First Polish Symposium on Econo- and Sociophysics

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Warsaw University of Technology
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November 19-20, 2004

Programme
and
Book of Abstracts

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Contents

Preface

Welcome in behalf of physicists who try to look over bridge between the methods used in physics and analysis of economical and social phenomena. This kind of physicists initiative rapidly develops in the recent decade as it is a part of the physicists great interdisciplinary interest in complex systems. The promise of the science of complexity is to provide at least common tools to tackling complex problems in natural and socio-economic scientific domains. This type of research activity is also stimulated by the *New and Emerging Science and Technology* work programme as a part of the 6th Framework Programme of the European Commission.

Our national Symposium takes place one year after the international conference *Applications of Physics in Financial Analysis 4* organized by the Faculty of Physics of Warsaw University of Technology which proved that also in Poland there is an increasing community interested in the interdisciplinary cooperation and studies. Moreover, this Symposium takes place ten days after the *Third Nikkei Workshop and Symposium: Practical Fruits of Econophysics*, where few of us presented results of our scientific studies.

The aim of our Symposium is to bring together Polish scientists, give them opportunity to discuss scientific problems and stimulate creation of the national society in this context. The more so an initial, formal step in this direction was recently done as a new section of the *Polish Physical Society* was created under the ambitious name *Physics in Economical and Social Sciences.* Moreover, we hope that our Symposium will also stimulate young researchers to their own effort.

Scientific-Organizing Committee

- Dariusz Grech (University of Wrocław, Institute of Teoretical Physics)
- Janusz Hołyst (Warsaw University of Technology, Fakulty of Physics)
- Ryszard Kutner (Warsaw University, Department of Physics)
- Danuta Makowiec (Gdańsk University, Institute of Theoretical Physics and Astrophysics)
- Olaf Morawski (Hewlett-Packard Polska)
- Wojciech Wiślicki (Warsaw University, Interdyscyplinary Centre for Matematical and Computational Modeling)

Symposium on Econo- and Sociophysics

Warszawa, 19-20 November 2004

Friday, November 19th

Personal registration and coffee, tea and cakes

11:00 - 12:15

Official Opening of the Symposium: Professor Katarzyna Chałasińska-Macukow Pro-Rector of Warsaw University and Vice-President of the Polish Physical Society

12:15 - 12:20

Introduction of President of the PTF Section: Physics in Economy and Social Sciences (FENS) - Janusz A. Holyst

12:20 - 12:35

TIME-SERIES ANALYSIS & MARKETS MODELING I - Ryszard Kutner
Warsaw University, Department of Physics, Pasteur 7 Str., Room 17 (ground-floor)

12:35 - 14:40

How much noise is at stock markets ?

12:35 - 13:00
Oral

Janusz A. Holyst[1,2], Krzysztof Urbanowicz[2]
1) Faculty of Physics and Center of Excellence for Complex Systems Research, Warsaw University of Technology, Koszykowa 75, Warszawa 00-662, Poland
2) Max-Planck Institute for Physics of Complex Systems (MPIPKS), Noethnitzer Strasse 38, Dresden D-01187, Germany

Using a recently developed method of noise level estimation [1] that makes use of properties of the coarse grained-entropy we have analyzed the noise level for the Dow Jones index and some stocks from the New York Stock Exchange as well as Warsaw Stock Exchange. We have found that the noise level ranges from 40 to 100 percent of the signal variance. The condition of the minimal noise level has been applied to construct optimal portfolios from selected shares [2]. We have observed that the level of noise is statistically correlated with the stock price changes and this fact has been used to create our investment strategy.

Using our method we have calculated 40000 recommendations for portofolio optimalization for periods 4-7 days at Warsaw Stock Exchange. The annual return received in such a way after substracting commissions was around 23%.

[1] K. Urbanowicz and J. A. Holyst, Phys. Rev. E 67, 046218 (2003).
[2] K. Urbanowicz and J.A. Holyst, Proceedings of the Conference Application of Physics in Financial Analysis 4, Physica A (2004).

13:00 - 13:25
Oral

Properties of old and new techniques of detrended analysis in time series.

Zygmunt Mazur, Dariusz Grech

Recently introduced Detrended Moving Average (DMA) method is examined to calculate Holder-Hurst exponent for artificial stochastic time series of various length. Good agreement with Detrended Fluctuation Analysis (DMA) method is confirmed for long time series (N>=3x10^4), however for shorter series disagreements are found. We show on a statistical basis of 10^3-10^5 time series, representing artificial arithmetic and geometric Brownian motion of a given length, how results of DMA and DFA methods relate to each other. Finally, the new method called Modified Detrended Moving Average Analysis (MDMA)is introduced which gives Holder-Hurst exponent results much closer to DFA method than DMA analysis does. It might be of a big importance, especially for short time series or if sufficient number of data in a time series is not avilable.

13:25 - 13:50
Oral

A comparative study of the applicability of the MF-DFA and the wavelet methods in the context of financial data

Paweł Oświęcimka[1), Jarosław Kwapień[1), Stanisław Drożdż[1,2)

1) Polish Academy of Sciences, Institute of Nuclear Physics (IFJ PAN), Radzikowskiego 152, Kraków 31-342, Poland

2) University of Rzeszow, Institute of Physics, Rejtana 16, Rzeszów 35-310, Poland

In recent years new tools have been developed in order to investigate multifractal properties of experimental and simulated data. One of them is based on the scaling behaviour of partition function calculated from the maxima of the wavelet transform coefficients. This method seems to be very useful for unfolding in the space-scale halfplane the hierarchical structure of fractal data. Another method proposed in this context is a multifractal generalization of the detrended fluctuation analysis (MF-DFA). Both methods are widely spread and commonly used for estimating the multifractal spectra of signals. We critically examine validity of each method if it is applied to high-frequency financial data and also compare the results obtained for some well-known mathematical multifractals.

13:50 - 14:15
Oral

From Riemann zeta through L-functions, random matrices, quantum chaos, brownian diffusion, critical collective phenomena ... to financial correlations

Ryszard Wojnar[1)

1) Polish Academy of Sciences, Institute of Fundamental Technological Research (IPPT PAN), *Świętokrzyska 21, Warszawa 00-049, Poland*

Computations of 10^{13} zeros of zeta function and many primes are the richest source of the best data to study important correlations.
May be the power of visual and audible perception with use of animation and sound musical sequences could help to reveal some laws common to similar correlations in random matrices and in financial fluctuations.
L-function closest to Riemann zeta may permit to analyse the simplest model of crystallization. Similarity of correlation in random matrix eigenvalues to financial correlations indicates a possible analogy between stock price fluctuations, brownian diffusion and critical collective phenomena [1].

[1] H. E. Stanley et al., Self-organized complexity in economics and finance, Proc. Natl. Acad. Sci. 99-Supp, 2561-2565 (2002).

Effective portfolios. Econometrics and statistics in search of profitable investments.

14:15 - 14:40
Oral

Urszula Skornik-Pokarowska[1)]

1) Szkoła Główna Gospodarstwa Wiejskiego (SGGW), Nowoursynowska 166, Warszawa 02-787, Poland

Various methods of constructing effective portfolios are presented. More or less standard methods based on econometrics and mathematical statistics are presented and compared with the problem of on-line management of existing portfolios. As a by-product some interesting observations regarding different classification schemes are provided.

Coffee, tea and cakes

14:40 - 15:10

TIME-SERIES ANALYSIS & MARKETS MODELING II - Dariusz Grech Warsaw University, Department of Physics, Pasteur 7 Str., Room 17 (ground-floor)

15:10 - 17:35

Analysis of fluctuations in financial time series

15:10 - 15:35
Oral

Arkadiusz J. Orłowski[1)], Magdalena A. Zaluska-Kotur[1)], Zbigniew Struzik[1)]

1) Polish Academy of Sciences, Institute of Physics (IFPAN), al. Lotnikow 32/46, Warszawa 02-668, Poland

Various methods developed in statistical physics to study fluctuations in nonlinear and non-stationary time series are reviewed. Theoretical concepts are illustrated by practical analysis of exchange rates data coming from the Polish financial market. More standard econometric approach is also presented for comparison.

15:35 - 16:00
Oral

Non-linear long-term autocorrelations present in empirical and synthetic high-frequency financial time-series. Possibility of risk classification

Ryszard Kutner[1)], Marzena Kozłowska[1)], Filip Świtała[1)]

1) Warsaw University, Faculty of Physics, Hoza 69 Str., Warszawa 00-681, Poland

We consider the basis of the non-linear, long-term (power-law) autocorrelations present in empirical and our synthetic high-frequency financial time series. The former was studied by physicists since more than one decade [1,2, and refs. therein] while the synthetic time-series was received by us from the recently developed, hierarchical, one-dimensional Continuous-Time Random Walk model [3-8, and refs. therein].

This combined model is defined by the non-separable Weierstrass walk which can be occasionally intermitted by momentary localizations (WWRIL); the localizations themselves are also described by the Weierstrass process. It should be emphasized that the steps of the walk as well as momentary localizations are uncorrelated. This approach makes it possible to study by hierarchical stochastic simulations the whole spatial-temporal region while analytically it is possible to study only the initial, pre-asymptotic and asymptotic ones but not the very important intermediate region.

The basic continuous-time series obtained from this stochastic simulation is shown as a sequence of vectors in the temporal-spatial plane. These vectors connect the turning points of a single realization random walk trajectory (given time-series) expanding in the positive temporal and spatial directions as we study only the absolute values of stock price variations. This simulation is supported by the waiting-time distribution which is the main quantity of our two-state (walking-localization) model. These states are again characterized by their own waiting-time distributions.

The synthetic, discrete time-series was obtained by discretization of the original (basic) continuous-time series at fixed time horizon. The autocorrelation function was studied versus time just for this discrete time-series. We found that the autocorrelation exhibits a persistent power-low relaxation both for the Gaussian and non-Gaussian basic processes. Our study shows that this relaxation is the result of so-called 'domino effect' occurring within the discrete time-series. We suppose that this effect is responsible for the analogous long-term autocorrelatios commonly occurring in the empirical financial high-frequency time-series.

For example, by applying the Continuous-Time Weierstrass Flights model [9] developed in the framework of the nonseparable Continuous-Time Random Walks formalism, we constructed a series of diffusion phase diagrams of increasing orders [9,6] on the plane defined by the spatial and temporal fractional dimensions of the Weierstrass flights. To define the risk of a given asset the moments of increasing orders should be calculated (by using a moving average) from the time series represented the price dynamics of this asset. Hence, we are able to locate the asset on these phase diagrams and define its global and local risk of arbitrary order as well as the level of its mobility and activity again of arbitrary order [2].

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[9] R. Kutner, Hierarchical spatio-temporal coupling in fractional wanderings. I. Continuous-time Weierstrass flights, Physica A 264 (1999) 84-106.

Statistical properties of stock market eigensignals

16:25 - 16:50
Oral

Jarosław Kwapień[1)], **Paweł Oświęcimka**[1)], **Stanisław Drożdż**[1,2)]
1) Polish Academy of Sciences, Institute of Nuclear Physics (IFJ PAN), Radzikowskiego 152, Kraków 31-342, Poland
2) University of Rzeszow, Institute of Physics, Rejtana 16, Rzeszów 35-310, Poland

One of the most characteristic properties of complex systems, including the stock market, is that their temporal evolution comprises both noisy and collective components. Despite the overwhelming noise, dominating especially on short, minutely time scales, identification of the collective components is relatively easy by using the correlation matrix analysis. In this case each correlation matrix eigenvalue can be associated with an independent component of the signal (so-called eigensignal). Those components corresponding to the collective eigenvalues can reveal different properties if compared with the random ones. In the present study we analyze statistical characteristics of the eigensignals for the correlation matrices calculated for stocks of the largest companies listed either on the German or the American stock market. In particular, we examine the differences in properties of the eigensignals corresponding to largest and smaller eigenvalues. We also analize fractal features of the eigensignals.

Statistics on emergent markets

16:50 - 17:15
Oral

Danuta Makowiec[1)]
1) Gdansk University, Institute of Theoretical Physics and Astrophysics, (IFTiA UG), Wita Stwosza 57, Gdańsk 80-952, Poland

Properties of returns r(Δt) defined as changes in a price p(t) of some financial asset over a time interval Δt, have been carefully studied by econophysicists for the last decade, see [1-3] for introduction and bibliography. The basic effort of investigations is aimed on the identification of some universal features in a time series of a financial asset hoping that these features may give us a better understanding of the underlying mechanism that drives the dynamics of the stock market. The main features that have been found are:
(i) an absence of short time correlation in a series of returns and a persistence of correlation when a series of absolute value of returns is investigated,
(ii) the wings of distributions of returns are characterized by the power law decay with the exponent value about 3. The listed properties are called stylized-facts because they are present independently of the kind of the financial asset: stock, money or derivative, and independently of the geographic location of a market: Tokyo, New York or London.

However, in the studies of Polish stock market (WSE) a local, emergent and inefficient market, we have found at least four characteristics that are different from the ones described above:
(A) The wings of distributions of returns decay faster. The exponent value of this decay is about 4, [4]
(B) The nonlinear short-time correlation in daily returns investigated by Artificial Insymmetrized Patterns (AIP in short) indicates at the Gaussian origin of the noise while the series from the mature markets exhibit self-similarity to the Levy noise [5]. Moreover, we show that the present state of this market in the AIP presentation is completely different from famous markets.
(C) The Polish market crash in April 2000 can be named the anti-bubble crash. Before that crash the Polish stock market had been a growing market since the Russian crash which happened in August of 1998. However, in contrast to the before-crash ordinary log-periodic price

development, see [6], the price of Polish stocks developed in the log-periodic style as the market would suffer from the Russian crash. That is, the log-periodic oscillations were initiated by the Russian crash. This price dependence ended with the New Technology crash in April 2000. Such the after-crash behavior observed before the crash is called the anti-bubble crash, [7].
(D) The deficit in small returns is noticable. It appears that the zero-return peaks are accompanied with valleys on the left always and sometimes on the right side. This feature is observed not only in stocks of companies with low capital and low liquidity or on the verge of bankruptcy; the returns of liquid stocks from the top of the volume also exhibit the described property, [8].

On poorly developed markets, such as emergent and local markets, the investors deal with assets of little liquidity. For example, on Polish stock market the majority of stocks (about 2/3 out of 235) are with less than 20 transactions per session (data from 2002 [9]). In addition, the investors meet in their activity a strong political interference.

As the result, the investors could decide to:
- follow the leader: identify a "well-informed" agent: the leader, and form a team with the leader. If it is impossible then observe the leader deccisions to copy them as fast as it is possible, [10].
- follow the trend: the present decission of an investor is strongly conditioned by the last time step price change,[11]

In both models the synchronized decisions of many investors effect in a noticeable deficit in small returns. To our study purpose we choose the model of Cont and Bouchaud [12] modified to a lattice version by Stauffer et al. [13]. The intentional imitation mechanism can be easily applied to other market models as, for example, Lux-Marchesi [14] or Levy-Levy-Solomon [15]

Acknowledgement:
This work is supported by Gdansk University Project: BW/5400-5-0256-4

Optimum Finite Impulse Response (FIR) low pass-filtering of market quotations

17:15 - 17:40
Oral

Andrzej Dyka[1)], **Marek Kaźmierczak**[1)]
1) Gdansk University of Technology (PG), Narutowicza 11/12, Gdańsk 80-952, Poland

One of the most common operations performed on market data is a smoothing, low-pass FIR (Finite Impulse Response) filtering, which enables us to obtain less noisy data. Such a filtering, however, results in delaying and distorting output data. Both, high noise-content in original input data, and delay and distortion in output data have a negative impact on attempts of predicting further market movements or attaining positive returns from investments. Therefore, it is important to choose the appropriate filter impulse response to obtain a reasonable tradeoff between the delay and distortion on one hand, and the smoothness of output data on the other hand. The goal of this contribution is to compare commonly used FIR filters impulse response, by using approximation theory based norms for the following output parameters: delay, correlation between input and output signal, and smoothness of the output signal. The comparison is made for two classes of the impulse response shape, i.e., symmetric (even function), and asymmetric one. In the first case the focus is on the minimum of distortion i.e., maximum correlation between input and output signal vs. smoothness of the output signal. In the asymmetric case the main goal is to attain a minimum delay between filter output and input signal. Nine cases of impulse response are considered, namely rectangular, triangular, Hanning, Hamming, Blackman, and four Chebyshev windows. One-minute quotations for the futures contracts on WIG 20, Warsaw Stock Exchange index, covering period of time from October 30,2001 thru June 16, 2003, (ca. 145000 samples), has been used for the computations. The results indicate that the most commonly used filter of rectangular impulse response shape is not necessarily the best choice, and that depending upon assumed performance criteria other filters would perform better.

Dinner

17:40 - 18:20

NETWORKS, GRAPHS, EXTREMES & MARKET DYNAMICS - Danuta Makowiec
Warsaw University, Department of Physics, Pasteur 7 Str., Room 17 (ground-floor)

18:20 - 20:25

An outline of equilibrium thermodynamics for network games

18:20 - 18:45
Oral

Wojciech Wislicki[1]

1) Warsaw University, Interdyscyplinary Centre for Matematical and Computational Modeling (ICM UW), Pawinskiego 5,building D,floor 5, Warszawa 02-106, Poland

A number of agents asking for resources distributed over networks can be modelled as a n-party game. A resource broker defines the game payoff matrix. Linearly transformed agents' payoffs define their utilities. Taking statistical ensemble of such systems, with agents playing the role of subsystems, one can treat it in the framework of statistical thermodynamics, where an overall system's utility is an analog of the energy function. However, for games with no predefined agent resources, the systems are correlated, the probability measure is not Boltzmann-like, and the generalized, nonextensive thermodynamics has to be incorporated. Among many fields of application of this scheme, job scheduling on a computing Grid with distributed resources is found particularly interesting.

Statistical thermodynamics for choice models on graphs

18:45 - 19:10
Oral

Arkadiusz Majka[1], Wojciech Wislicki

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The presented research is related to choice models which are of the great importance for many branches of economy, behavioral sciences, politology and social sciences. In discrete choice models, one assumes that there exists the choice set consisting of a countable and finite set of comparable alternatives. These are related to preferences of each decision maker, what mathematically is described by so called utility function. It is itself a random variable for which probability density function has been found. I will show the analogy between properties of the utility and the total energy functions of finite physical systems thus enabling applications of equilibrium thermodynamic formalism to economic system analysis. The model will be built in the framework of graphs. Some analytical results and numerical simulations for some network topologies with different degrees of symmetry will be presented.

Truncated Levy flights on Warsaw Stock Exchange

19:10 - 19:35
Oral

Andrzej Palczewski[1], Emilia Rudzka[1]

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It is well known that Gaussian distributions can be a reasonable zero order approximation in modelling financial data. It has been observed that a much better approximation can be achieved by Levy distributions. The superiority of Levy distributions over Gaussian can be twofold. First, Levy distributions allowed for big jumps which are frequently observed on real markets. Second, they have fat tails which again agrees with observations. Levy distribution has however one unpleasant property: infinite moments.

To remove the bad property while retaining other good ones, Mantegna and Stanley (1994) introduced truncated Levy distributions. Then Koponen (1995) defined a different truncation which is better suited for analytical treatment. Financial data analyzed in recent years show however quite complicated behaviour. The empirical distributions of returns on real markets are symmetric near the origin but with much fatter left tail than the right one (cf. Cont at al (1997), Matacz (2000)). This behaviour cannot be obtained by Koponen's family. A satisfactory solution of this difficulty has been proposed by Boyarchenko and Levendrovskii (2000,2002).

Since the distribution function of the Levy process cannot be represented analytically the discussion is restricted to the characteristic function of the process. The starting point is the Levy-Khintchine formula, which for a purely non-Gaussian driftless process X_t has the form

$\phi_t(k)=E[\exp(izk)-1-z/(1+z^2)]$, (1)

where expectation is taken with respect to the Levy measure $\Pi(dz)$ corresponding to the underlying Levy process X_t.

The idea of Koponen was to take a Levy measure for which the defined process has bounded variation. The measure with such a property can be defined by the following density function

$f(z)=c_{+/-}\ \exp(-\lambda|z|)\ |z|^{-1-\alpha}$, (2)

where c_+ and c_- correspond to positive and negative values of z, respectively. These constants are responsible for the asymmetry of the Levy process and λ is the cut-off parameter, which gives finite variance. In particular letting λ to zero we obtain a standard Levy process.

Formula (2) gives a truncated Levy process which only partially suits the analysis of financial data. To obtain a symmetry near the origin we have to assume $c_+=c_-$. But then also tails became symmetric. To get nonsymmetric tails we should assume different cut-off parameters for positive and negative values of z. This was already suggested by Matacz, who however was unable to figure out how to insert these two parameters to the Koponen formula. The same idea was risen also by Boyarchenko and Levendrovskii, who introduced abstract nonsymmetric Levy measures.

We have applied that approach to the density function of Koponen proposing its nonsymmetric version

$f(z)=c_{+/-}\ \exp(-\lambda_{+/-}|z|)\ |z|^{-1-\alpha}$. (3)

The obvious advantage of this formula is its simplicity, which allows for analytical calculation of the integral in formula (1). Long calculations lead to the following simple expression

$\phi_t(k)=t\Gamma(-\alpha)(c_-(\lambda_-+ik)^\alpha-c_-\lambda_-{}^\alpha+c_+(\lambda_+-ik)^\alpha-c_+\lambda_+{}^\alpha)$ (4)

Taking in this expression $c_+=c_-$ but different values of λ_+ and λ_- we can obtain a truncated Levy process which is symmetric near the origin but possesses nonsymmetric tails.

The obtained formula has been calibrated to the index data on Warsaw Stock Exchange (strictly speaking to WIG20 data). We have found quite satisfactory agreement and good fit of truncated Levy distribution to empirical data.

Essentially there is no obstacle in using that calibration to option pricing. It is however not a very reasonable project for near future as options traded on WSE are not liquid enough to reflect noarbitrage prices.

References

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On tail expansions of copulas and modeling multivariate extremes.

19:35 - 20:00
Oral

Piotr Jaworski[1)]

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The theory of copulas provides a useful tool for modeling dependence in risk management. In insurance and finance, as well as in other applications, especially important is the dependence of extreme events, hence there is a need for the detailed study of the tail behaviour of the multivariate copulas.

In my presentation I am going to investigate the class of copulas having regular tails which allow the uniform expansion i.e. such that near the origin they can be approximated by a homogeneous function L(u) of degree 1. Having introduced the notion of the uniform tail expansion for the multivariate copulas I will describe its main properties and determine the set of all possible leading parts L(u). Between others I will show that L is concave. Next I will deal with the measure induced by L. I will show that it is a product of the Lebesque measure on the real half line and a measure on the unit simplex.

At the end I will present the example of an application of the uniform tail expansion to the problem of estimation of the extreme risk of the portfolio consisting of long positions in risky assets. The special attention will be given to the Value at Risk (VaR).

Key words: copulas, fat tails, tail expansions, dependence of extreme events, risk management, portfolio theory.

MSC2000: 62H05 91B28 91B30 62E20 62H20

Measuring subtle effects of persistence in the stock market dynamics

20:00 - 20:25
Oral

Rafał Rak[1)], **Stanisław Drożdż**[1,2)], **Jarosław Kwapień**[2)]

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2) Polish Academy of Sciences, Institute of Nuclear Physics (IFJ PAN), Radzikowskiego 152, Kraków 31-342, Poland

The conventional formal tool to detect effects of the financial persistence is in terms of the Hurst exponent. A typical corresponding result is that its value comes out close to 0.5, as characteristic for geometric Brownian motion, with at most small departures from this value in either direction depending on the market and on the time scales involved. We study the high frequency price changes on the American and on the German stock markets. For both corresponding indices, the Dow Jones and the DAX respectively, the Hurst exponent analysis results in values close to 0.5. However, by decomposing the market dynamics into pairs of steps such that an elementary move up (down) is followed by another move up (down) and explicitely counting the resulting conditional probabilities we find values typically close to 60%. This effect of persistence is particularly visible on the short time scales ranging from 1 up to 2 minutes, decreasing gradually to 50% and even significantly below this value on the larger time scales. This indicates a subtle nature of the financial persistence whose characteristics escape detection within the conventional Hurst exponent formalism.

Saturday, November 20th

08:30 - 08:50

Coffee, tea and cakes

08:55 - 11:00

GAMES & NETWORKS - Wojciech Wislicki
Warsaw University of Technology, main building, pl.Politechniki 1, room 208 (2nd floor)

08:55 - 09:20
Oral

Active agents modelling of investors behaviour

Janusz A. Holyst[1], Arkadiusz Potrzebowski[1]

1) Faculty of Physics and Center of Excellence for Complex Systems Research, Warsaw University of Technology, Koszykowa 75, Warszawa 00-662, Poland

We have developed the model of a stock market where heterogeneous agents buy or sell shares depending on information they get from neighbours and the relation of a temporary price to a fundamental price. Depending on the magnitude of the noise present in the system (magnitude of market temperature) prices oscillate between the bull and the bear phases or around a mean fundamental value. The oscillation period in the first case can be calculated from the mean field theory. In the presence of a market leader the market oscillations are shifted towards lower or towards higher price values depending on a characteristic value of a fundamental price assumed by the market leader.

09:20 - 09:45
Oral

Playing with Minority Games

Magdalena A. Zaluska-Kotur[1]

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The Minority Game was proposed as market model in 1997. The model turned out to be so interesting, that still is a subject of intensive investigations. Some of its properties can be analyzed within the framework of statistical mechanics of a disordered system. Dynamical steady states are mapped onto the ground state properties of a spin glass model. An application of the replica method allows finding critical values for control parameters of the Minority Game. On using simple computer simulations, it is easy to show that the critical parameters agree with the calculated ones. We analyze how the observed critical behavior of the system changes when model is modified. We discuss the variation of the model in the context of the exchange rates dynamics on Polish financial markets.

09:45 - 10:10
Oral

Information theory point of view on stochastic networks

Grzegorz Wilk[1], Zbigniew Wlodarczyk[2]

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It has been widely recognized since some time already that Nature is full of all kinds of random networks of complex topology, which describe such apparently disparate systems as biological, economical, sociological or informatical ones. Their most characteristic feature is the apparent scale-free character of interconnections between the nodes. We shall look at then from the information theory point of view and show that in this way we can easily describe a wide spectrum of possible types of distributions including, in the case of nonextensive version of information theory, the power-like scale-free distributions characterist of complex systems.

Matrix representation of evolving networks

10:10 - 10:35
Oral

Krzysztof Malarz[1)], **Krzysztof Kułakowski**[1)]

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In recent ten years, much attention has been paid to the problem of evolving networks - a new area with many interdisciplinary applications in social- and econo- science among others. Rapid progress in computer abilities allows today to simulate networks of actors and agents with their complex behaviour.

In the paper we present the connectivity and distance matrix evolution for different types of networks: exponential, scale-free and random ones. Statistical and spectral properties of these matrices are included as well as topological features of the networks.

Correlations between the most developed economies - network analysis

10:35 - 11:00
Oral

Janusz Miśkiewicz[1,2)], **Marcel Ausloos**[3)]

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3) University of Liege, Institute of Physics, SUPRATECS (ULg), B5, Liege B4000, Poland

The analysis of statistical correlation between the most developed countries based on chosen macroeconomy parameters is performed. The main aim of this analysis is to investigate similarities in the development pattern. The following set of countries is considered: Austria (AUT), Belgium (BEL), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany/footnote{Germany is considered as a one country. To have a record before consolidation the data are constructed as a sum of GDP of both German countries.} (DEU), Greece (GRC), Ireland (IRL), Italy (ITA), Japan (JPN), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), United Kingdom (GBR) and USA. The countries are described by theirs Gross Domestic Product (GDP), since in most countries GDP is considered as an official parameter of the economic situation. GDP is usually defined as a sum of all final goods and services produced in the country equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports [1]. Additionally in order to define a reference country an artificial "All" country is constructed. GDP of "All" country is defined as a sum of GDP of all 19 countries. So the GDP increment of "All" can be considered as a reference level of development.

The GDP values for each of these countries are first normalised to their 1990 value given in US dollars as published by the Groningen Growth and Development Center on their web page [2]. The data cover the period between 1950 and 2003, i.e. 54 points for each country.

The GDP yearly increment given by Eq.(1) is considered and its statistical properties are presented

Δ GDP(t) = [GDP(t) - GDP(t-1)]/[GDP(t-1)]. (1)

A distance matrix is calculated, where the distance is defined as

$d(i,j)_{(t,T)} = \{[1- corr_{(t,T)} (c_i,c_j)]/2\}^{1/2}$. (2)

The correlation function $corr_{(t,T)}$ is

$corr_{(t,T)} (c_i,c_j) = (<c_i c_j>_{(t,T)} - <c_i>_{(t,T)}<c_j>_{(t,T)})/[(<c_i^2>_{(t,T)} - <c_i>^2_{(t,T)})(<c_j^2>_{(t,T)} - <c_j>^2_{(t,T)})]^{1/2}$,

where c_i denotes the time series of increments of GDP for the i^{th} country, and $<c_i>_{(t,T)}$ is the average of yearly GDP increments in the time window (t,t+T) of size T. This definition gives the distance, which is decreasing while correlations are increasing, so the shortest distance is between the countries with the highest correlation GDP increments. Eq.(2) maps the linear space of the series L_n of the length n onto the interval [0,1]:

d: L_n x L_n ->[0,1],

where the distance d takes the value 0 for correlated time series and 1 for anticorrelated series.

The distances between country are illustrated for a few (5y, 15y, 25y, 35y, 45y) time windows, where y denotes years. It means that correlations between such countries are measured within very short, short, medium, long and very long time windows.

In order to obtain some quantitative information on the country correlations, we have looked for clusters or structures formation. Classical way to search for cluster is find subgraphs with high clustering coefficient [3]. The alternative way is to build a well defined structure e.g. Minimal Spanning Tree (MST) and look for a structures repeating in consecutive time windows or to find a set of nodes connected by short links. For the sake of simplicity minimal length path algorithm (MLP), which is a 1-D modification of the MST algorithm is used. This algorithm emphasizes the strongest correlation between entities with the constraint that the item is attached only once to the network. This results in a lack of loops in the "tree". The construction of more elaborate networks is left for further studies. Two different graphs: the unidirectional (with a given initial point) and bidirectional minimal length paths (UMLP and BMLP respectively) are constructed, as a function of time and for moving time windows of various sizes. The size of time window is constant during the displacement.

The UMLP and BMLP algorithms are defined as follows:
[UMLP]: The algorithm begins with choosing an initial point of the chain. Here the initial point is the "All" country. Next the shortest connection (in terms of the distance definition - Eq.(2) is looked for between the initial point and the other possible neighbours. The closest possible one is selected and attached to the initial point. One searches next for the entity closest to the previously attached one, and repeat the process.

[BMLP]: The algorithm begins with searching for the pair of countries which has the shortest distance between them. Then these countries become the root of a chain. In the next step the closet country for both ends of the chain is searched. Being selected it is attached to the appropriate end. Next a search is made for the closest neighbour of the new ends of the chain. Being selected, the entity is attached, a.s.o.

Considering different time windows a sort of critical correlation time has been found. It is pointed out that the size of the time window for which the correlations are well seen should not be shorter then 15y, but the most appropriate is 25y time window. This means that on the level of global economy correlations are well seen in the medium length time window and co-operations between countries form a stable relationship. In the case of medium and long time window formation of clusters, understood as a set of countries with highly correlated GDP increment is observed.

The properties of UMLP and BMLP algorithms are compared and it is found that BMLP algorithm is more sensitive to searching for a clustering patterns among considered entities, while UMLP is suitable for ranking countries (companies) and could be useful in solving portfolio problems.

A new method for estimating a realistic minimal time window to observe correlations in macroeconomy is thus suggested. This method could be also applied to a stock market analysis. The mean distances analysis is expected to be useful in estimating the shortest time window in analyzing correlations on a stock market as well. In such a case it should be compared to moving average windows.

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Coffee, tea and cakes

11:00 - 11:30

ARBITRAGE PRICING, RISK & PROFIT - Janusz A. Holyst Warsaw University of Technology, main building, pl.Politechniki 1, room 208 (2nd floor)

11:30 - 13:10

On a new approach to the arbitrage pricing theory

11:30 - 11:55
Oral

Karol Krzyżewski[1)]

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The Arbitrage Pricing Theory (APT) concerns a central problem of modern finance theory - the trade - off between risk and expected rate of asset return. It was discovered by Ross (1976). His proof of the approximate arbitrage pricing formula was not based on a formal definition of arbitrage. The first precise proof without the estimation of pricing errors was given by Huberman (1982) and with that estimation by Chamberlein and Rothschild (1983). A necessary and sufficient condition for an analogue of approximate arbitrage pricing, called 'approximate factor pricing', is given. The proof is very simple and is based on the Riesz representation theorem of a continuous linear functional on Hilbert space. It gives the upper and lower bounds on the pricing errors. The lower bound is attained. As corollaries one obtains the Chamberlain - Rothschild theorem on approximate arbitrage pricing and the Reisman theorem on approximate factor pricing.

Insurer's surplus model with varying risk parameter and delayed reporting

11:55 - 12:20
Oral

Wojciech Otto[1)]

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The discrete-time model of the insurer's surplus process S_t typically assumes:

$S_t = S_{t-1} + W_t$, t=1,2,...,

where W_1, W_2,..., are i.i.d. random variables, representing yearly premium less yearly aggregate claims, and the initial surplus S_0 is fixed. The model is intended to produce answers concerning the event of ruin (probability of ruin, time of ruin, deficit when ruin occurs etc.). Typically it is assumed that the premium component of W_t is constant, and the distribution of W_t is known.

In real life however, premium is written in advance to cover claims over the coming exposure period that are often reported and paid a number of periods later. The inadequacy is even more obvious in the case of the continuous-time model, where the time elapsed between receiving premium and paying (eventually) compensations is totally neglected. In order to

restore correspondence of the model to real life processes, we could change the interpretation of variables involved. Premium inflow less claims outlays appearing in the model as W_t could be interpreted as corresponding to accounting concepts of premium earned (premium written less increment of the premium reserve) less claims occurred (claims paid plus increment of the outstanding claims reserve). This leads to interpreting the surplus as the amount of free assets, and consequently the ruin as insolvency. Under this interpretation the surplus model is meaningful for practice, as in fact it focuses on phenomena of crucial importance for all involved parties: shareholders, tax authority, policyholders, and insurance supervision. However, the problem arises when we take into account that:
I. outstanding claims amount is a random variable, and the corresponding reserve is in fact its point predictor, based on information available at the accounting date.
Additional problem that makes predictions complex is that:
II. in real life the risk parameter (characterising the claims process) is not fixed, so its predictions are needed as well for premium setting as for reserving purposes.

The paper concerns on incorporating the two above mentioned complications into the model of the insurers surplus. It is shown that (at the cost of certain simplifying assumptions) the incorporation could be presented as such reinterpretation of the surplus S_t itself and the variable W_t, that leaves classical relationships between these variables unaffected. So, in a way the paper is focused on "calibrating" of the above elements of the model to the empirical evidence.

Techniques used in the paper resembles in general those used by Scheike (1992), who introduced the notion of fair premium for the claim process with dependent increments, applying to this purpose the Doob-Meyer decomposition for sub-martingales. Assumptions have been chosen so as to enable casting the model into the state-space form, which allows for explicit expressions of premium and reserves as based on predictors of respective claim payments. Although using Kalman filtering techniques for reserving purposes is not a new idea, their application for restoring the correspondence of the simple surplus model to real life processes is, to my best knowledge, new.

Remarks on risk neutral and risk sensitive portfolio optimization

12:20 - 12:45
Oral

Łukasz Stettner[1)]

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Assume we are given market with m risky assets. Denote by $S_i(t)$ the price of i-th asset at time t. We shall assume that the prices of assets depend on k economical factors $x_i(n)$, i=1,...,k, with dynamics changes in discrete time moments denoted for simplicity by n=0,1,...., in the following way:
for t belonging to the interval [n,n+1),

$dS_i(t)/S_i(t)=a_i(x(n))dt+\Sigma_{j=1}{}^{k+m}\sigma_{ij}(x(n))dw_j(t)$, (1)

where $(w(t)=(w_1(t),w_2(t),..., w_{k+m}(t))$ is a k+m dimensional Brownian motion defined on a given probability space $(\Omega,(F_t),F)$. Economical factors $x(n)=(x_1(n),...,x_k(n))$, satisfy the equation:

$x_i(n+1)=x_i(n)+b_i(x(n))+\Sigma_{j=1}{}^{k+m}d_{ij}(x(n))(w_j(n+1)-w_j(n))=g(x(n),W(n))$, (2)

where $W(n):=(w_1(n+1)-w_1(n),...,w_{k+m}(n+1)-w_{k+m}(n))$.

We assume that 'a', 'b' are bounded continuous vector functions, and 'σ ', 'd' are bounded continuous matrix functions of suitable dimensions. Additionally we shall assume that the matrix dd^T (the superscript 'T' stands for transponse) is nondegenerate. Notice that equation (2) corresponds to discretization of a diffusion process. The set of factors may include divident yields, price - earning rations, short term interest rates, the rate of inflation see e.g. [1]. The dynamics of such factors is usually modeled using diffusion, frequently linear equations eg. in the case when we assume following [1] that 'a' is a function of spot interest rate governed by the Vasicek process. Our assumptions concerning boundedness of vector functions 'a' and 'b' may be relaxed allowing linear growth, however in such case we shall need other more complicated assumptions.

Assume that starting with an initial capital V(0) we invest in assets. Let $h_i(n)$ be the part of the wealth process located in the i-th asset at time n, which is assumed to be nonnegative. The choice of $h_i(n)$ depends on our observation of the asset prices and economical factors up to time 'n'. Denoting by V(n) the wealth process at time 'n' and by $h(n)=(h_1(n), ..., h_m(n))$ our investment strategy at time 'n', we have that h(n) belongs to $U=\{(h_1,...,h_m), h_i >=0, \Sigma_{i=1}{}^m h_i=1\}$ and

$V(n+1)/V(n) = \Sigma_{i=1}{}^m h_i(n)\xi_i(x(n),W(n))$, (3)

where

$\xi_i(x(n),W(n))=\exp\{a_i(x(n))-\sigma^2{}_{ij}(x(n))/2 + \Sigma_{j=1}{}^{k+m}\sigma_{ij}(x(n))(w_j(n+1)-w_j(n))\}$.

We are interested in the following investment problems:
maximize risk neutral cost functional

$J^0{}_x(h(n))= \lim \inf_{n->oo} \{\{E_x\{\ln V(n)\}\}/n\}$, (4)

and maximize risk sensitive cost functional

$J^0{}_x(h(n))= \{\lim \sup_{n->oo} \{\{E_x\{V(n)^\gamma\}\}/n\}\}/\gamma$, (5)

with γ <0. Using (3) we can write the cost functionals (4) and (5) in the more convenient forms. Namely,

$J^0{}_x(h(n))= \lim \inf_{n->oo} \{\{E_x\{\Sigma_{t=0}{}^{n-1} \ln (\Sigma_{i=1}{}^m h_i(t)\xi_i(x(t),h(t))\}\}/n\}$
$=\lim \inf_{n->/infty} \{\{E_x\{\Sigma_{t=0}{}^{n-1} c(x(t),h(t))\}\}/n\}$, (6),

with $c(x,h)=E\{\ln(\Sigma_{i=1}{}^m h_i\xi_i(x,W(0)))\}$. It is clear that risk neutral cost functional J^0 depends on uncontrolled Markov process (x(n)) and we practically maximize the cost function c itself. Consequently an optional control is of the form control (u'(x(n)), where $\sup_h$ c(x,h)=c(x, u'(x)) and function Borel measurable u': R^k -> U exists by continuity of c for fixed x belonging to R^k. This control does not depend on asset prices and is a time independent function of current values of the factors x only. The Bellman equation corresponding to the risk neutral control problem is of the form

$w(x) + \lambda = \sup_h (c(x,h) + Pw(x))$, (7)

where $Pf(x):= E_x\{f(x(1))\}$ for f belonging to $bB(R^k)$ - the space of bounded Borel measurable functions on R^k, is a transition operator corresponding to (x(n)). We shall show that there are solutions w and λ to the equation (7) and λ is an optimal value of the cost functional J^0. Letting

$\xi^{h,\gamma}{}_n(\omega):=$
$\Pi_{t=0}{}^{n-1}\exp\{\gamma \ln (\Sigma_{i=1}{}^m h_i(t)\xi_i(x(t),W(t)))\}(E\{\exp\{\gamma \ln (\Sigma_{i=1}{}^m h_i(t)\xi_i(x(t),W(t))\}|F_t\})^{-1}$

consider a probability measure $P^{h,\gamma}$ defined by its restrictions $P^{h,\gamma}$ to the first n time moments given by the formula

$P_{|n}{}^{h,\gamma}=\xi^{h,\gamma}{}_n(\omega)=P_{|n}(d\omega)$.

Then

$J_x{}^\gamma(h(n))=\{\lim \sup {}_{n->oo}\{\ln E_x\{\exp\{\gamma\ \Sigma_{t=0}{}^{n-1}\ln(\Sigma_{i=1}{}^m h_i(t)\xi_i(x(t), W(t)))\}\}/n\}\}/\gamma$
$=\{\lim \sup_{n->oo} \{\ln E^{h,\gamma}{}_x\{\exp\{\Sigma_{t=0}{}^{n-1} c_\gamma(x(t),h(t))\}\}/n\}\}/\gamma$, (8)

with

$c_\gamma(x,h):=\ln(E\{(\Sigma_{i=1}{}^m h_i\xi_i(x,W(0)))^\gamma\})$. (9)

Risk sensitive Bellman equation corresponding to the cost functional J^γ is of the form

$\exp(w_\gamma(x))=\inf_h \{\exp(c_\gamma(x,h)-\lambda_\gamma)/int_E \exp(w_\gamma(y))P^{h,\gamma}(x,dy)\}$, (10)

where for f belonging to $bB(R^k)$

$P^{h,\gamma}=E\{(\Sigma_{i=1}{}^m h_i\xi(x,W(0)))^\gamma \exp\{-c_\gamma(x,h)f(g(x,W(0)))\}$, (11)

and where λ_γ/γ corresponds to optimal value of the cost functional (8). Notice that under measure $P^{h,\gamma}$ the process (x(n)) is still Markov but with controlled transition operator $P^{h,\gamma}(x,dy)$. Following [5] we shall show that

λ_γ/γ -> 0

whenever γ ->0.

The study of risk sensitive portfolio optimization has been originated in [1] and then continued in a number of papers in particular in [12]. Risk sensitive cost functional was studied in papers [9], [5], [6], [3], [4], [8], [2], [7] and references therein. Using splitting of Markov processes arguments (see [11]) we study Poisson equation for additive cost functional the solution of which is also a solution to risk neutral Bellman equation. We consider then risk sensitive portfolio optimization with risk factor close to 0. We generalize the result of [12], where uniform ergodicity of factors was required and using [7] show the existence of Bellman equation for small risk in a more general ergodic case. The proof of that nearly optimal continuous risk neutral control function is also nearly optimal for risk sensitive cost functional with risk factor close to 0 is based on modification of the arguments of [5] using some results from the theory of large deviations.

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12:45 - 13:10
Oral

Sznajd model and its applications

Katarzyna Sznajd-Weron[1)]

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Modern societies rely heavily on group decision, but the part of what makes for healthy faith communities is a sense that all members feel heard. That is why finding consensus is very important in many branches of social life - from very personal problems (like religion, abortion, etc.) to economic problems (like marketing, investments, etc.). Recently both sociologists and physicists have tried to find out when a complete consensus from initially diverging opinion emerges. In this paper we propose a model which allows to discriminiate between two kinds of behavior, connected with areas which we call personal and economic. It seems that an attitude with regard to the personal area spreads in a different way than that with regard to the economic area. Thus, we assume that each agent tries to influence its neighbors, but in the personal area the information flows inward from the neighborhood (like in most opinion dynamic models), whereas in the economic area the information flows outward from the agent or group of agents to the neighborhood (like in the Sznajd model [1]).

In 2000 we proposed a new model [1] of opinion formation named by Stauffer the Sznajd model (SM). The model has found many applications - from politics to finance and marketing. For the review of the model and its applications see [2-7] and refs. therein. We assumed that individual opinion is represented by an Ising spin (yes or no), like in many opinion dynamics models. The really new thing that we introduced was the dynamics of spins. The motivation to propose this new dynamics was a phenomenon called by social psychologists the Social Validation - one fundamental way that we decide what to do in a situation is to look to what others are doing. A group of people sharing the same opinion influences the neighborhood much easier than isolated individuals. On the other hand, it seems that social validation phenomena works much weaker in private aspects of life, such as religion. These attitudes are mostly influenced by the family or friends. For this reason we believe that to model the evolution of attitude to personal freedom one should use Glauber dynamics.

In this paper we will show that building consensus in personal life is much more difficult that in economics. On the other hand, the dynamics connected with economic freedom is much more complicated than the one connected with personal freedom. The model can be used to describe the formation of social attitude regarding economic freedom, i.e., whether the society prefers an open market or a state controlled market. We will also show how the personal attitudes and tolerance influence this formation process, a problem that is discussed in the behavioral finance literature [8].

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Lunch

13:10 - 14:15

SOCIAL DISTANCE, WEALTH CONDENSATION & BUSINESS - Olaf W. Morawski
Warsaw University of Technology, main building, pl.Politechniki 1, room 208 (2nd floor)

14:15 - 16:45

14:15 - 14:40
Oral

The Heider balance and social distance

Krzysztof Kułakowski[1)], **Przemysław Gawroński**[1)], **Piotr Gronek**[1)]

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The Heider balance is usually discussed in terms of cognitive dissonance. Here we stress its role for theory of conflicts. The model system is a group of N persons, represented by nodes of a fully connected graph. A set of differential equations is proposed for the time evolution of the social distance between the group members. This distance can be measured in the Bogardus scale. In the Heider approach, the distance r(i,j) is positive if i and j accept each other, and negative in the opposite. After some time T(N), the system reaches the Heider balance, i.e. two subgraphs appear. Within both subgraphs, all distances are positive; others are negative. We discuss an influence of limitations of the allowed range of the social distance on the system dynamics.

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14:40 - 15:05
Oral

Measuring of social relations: the social distance in social structure and communication - a study of prison community

Barbara Pabjan[1)]

1) Institute of Sociology, Wroclaw University (UWr), Koszarowa 3b, Wrocław 51-149, Poland

Social relations and their influence on various phenomena are one of the key issue not only in sociology. The crucial problem, however, is how to measure the social relations and their implication in society.
I try to adopt a physical perspective to the typical sociological analysis and to measure the qualitative nature of human community adopting the category of social distance. This category is used to explore the properties of social relations in the structure and the communication system of prison community. The issues that will be discussed:
-The specific properties of social relations as the constitutive factors for different type of group structure and type of communication.
-How the elementary social networks [short-range group structures] form the dynamics of prison community?
-What is the role of the numerical force of the group for prison community?
- The interplay between the microstructures and macrostructures?
The communication structure: how the social forces shape the communication.

15:05 - 15:30
Oral

Wealth condensation in Pareto macro-economy

Zdzislaw Burda[1)]

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We discuss macro-economy of Pareto type in a closed system with fixed total wealth. We show that the system has an instability which may lead to a wealth condensation if the economy is too restrictive (too social). This can be interpreted as a corruption phenomenon in which a sizeable fraction of the total wealth is amassed by a single individual.

Problems of the electric power market

15:30 - 15:55
Oral

Barbara Kołodziejczyk[1)]
1) Prywany, Piotrkowska, Łódź 00-000, Poland

Power market is an online market, which operates according to the specific rules. Power must be supplied at the same moment, as it is demanded and there are insignificant storage possibilities. Therefore the characteristic element of the power market is the balancing market where the system operator provides balancing services and organizes financial settlements for markets participants.
The main problems related to the power market are the following:
(i) Predicting power demand in different time interval (hour, day, month, year) particularly in order to determine contract position.
(ii) Predicting power exchange and balancing market temporary prices.
(iii) Determining risk while signing short-term bilateral contracts in function of power demand and temporary prices.
(iv) Transferring variable power prices from the wholesale market to the retail market particularly in order to:
(a) calculate tariffs in a proper way,
(b)facilitate implementation of the TPA principle.

Beyond Business Intelligence. Integration of business knowledge and technology in xIS Solutions

15:55 - 16:20
Oral

Łukasz Kociuba[1)]
1) SAS Institute Sp. z o.o., Gdańska27/31, Warszawa 01-633, Poland

Organizations spend tremendous amounts of time, effort, and money building operational environments. Despite this, they don't have the information they need readily at hand to make business decisions. Even when they start development projects, they don't get the information fast or accurate enough to make an impact on the business decisions they need to make today.

SAS provides a layer of unique business intelligence which includes the SAS® Industry Intelligence Solutions (xIS). xIS build on the customer's operational environments and help transform organizations into Intelligent Enterprises by surfacing know-how based on their own real-world data.

xIS bring together what has been learnt from many projects that SAS has been involved in worldwide to address industry's hottest business topics. They represent a quality, validated intelligence solution with a standard architecture that is so flexible that it can be applied to most organizations.

From physics to business

16:20 - 16:45
Oral

Roman Szwed[1)]
1) ATM S.A., Grochowska 21a, Warszawa 04-186, Poland

A story will be told on "how understanding of the physical phenomena and proper education help in business"

Coffee, tea and cakes

16:45 - 17:15

17:15 - 18:00

ROUND-TABLE DISCUSSION & SUMMARY - Ryszard Kutner, Janusz A. Holyst

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18:00 - 19:00

SKŁADANIE DEKLARACJI O CZŁONKOSTWO W FENS - Janusz A. Holyst

19:00 - 20:00

ZEBRANIE ZARZĄDU FENS - Janusz A. Holyst

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Index