Oral

### **Non-causal FIR filters for the maximum return from capital markets**

Andrzej Dyka

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The low-pass FIR filtering commonly used in the analysis of market data is the cause of inevitable changes in the original data. The desirable change, which is a rationale of such filtering, consists in smoothing the data. It is believed that this positive change enables a better estimation of market movements. On the other hand, the undesirable change in the original data consists in delaying the filter output data to such an extent that anticipations of future market movement are hardly possible. A tradeoff between the degree of desirable smoothing and undesirable delay provides a very little room for optimizing such filters, e.g., [1]. The aim of this paper is to determine the "best" non-causal smoothing FIR filters, which provide maximum of the return from the market. The assumed non-causality is obtained by advancing the output filter signal to compensate for the delay introduced by the a priori known filter. This way the smoothed data is not delayed with respect to the original data. Upon this assumption the following investment criterion is introduced: the long position is opened ( i.e. the shares or currency is bought) when the derivative of the filter output signal upwardly crosses zero. The

position is closed ( i.e. the shares or currency is sold) when the derivative of the filter output signal downwardly crosses zero. The "best" filters are those which yield maximum return, irrespective of the length of filter impulse response. For the computation the data of one-minute quotations for the futures contracts on WIG 20, covering period of time from October 30,2001 thru June 16, 2003 were used. For this period of time the average transaction fee offered by brokers was between 10 -14 PLN. The computation were performed for the idealized case without including the transaction fee, and the more realistic case including the 12 PLN transaction fee. It was found, that in the idealized case practically all filters provide some return from the market. However, when the real transaction fee is included, only some of them provide positive return, whereas other generate loss.

References:

- [1] Andrzej Dyka, Marek Kaźmierczak, Optymalna dolnopasmowa filtracja danych rynkowych z użyciem filtru o skończonej odpowiedzi impulsowej *Acta Physica Polonica B*, Vol. 36, No8, 2005, 2487-2493

## Saturday, 22 April

### **Closing Ceremony**

*WFAiS UJ, 057*

Saturday evening, 22 April, 18:30

*Chair: Janusz A. Holyst, Karol Zyczkowski, Krzysztof Kułakowski*





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# Sociophysics

## Programme

Saturday, 22 April

### Sociophysics 1

WFAiS UJ, 057

Saturday morning, 22 April, 9:00

Chair: Krzysztof Kułakowski

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9:00

Oral

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### Universalism versus particularism through ESS lenses

Maria Nawojczyk

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Since the late 1980s the "new economic sociology" (see, Swedberg 1993; Smelser and Swedberg 1994) has been a very dynamic current attempting to unify sociological and economic traditions, and has proven itself to be a fruitful approach to research. In 1985 Mark Granovetter proposed the analysis of the embeddedness of economic processes in social structure, and his article became very influential, serving perhaps as a "program manifesto" for this current of thought. It opened the road to a number of interesting studies which brought a broader, more diverse view of the socio-economic realm.

In the light of all these analyses, there is no doubt that today the concept of capitalism is, culturally speaking, heterogeneous (Bell 1979; Sachs 1995), and that we have to do with different patterns of capitalism: Anglo-Saxon, German, Scandinavian, Mediterranean, to mention only European variations. The cultural variation of economic activity is wide and multi-dimensional. In my presentation I will refer to the analyses of the culture of capitalism provided by Alfons Trompenaars and Charles Hampden-Turner (Trompenaars and Hampden-Turner 1998; Hampden-Turner and Trompenaars 1993). According to them there are seven processes and related dilemmas which are important in analyzing the construction of a cultural system of economy. I will focus only on one of them, universalism versus particularism.

Using the database of Trompenaars and Hampden-Turner I will show how this dilemma was solved by managers from different European countries. That will be starting point for my analysis of universalism-particularism attitudes of respondents of European Social Survey. I will be particularly intere-

sted in verification of hypothesis on the place of post-communist countries on the mosaic of European cultures of capitalism.

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9:45

Oral

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### Influence of economic and social factors on disease control strategies

Bartłomiej Dybiec<sup>2</sup>, Adam Kleczkowski<sup>1</sup>, Christopher A. Gilligan<sup>1</sup>

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The past two decades have seen several large scale outbreaks of epidemics. Notable among these are avian influenza, SARS, foot-and-mouth disease, citrus canker, sudden oak death and rhizomania. The structure of social and technical interactions between individuals creates an environment which makes it possible for the disease to spread not only locally, but also globally. Prevention and control of outbreaks is therefore of utmost importance in the world where diseases can travel long distances before being detected. Large scale of these outbreaks also makes them very difficult to control, as authorities are overwhelmed with the need of taking vital decisions very quickly and implementing their strategies.

Traditionally, in controlling disease outbreaks, only expenses of the infection were considered, with the aim of reducing the number of infected individuals at any cost. Nevertheless, this kind of strategy is not realistic due to rigid constraints on available resources and economic capacities. It is also important to consider prevention costs, and this leads to a concept of an optimal strategy in which we can treat only a subset of individuals. However, it is not clear how to construct an optimal set of individuals to be treated in response to observed outbreaks. On regular networks, this set usually consists of the nearest neighbors; however, for networks with non-local links or scale-free networks, it is not clear how many non-local links need to be included. Selective preventive action can result in social responses making not all potential strategies applicable.

For real systems, connections between individuals form a complicated network of interactions that can be potentially used for transmission of biological agents. Therefore, prevention and control strategies need to incorporate dynamical structure of the topology of interactions and costs associated with contact tracing. Optimal strategy can be significantly affected by additional cost incorporated by the contact recognition.

10:10

Oral

**Methods of dynamical systems theory in modelling economic growth**

Adam Krawiec

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The methods of dynamical systems theory are used to investigate the evolution of economic systems. On the ground of endogenous economic growth theory we study the main determinants of the rate of growth of product, capital as well as consumption. We consider different types of knowledge dynamics and their effects on the long-term behaviour of economic system.

10:35

Oral

**Sociology as social physics. Myth or reality?**

Magdalena Szpunar

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In present article the author attempts to answer the question whether sociology is - according to the concept of the father of sociology, A. Comte - able to bring a solution to many practical issues and help in creating a proper social order. Is it justified to call sociology social physics, drawing on research methods taken from natural sciences and studying exclusively facts? Or rather should one accept an idea of humanistic sociology, according to which world is being constantly created in a process of interaction between subjects endowed with consciousness? Can these concepts be unified, or rather they are entirely dichotomous, mutually excluding positions? Where should sociology draw on tools and methods applied in natural sciences, and where should such borrowing not be permitted?

**Coffee Break**

*WFAiS UJ*

Saturday morning, 22 April, 11:00

**Sociophysics 2**

*WFAiS UJ, 057*

Saturday morning, 22 April, 11:30

*Chair: Maria Nawojczyk*

11:30

Oral

**Diffusion processes and Penrose's law in voting theory**

Wojciech Słomczyński<sup>1</sup>, Karol Zyczkowski<sup>2</sup>

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The power of mathematics as a language of science lies in the fact that it allows us to describe apparently different phenomena by means of a common pattern. In this lecture I explain the relationships between voting systems in the Council of Ministers of the European Union and the Brownian Motion. We show why some quantities (the voting power of a country in the 'fair' voting system, the mean distance of a diffusing particle from the origin) depend on others (population, time) as the square root.

12:15

Oral

**Gossip in random networks**

Krzysztof Malarz<sup>1</sup>, Zsuzsanna Szvetelszky<sup>2</sup>, Balazs Szekfu<sup>3</sup>, Krzysztof Kułakowski<sup>1</sup>

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We consider the average probability  $X$  of being informed on a gossip in a given social network. The network is modeled within the random graph theory of Erdős and Rényi. In this theory, a network is characterized by two parameters: the size  $N$  and the link probability  $p$ . Our experimental data suggest three levels of social inclusion of friendship. The critical value  $p_c$ , for which half of agents are informed, scales with the system size as  $N^{-\gamma}$  with  $\gamma=0.68$ . Computer simulations show that the probability  $X$  varies with  $p$  as a sigmoidal curve. Influence of correlations between neighbors is also evaluated: with increasing the clustering coefficient  $C$ ,  $X$  decreases.

[1] arXiv preprint: physics/0601158

12:40

Oral

### Efficiency of social dimerization

Mateusz Waśko, Krzysztof Kułakowski

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In a recent paper [1] a set of differential equations was proposed to describe a social process, where pairs of partners emerge in a community. The choice was performed on a basis of attractive resources and of random initial preferences. An efficiency of the process, defined as the probability of finding a partner, was found to depend on the community size. Here we demonstrate, that if the resources are not relevant, the efficiency is equal to unity; everybody finds a partner.

[1] J. Karpińska, K. Malarz and K. Kułakowski, *Int. J. Mod. Phys. C* 15 (2004) 1227.

13:05

Oral

### On Winning and Blocking Power in Voting Games

Tadeusz Sozański

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A VOTING GAME  $(N, W)$  is a set  $N$  of VOTERS with a family  $W$  of its subsets such that: (1)  $N \in W$ ; (2) If  $C \in W$  and  $C' \subseteq W$ , then  $C' \in W$ ; (3) If  $C \in W$ , then  $N - C$  is not in  $W$ . The set  $P(N)$  of all subsets of  $N$  consists of 3 sets:  $W$ ,  $L = \{C : N - C \in W\}$ , and  $B = P(N) - W - L$ , with elements termed WINNING, LOSING, and BLOCKING COALITIONS. A winning/blocking coalition  $C$  is called MINIMAL if no proper subset of  $C$  is in  $W/B$ . In practice, voters are assigned positive WEIGHTS  $p_i$  and  $W$  is defined - given a QUOTA  $q > \frac{1}{2}p(N)$  - as the set of such  $C$ s that  $p(C) \geq q$ ;  $p(C)$  stands for  $\sum_i p_i$  over all  $i$  in  $C$ .

Measuring the degree to which group decisions depend on each voter is the key topic of the THEORY OF VOTING GAMES. The theory assumes that VOTING POWER must not be confused with a voter's relative weight  $p_i/p(N)$ , but should be construed as dependent on the number of winning coalitions in which  $i$ 's presence is necessary to stay winning. Next, one proceeds to define indices of which the Banzhaf and Shapley-Shubik are favored by most ACADEMIC analysts.

Voting power became a hot issue in mathematical political science when the decision rules for the enlarged EU were set up by the Nice Treaty (2001). Since then various voting games have been proposed for the E. Council and analyzed by

many experts (see <http://www.cyf-kr.edu.pl/~ussozans/voting.htm>). In June 2004, some 50 scientists advocated (in a letter to the governments) a game with weights computed as square roots of the EU states populations. This meant to reject both the crude demographic weights, retained in the Constitution Treaty, and "political" weights reflecting a negotiated division of power. The scholars argued that the system based on Penrose's theorems more faithfully renders democratic principles and yields a flatter power distribution than the Constitution game.

The aim of this paper is not to convert politicians to scientific methods of constructing voting systems, but to propose a scientific reconstruction of their priorities and to explain such outcomes as the consent of France, UK and Italy to the game which - IF voting power is measure by means of classical indices - gives Germany a big power advantage over them. The author claims that what the negotiators wanted to maximize for their states was, in fact, blocking power described as follows: the BLOCKING POWER of an actor decreases with the number of other actors needed to form with him a minimal blocking coalition and increases with the number of voters from among whom he may choose partners for SMALL SIZE minimal blocking coalitions. The WINNING POWER has a similar meaning. The paper brings a mathematical elaboration of these two relatively independent facets of voting power and presents an analysis of the EU Constitution game in terms of certain new indices.

### Lunch

Saturday afternoon, 22 April, 13:30

### Sociophysics 3

*WFAiS UJ, 057*

Saturday afternoon, 22 April, 15:30

*Chair: Krzysztof Malarz*

15:30

Oral

### Blog as a new form of sociality

Marta Olcoń

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Blog as a new form of sociality

15:55

Oral

### Modelling Homogeneous Complex Networks

Bartłomiej Waclaw

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Theory of complex networks applies to many problems in sociology and economy. Most networks are considered to result from a growth process. However, some networks can also rearrange their structure in a sort of thermalization processes. Such processes lead to a class of networks, whose statistical properties can be quite different from those observed for growing networks. In this talk I would like to discuss a simple model of homogeneous network, where the homogeneity is forced by rewiring. Although some properties are similar to those of growing networks, some others like for instance the distance distribution are different. As I will argue, it is related to the lack of causal ordering of nodes.

16:20

Oral

### **Voter model on Sierpinski fractals**

Krzysztof Suchecki, Janusz A. Holyst

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We have investigated ordering of voter model on fractal lattices: Sierpinski Carpets and Sierpinski Gasket, with fractal dimensions between 1 and 2. A power law ordering, similar to the one-dimensional case has been observed. The dynamics responsible for the power law ordering is found to differ significantly for finite and infinite ramification order of investigated fractals.

### **Coffee Break**

*WFAiS UJ*

*Saturday afternoon, 22 April, 16:45*

### **Sociophysics 4**

*WFAiS UJ, 057*

*Saturday afternoon, 22 April, 17:15*

*Chair: Karol Zyczkowski*

17:15

Oral

### **Solidarity in the shadow of class-struggle history. Some experimental evidence on redistributive behavior.**

Szymon Czarnik

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The basis for experiment was two-person redistribution game played by subjects who had previously earned 15, 30, or 60 PLN in proportion to the job actually done. Subjects were paired to form dyad societies in which income inequality occurred.

Single stage of the game comprised two kinds of decisions.

First both members of the dyad society were to democratically establish the rate of redistributive income tax which benefited the poorer at the expense of the richer. Then (after fiscal mechanism had been executed) they could pass freely any amount of money to each other. Thus the game allowed both for involuntary transfers brought about by fiscal system, and voluntary transfers left to players' individual discretion. While voluntary transfers were costless (there's no need to employ resources to force anyone to do what one is willing to do on one's own), involuntary transfers entailed extra cost defined as a percentage of total tax revenues. Half games were played under 10% cost, and half under 30% cost - the latter one made a particularly sharp case of Okun's leaky bucket.

Due to the inefficiency of tax transfers, it was socially desirable to substitute voluntary transfers for costly involuntary ones thus reducing loss-generating tax-rate to zero. Though in each game there was a range of Pareto-optimal substitutions, individual rationality urged poor player to demand maximal tax, and rich player to refuse any free transfer. That feature of the redistribution game gives it a semblance of asymmetric prisoner's dilemma with continuous strategy sets.

Results of the experiment show that subjects' behavior largely depended on income differences within the dyad while adverse impact of fiscal cost on efficiency was hardly taken into account. Certain measure of crowding-out was present. To much surprise, in later games structural aspects of the situation were almost completely overridden by historical factors.

17:40

Oral

### **Modeling hierarchical structures - Hierarchical Linear Modeling using MPlus.**

Magdalena Jelonek

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The aim of this paper is to present the technique overcoming problems connecting to modeling social structures which are typically hierarchical.

Hierarchical Linear Models provide a conceptual and statistical mechanism for drawing conclusions regarding the influence of phenomena at different levels of analysis.

In Social Sciences it is used for analysis of a variety of problems such as educational, organizational or market dilemma.

This paper introduces to the logic of modeling hierarchical linear equations and estimation based on MPlus software.

I presents my own model which illustrates the impact of different factors on school acceptance level.

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18:05

Oral

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### **Needs and decisions in ghetto**

Krzysztof Kułakowski

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We consider ghetto as a community of people ruled against their will by an external power. Members of the community feel that their laws are broken. However, attempts to leave ghetto makes their situation worse. We discuss the relation of the ghetto inhabitants to the ruling power in context of their needs, organized according to the Maslow hierarchy. Decisions how to satisfy successive needs are undertaken in cooperation with or defection the ruling power. This issue allows to construct the tree of decisions and to adopt the pruning technique from the game theory. Dynamics of decisions can be described within the formalism of fundamental equations. The result is that the strategy of defection is stabilized by the estimated payoff.

[1] arXiv preprint: [physics/0512058](https://arxiv.org/abs/physics/0512058)



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# Econophysics

## Programme

### Saturday, 22 April

#### Econophysics 1

WFAiS UJ, 055

Saturday morning, 22 April, 9:00

Chair: Maciej A. Nowak

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9:00

Oral

#### Gain-loss asymmetry for emerging stock markets.

Magdalena A. Zaluska-Kotur<sup>2</sup>, Krzysztof Karpio<sup>1</sup>, Arkadiusz J. Orłowski<sup>1,2</sup>

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Stock indices for European emerging markets are analyzed using investment horizon approach. Gain-loss asymmetry, originally found for American DJIA index, is observed for all analyzed data. It is shown, that this asymmetry has different character for emerging and for established markets. Austrian ATX index and Dow Jones have been studied and compared with several emerging European markets. When optimal investment horizon is plotted as a function of absolute return value, for established markets gain curve lies typically above loss curve, whereas in the case of emerging markets the situation is opposite. In the latter case one has to wait longer for loss than for gain of the same return value. We propose a measure quantifying the gain-loss asymmetry that clearly exhibits a difference between emerging and established markets.

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9:45

Oral

#### The Asymptotic Dependence of Elliptic Random Variables

Krystyna Jaworska

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Let  $X$ ,  $Y$  be insurance claims due to flood disasters ( $X$ ) and wind storms ( $Y$ ). Last year events taught us that very often the extremal values of  $X$  are accompanied by extremal values of  $Y$ . In mathematical language it means, that  $X$  and  $Y$  are asymptotically dependent. Traditional models based on multi-dimensional normal probability law give rise to quite opposite

conclusion. Therefore in modelling of extremal events more and more often the researchers are using the elliptic probability law instead of the normal one. In my presentation I'm going to answer the question, for which two-dimensional elliptic random variables  $(X, Y)$  the one-dimensional random variables  $X$  and  $Y$  are asymptotically dependent.

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10:10

Oral

#### Electricity market and real options theory.

Ewa Broszkiewicz-Suwaj

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The Polish electricity market, after liberalization, should be regulated by free market mechanisms. However the electricity market is more complicated than financial market and there is a big problem connected with modeling on it. In this paper some applications of real options theory for liberalized electricity market are presented. The option pricing methodology, from theoretical and practical point of view are described. Some numerical results as parameters and plots are included. The event tree is built and the value of option is calculated.

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10:35

Oral

#### Measures of dependence for PARMA models with stable innovations

Agnieszka Wylomańska, Joanna Nowicka-Zagrajek

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PARMA (Periodic Autoregressive Moving Average) models, i.e. ARMA models with periodic coefficients, are an alternative to the conventional stationary time series as they allow for modeling many real-life phenomena in various areas (e.g. in hydrology, meteorology, economics, electrical engineering). PARMA models exhibit a periodic "rhythm" that is generally much more complicated than periodicity in the mean. In the case of PARMA models with Gaussian innovations the covariance function can be used to investigate the dependence structure of these processes - it turns out to be periodic with the same period as their mean.

The assumption of normality for the observations seems not to be reasonable in the number of applications, such as signal processing, telecommunications, finance, physics and chemistry, and heavy-tailed distributions seem to be more appropriate. An important class of distributions in this context is the class of stable distributions as it is a flexible class for data modeling and includes the normal distribution as a special case.

In this paper we consider PARMA models with symmetric  $\alpha$ -stable innovations. In this case the covariance function is not defined and therefore other measures of dependence have to be used. After obtaining the form of the bounded solution of the PARMA system, we study the codifference (CD) and the covariation (CV) - the most popular measures of dependence that extend the covariance and are defined for symmetric  $\alpha$ -stable time series. We show that, as in the case of Gaussian noise, in the case of stable innovations both CD and CV are periodic. Moreover we determine the cases when the codifference and the covariation are asymptotically proportional with the coefficient of proportionality equal to  $\alpha$ . In order to illustrate theoretical results we give some examples.

### Coffee Break

WFAiS UJ

Saturday morning, 22 April, 11:00

### Econophysics 2

WFAiS UJ, 055

Saturday morning, 22 April, 11:30

Chair: Jerzy Jurkiewicz

11:30

Oral

### PDEs in finance

Marek Capiński

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Mathematical modelling of financial market is based on construction of stochastic processes representing particular securities. The problems arising require finding prices of some contingent claims based on the securities modelled. To this end the theory of partial differential equations becomes a valuable tool. This is related to the basic fact linking stochastic analysis and PDEs, namely the Feynman-Kac formula. As a result we may solve the pricing problem by solving the corresponding PDE. This approach is particularly useful if the underlying securities are given by means of a nonlinear stochastic differential equation and when the noise includes the Poisson process resulting in diffusions with jumps. These cases are relevant when addressing the credit risk issues, like pricing defaultable bonds and credit derivative securities.

12:15

Oral

### Multifractal Model of Asset Returns versus real stock market dynamics

Paweł Oświęcimka<sup>1</sup>, Jarosław Kwapien<sup>1</sup>, Stanisław Drożdż<sup>1,2</sup>, Andrzej Z. Górski<sup>1</sup>

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More and more empirical evidence is coming that multifractality constitutes another and perhaps the most significant financial stylised fact. Our own study shows that it applies both to the price increments and to the waiting times between the consecutive transactions. A realistic model of the financial dynamics should therefore incorporate such effects. The most promising in this respect is the Multifractal Model of Asset Returns introduced by Mandelbrot and coworkers. In this model the multifractality of returns results from a deformation of time due to the fact that at the microscale the so-called business time is dictated by the density of transactions rather than by any constant time units. Of course, several variants of this model can be considered. A principal purpose of our study is to identify the optimal one by relating their performance to the real stock market dynamics. We focus mainly on the Polish Stock Market and on the issue of forecasting volatility but carry out some comparative studies for the U.S. stock market as well.

12:40

Oral

### Non-Hermitean matrices in an analysis of financial correlations

Jarosław Kwapien<sup>1</sup>, Stanisław Drożdż<sup>1,2</sup>, Andrzej Z. Górski<sup>1</sup>, Paweł Oświęcimka<sup>1</sup>

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Financial markets are highly correlated systems that reveal both the inter-market dependencies and the correlations among their different components. Standard analyzing techniques include correlation coefficients and auto- or cross-correlation functions used in a case of one, a pair or at most a few signals under study, as well as correlation matrices useful if one deals with rich multivariate data. In the latter case, if the data consists of N signals, one constructs an N×N real symmetric matrix with N real non-negative eigenvalues describing the correlation structure of the data. Properties of this



matrix can then be compared with predictions of Random Matrix Theory and the related ensemble of Wishart matrices in order to reveal any genuine nonuniversal properties of the system under study.

However, a serious limitation of this approach is that such a formalism is a good choice only in a case of signals recorded simultaneously in time or of signals without this time-synchronism but still in absence of any variable time delays. In the opposite case, if one performs a correlation-function-like analysis of multivariate data, when a stress is put on investigation of delayed dependencies among different types of signals, one has to calculate the correlation matrix in a slightly different way which results in its different properties. For example, if there are two sets, each of them comprising  $N/2$  signals, and one is to describe solely the cross-correlations between these sets without looking at the intra-set dependencies, it is recommended to calculate an  $(N/2) \times (N/2)$  matrix with elements being the  $\tau$ -delayed correlation coefficients for pairs of signals such that each signal in a pair comes from a different set. Now the matrix is no longer Hermitian and has the spectrum consisting of pairs of complex conjugate eigenvalues with some real eigenvalues also possible. From the RMT point of view this kind of matrices is closely, though not exactly, related to the so-called Ginibre Orthogonal Ensemble (GinOE) and the RMT predictions for this ensemble can be treated as a null hypothesis in this case.

In our talk we present a few examples of practical application of real non-Hermitian matrices in correlation analyses of empirical data. Treating the time lag  $\tau$  as a variable, we are able to identify temporal structure of the inter-market correlations.

13:05 Oral

**Correlation matrix decomposition of intraday WIG20 fluctuations**

Rafał Rak<sup>1</sup>, Stanisław Drożdż<sup>1,2</sup>, Jarosław Kwapien<sup>2</sup>

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Quantifying correlations among various financial assets is of great interest both for practical as well as for fundamental reasons. These relate for instance to the theory of risk management, and to the universal aspects of evolution of complex systems, respectively. The financial correlations can be classified as correlations in space (among companies comprised by a single stock market, among a group of subjects and even between different stock markets) and correlations in time, the latter directly reflecting nature of the financial dynamics. Both types of correlations can be quantified by adopting some appropriately defined correlation matrices, such that the related

procedure allows to identify the noise and collectivity components in the underlying dynamics. The random matrix theory (RMT) provides a useful null hypothesis in this respect. Noise is consistent with the RMT predictions. What however is even more interesting in this connection are deviations. These identify certain system-specific, non-random - thus perhaps deterministic - aspects of the dynamics. Due to strong nonstationarity of the parameters characterizing the financial world, the above interplay between collectivity and noise is also expected to vary in time and in space. In this contribution we concentrate on temporal aspects of the Warsaw Stock Market evolution as represented by the WIG20 index. This study is based on high frequency (1 min) WIG20 recordings over the time period between January 1999 and October 2005. One principal conclusion is that a bulk of this stock market dynamics is governed by the uncorrelated noise-like processes. The formalism of the correlation matrix allows however to filter out some small number of components of coherent short term repeatable structures in fluctuations that may generate some memory effects.

**Lunch**

Saturday afternoon, 22 April, 13:30

**Econophysics 3**

WFAiS UJ, 055

Saturday afternoon, 22 April, 15:30

Chair: Arkadiusz J. Orłowski

15:30 Oral

**Bayesian Analysis of the Conditional Correlation Between Stock Index Returns with Multivariate SV Models**

Anna Pajor

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In the paper we analysis and compare the modelling ability of discrete-time Multivariate Stochastic Volatility models to describe the conditional correlations and volatilities of stock index returns. We consider four multivariate stochastic volatility models, including the specification with zero, constant and time-varying conditional correlations. These MSV specifications are used to model volatilities and conditional correlations between stock index returns. We study trivariate volatility models for the daily log returns on the WIG, S&P 500 and FTSE 100 indices for the period 4 January 1999 to 30 December 2005.

Given a model, inference about the volatilities and conditional correlations is based on the joint posterior distribution of the latent variables and the parameters, which we simulate via

Markov chain Monte Carlo methods (the Metropolis-Hastings algorithm is used within the Gibbs sampler). Model comparison is fully Bayesian, based on Bayes factors obtained under proper prior densities for each model parameters.

The results indicate that the most adequate specifications are those that allow for time-varying conditional correlations and that have as many latent processes as there are conditional variances and covariances. The empirical results clearly show that the conditional correlations change over time and tend to be higher when markets are down trending.

15:55

Oral

### **The average behaviour of financial market by 2 scale homogenisation**

Ryszard Wojnar

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The financial market is nonpredictable, as according to the Bachelier, the mathematical expectation of the speculator is zero. Nevertheless, we observe in the price fluctuations the two distinct scales, short and long time. Behaviour of a market in long terms, such as year intervals, is different from that in short terms (months, quarters).

The short term behaviour (microscale) is subject to a normal distribution, while long term (macroscale) seems not to resemble that one. Long term behaviour of cotton market stimulated Mandelbrot (1963) to go off the Bachelier Brownian motion analogy of the market by using a fractal representation with a Pareto-Levy stable distribution.

In the present contribution we propose to use a two scale homogenisation method to describe an average behaviour of a financial market in a long time.

A diffusion equation with a time dependent diffusion coefficient that describes the fluctuations of the financial market, is subject to a two-scale homogenisation, and long term characteristics of the market such as mean behaviour of price and variance, are obtained.

16:20

Oral

### **Bayesian Comparison of GARCH Processes with Asymmetric and Heavy Tailed Conditional Distributions**

Mateusz Pipień

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The main goal of this paper is an application of Bayesian model comparison, based on the posterior probabilities and posterior odds ratios, in testing the explanatory power of the set of competing GARCH (ang. Generalised Autoregressive Conditionally Heteroscedastic) specifications, all with asymmetric and heavy tailed conditional distributions. In building competing volatility models we consider, as an initial specification, GARCH process with conditional Student-t distribution with unknown degrees of freedom parameter, proposed by Bollerslev (1987). By introducing skewness into Student-t family and incorporating the resulting class as a conditional distribution we generated various GARCH models, which compete in explaining possible asymmetry of both conditional and unconditional distribution of financial data.

In order to make Student-t family skewed we consider various alternative methods recently proposed in the literature. In particular, we apply the hidden truncation mechanism, an approach based on the inverse scale factors in the positive and the negative orthant, order statistics concept, Beta distribution transformation, Bernstein density transformation and the method recently proposed by Ferreira and Steel (2004). Additionally, we consider GARCH process with conditional  $\alpha$ -Stable distribution, see Rachev and Mittnik (2002).

Based on the daily returns of hypothetical financial time series, we discuss the results of Bayesian comparison of alternative skewing mechanisms applied in the initial Student-t GARCH framework. We also check the sensitivity of model ranking with respect to the changes in prior distribution of model specific parameters. Additionally, we present formal Bayesian inference about conditional asymmetry of the distribution of the daily returns in all competing specifications on the basis of the skewness measure defined by Arnold and Groenveld (1995).

Arnold B.C., Groenveld R.A. (1995) Measuring Skewness with Respect to the Mode, *The American Statistician* 49, 34-38.

Bollerslev T. (1987) A Conditionally Heteroscedastic Time Series Model for Speculative Prices and Rates of Return, *The Review of Economics and Statistics*

Ferreira J.T.A.S, Steel M.F.J. (2004) A Constructive Representation of Univariate Skewed Distributions, Department of Statistics University of Warwick technical report.

Rachev S., Mittnik S., (2002) *Stable Paretian Models in Finance*, J. Wiley, New York.

### **Coffee Break**

*WFAiS UJ*

Saturday afternoon, 22 April, 16:45

## Econophysics 4

WFAiS UJ, 055

Saturday afternoon, 22 April, 17:15

Chair: *Jacek Osiewalski*

17:15 Oral

### Geometrical (Brownian) Motion Driven by Color Noise

Ryszard Zygadło

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The evolution of prices on ideal market is given by geometrical Brownian motion, where Gaussian white noise is used to describe fluctuations. We study the effect of correlations introduced by color noise.

17:40 Oral

### Complexity characteristics of currency networks

Andrzej Z. Górski<sup>1</sup>, Stanisław Drożdż<sup>1,2</sup>, Jarosław Kwapieni, Paweł Oświęcimka<sup>1</sup>

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Realistic complex systems are often represented as networks of interacting nodes. To this end the graph and complex networks theory is usually applied. The basic notions for graphs and networks are recalled, in particular the scale free distribution of interconnections among nodes. The special role of these interconnections in complex physical systems is also reminded. Correlation matrices of large number of FOREX time series are constructed. The triangle effect is shown to distinguish the currency and equity markets reducing the number of independent returns (time series) by one. The basic properties of correlation matrices are also listed. The Minimum Spanning Trees for correlation coefficients are constructed using the Mantegna algorithm. The rule of the choice of the base currency is explained. Finally we show the scale free (power like) behavior of the degree distribution of the Mantegna graphs for various base currencies.

18:05 Oral

### Empirical Covariance Matrix with Heavy Tails in Quantitative Finance

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Random Matrix Theory may be applied to clean the covariance matrix from the statistical noise. This is especially important for short time series and has practical relevance to risk management in portfolio optimisation. In this talk, the relation between spectral densities of empirical covariance matrix and exact correlation matrix will be discussed. The presented method is able to capture heavy tails in the probability density functions of individual stocks returns. Furthermore it enables dealing with both temporal and inter-asset correlations. It makes use of a fact that spectrum of the corresponding correlated Wishart ensemble is known. The method may be applied to a broad class of distributions, and an example of multivariate Student distribution will be shown here.



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