# APFA5

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Torino, Italy

# Applications of Physics in Financial Analysis

**Abstracts**
**and**
**Author Index**

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## Preface

This volume contains the abstracts of all the contributions presented at the $5^{th}$ International Conference on Applications of Physics in Financial Analysis Torino, June 29 to July 1, 2006.
The presentations are about 130. The Conference is organized in plenary sessions, parallel symposia and poster sessions. It provides a forum for updating and reviewing a wide range of subjects in the field of Statistical Physics with specific applications in Economics and Finance. The aim of the conference is to bring together scientists, both economists and physicists, interested in problems in economics and finance. Previous meetings (Dublin 1999, Liege 2000, London 2001 and Warsaw 2003) have served to build the community and foster links with disciplines such as econometrics and statistics. A wide range of topics has been covered including, for example, analysis of time series, option pricing, agent models and game theory. It is now increasingly recognized by both the physics and economic communities that a number of conceptual and methodological approaches based on tools of statistical mechanics may be employed to understand particular economic phenomena in terms of the underlying direct interaction of agents and to model the dynamics of heterogeneous populations of economic agents. In addition to traditional economic notions of coordination via the price system and strategic interaction, models of collective phenomena are now making their appearance in many branches of microeconomics to describe, for example, herding behavior in financial markets. Other instances of the complexity approaches, familiar to physicists, appear in evolutionary game theory, demand theory, behavioral economics and social economics. In macroeconomics and econometrics, there is a new appreciation of the role of individual heterogeneity which has provided new insights into economic aggregation. New models of the theory of growth, based on non-linear and stochastic processes have emerged and are being tested against real data. In finance, the analysis of time series, distributions of asset prices and price returns with attendant phenomena, such as scaling and universality, is leading to radically new insights and new questions, both theoretical and empirical, about the functioning of financial markets. All these approaches employ analytical and numerical tools from what has become known as the science of complexity, a new interdisciplinary approach, initially used for the analysis of systems with strongly interacting subunits in physics, biology, engineering.

## Hidden forces and fluctuations from moving averages.

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The possibility that price dynamics is affected by its distance from a moving average has been recently introduced as new statistical tool [1]. The purpose is to identify the tendency of the price dynamics to be attractive or repulsive with respect to its own moving average. We consider a number of tests for various models which clarify the advantages and limitations of this new approach. The analysis leads to the identification of an effective potential with respect to the moving average. Its specific implementation requires a detailed consideration of various effects which can alter the statistical methods used. However, the study of various model systems shows that this approach is indeed suitable to detect hidden forces in the market which go beyond usual correlations and volatility clustering [2]. This model has also been applied to real data from NYSE and results show an asymmetrical shape of the potential.

[1] M. Takayasu, T. Mizuno, and H. Takayasu, preprint physics/0509020.
[2] V. Alfi, F. Coccetti, M. Marotta, L.Pietronero, and M. Takayasu, preprint physics/0601089.

## Scaling properties of the DMA algorithm.

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The function:

$$\sigma^2_{DMA} = \frac{1}{N_{max} - n} \sum_{i=n}^{N_{max}} [y(i) - \widetilde{y}_n(i)]^2,$$

where $\widetilde{y}_n(i)$ is defined as $1/n \sum_{k=0}^{n-1} y(i-k)$, $n$ is a moving window and $N_{max}$ is the dimension of the stochastic series has been proposed to investigate the long-range correlation properties of stochastic time series $y(i)$ [1].
It has been shown that the function $\sigma^2_{DMA}$ exhibits interesting statistical properties related to very general aspects of nonlinear stochastic systems. In particular, the relation with the self-organized criticality and the information content of the stochastic process, underlying the time series, have been established [2-4].
Here, we propose an extension of the algorithm with $\widetilde{y}_n(i)$ replaced by a higher-order approximation of the time series $y(i)$. Finally, we provide the analytical proof that the $\sigma^2_{DMA}$ variance scales as $n^{2H}$.

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## Dynamical networks from correlations.

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The extraction of relevant and meaningful information from large streams of data has become one of the major challenges for scientists working in the field of complex systems. In particular, one of the main goals is to get information about the underlying system of interactions that leads to complex collective dynamics. In this talk we discuss how a set of relevant interactions can be extracted from the analysis of the cross-correlation matrix. We show that an active and adaptive correlation filtering procedure can be associated to the dynamics of a network which is a sort of 'hyper-molecule' warped on a D-dimensional unitary sphere.

## Clusters or networks of economies? A macroeconomy study through GDP correlations.

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We follow up on the study of correlations between GDPs of rich countries, as in refs. [1-2]. We analyze web-downloaded data on GDP that we use as individual wealth signatures of the country economical state. We calculate the yearly fluctuations of the GDP. We look for forward and backward correlations between such fluctuations. The system is represented by an evolving bipartite network, nodes being the GDP fluctuations (or countries) at different times.
In order to extract structures from the network, we focus on filtering the time delayed correlations by removing the least correlated links. This percolation idea-based method reveals the emergence of connections, that are visualised by a branching representation. However the system is pretty unstable. Such a measure of collective habits does not fit the usual expectations defined by politicians or economists.

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## Price forecast in the competitive electricity market by support vector machine.

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Price forecast is a task challenging and very important in competitive electricity market context. Both market players and regulators concern very much about the price evolution, on one hand, the prediction of the market price is a crucial information for the production arrangement and bidding strategies. On the other hand, the regulators need to analyze the market behavior and monitor the market evolution. Price forecast tools provide them a useful tool to foresee the future market and examine the potential regulations.
The price forecast tools are categorized in two fields. One is the detailed market simulation [1]-[4], which needs lots of market information, the other price forecast technology refers to those mathematic approaches without market modeling. The most popular approach is the time series algorithm, which has been widely used in many forecast fields. Garcia introduced GARCH forecast model to capture the price volatility for next day electricity price prediction [5]. Contreras applied ARIMA models to predict the next day electricity price[6], while Conejo developed a hybrid ARIMA approach with wavelet transform for ill-behaved price series[7]. In [8] dynamic regression and transfer function models are proposed by Nogales. Artificial Intelligence (AI) that has been also widely used in load forecast is popular for price forecast. Szkuta proposed a three-layered artificial neural network (ANN) with back propagation for price prediction in [9]; support vector machine (SVM) as a new AI method has shown its excellent performance for classification, regression and pattern recognition, and has been successfully applied in load forecast [10], some preliminary attempt has been implemented in price forecast [11] as well.
Price forecast can be classified in three types according to the time frame,
- Short term price forecast;
- Medium term price forecast;
- Long run price forecast.
Apparently, the short-term price forecast is the most elusive, due to the incomplete information or uncertain strategic bidding. With the time frame enlarged, the price is more and more reasonable with reference to the corresponding context, namely it is easier to find the mapping relation between the context and the price. Hence the major difficulty for the long run price forecast is the uncertainty of the future context.
The market price will be hugely influenced by the subjective bidding strategies and the regulations, which accounts for much stronger volatility of the price. One direct method to alleviate the impacts of those subjective factors is to use the latest information; in the short period all those subjective factors that cannot be forecasted precisely can be taken as constant which also means that we can reduce the number of samples and we need to solve the problem of effective data identification.
SVM is especially suitable for solving problems of small sample size [12]. In this paper, we present a flexible $C_i$ SVR model for price forecast based on classic -intensive SVR for forecasting the next day price. According to the particularity of the price forecast task, uniform $C$ and $\epsilon$ have been replaced by different $C_i$ and $\epsilon_i$ optimally assigned to each sample considered with the help of Particle Swarm Optimization (PSO). The flexible $C_i$ SVR model has also applied to long-term price forecast with data information provided by Long Run Electricity Market Sim-

ulator (LREMS) for Italian electricity market.
SVM approach has good performance in dealing with the nonlinear price forecast problem, which cannot be well captured by the linear methods such as time series approaches. SVM is based on structural risk minimization, which is proved better than the empirical risk minimization of the ANN.
SVM is powerful for the problem characterized by small samples. Therefore it is suitable for long term price forecast, which can only has small number of history data. While due to the subjective factor of the price determination the short term price forecast can only adopt limited number of history data, hence is also suitable to be solved by the SVM approach.
Moreover, precise distinguish among the data usually can bring better results. Based on the classic Vapnik $\epsilon$-intensive SVR, the flexible $C_i$ SVR model introduces various $C_i$ $\epsilon_i$ among the training data, hence the model can capture the various validation among the data effectively. Combined to the practical empirical method of the Vapnik model, PSO approach with the particularly designed data initialization are presented to efficiently find the optimal value of those $C_i$ $\epsilon_i$. Compared to the Vapnik $\epsilon$-intensive SVR, our new model with flexible $C_i$ always presents much better results. For long-term price forecast, good mapping between the input (reserve margin, fuel price, HHI) and output (yearly average market price) shows good performance of the new model within the Italian market with the data provided by LREMS.

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## Bayesian networks for enterprise risk assessment.

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Every human activity can be more or less at risk. A risk is an event that is more uncertain than a real danger situation, therefore it is a potential damage. The risk for every single human being or organization, to according to different typologies of activity and priority can assume diverse values, meanings and it can be classified in different ways.
From an entrepreneurial point of view the risk is defined as the possibility that something happens and that it will have impact on the goals. The risk is measured in terms of combination of probability of an event (frequency) and of its consequence (impact). The combination of the frequency and the impact produces the distribution of losses. By such a distribution the maximum admissible loss is calculated. This maximum is called Value at Risk (VaR) that is the percentile at 99 percent of the loss distribution, [4,5,7,9].
To estimate the frequency and the impact are used or the historical data (quantitative data) or the expert opinions (qualitative data) collected by scorecard approach, either together, [5,7,9].
Using of qualitative data result more difficulty, because it is necessary to ponder in a proper way such information to shift from qualitative to quantitative data used in the model.
In the case of the enterprise risk assessment the considered risks are, for instance, that strategic, operational, operative, legal and of image, which many times are difficult to be quantified. So, in general, only qualitative data, gathered by scorecard, are available for the VaR calculation.
Among the techniques used to define the distribution of losses there is the Bayesian Network (Probabilistic Expert Systems). This kind of net can also be used for the monitoring, control and the evaluation of strategies of intervention but in such a case it takes the name of decisional graph, [2,3].
A Bayesian Network (BN) is a graphical probability model formed by nodes, direct arcs and without cycles. Every node represents a discreet or continuous casual

variable. The relationships among variables pointed out by oriented arcs are interpreted in terms of conditional probability according to the Bayes Theorem.
With the BN is implemented the concept of conditioned independence that allows the factorization of the joined probability through the Markov property, in a series of local terms which describe the relationships among the variable:

$$f(x_1, x_2, ..., x_n) = \prod_{i=1}^{n} f(x_i|pa(x_i))$$

Where with $pa(x_i)$ is denoted the probability of the parents of the variable of the node $X_i$, [2,3,6].
The problem of the BN is that it requires an appropriate database to extract the conditional probabilities (learning parameters problem) and the network structure (learning structure problem), [1,3].
The purpose of our job is focused on this last point, therefore to obtain a BN that link together the frequency of each single risk in terms of conditional probabilities and using only qualitative data. This means to know merely expert opinions about marginal probabilities (priors) and relations (what describe the net structure) among risks.
Our approach could represent an alternative to calculate the probability conditional tables (CPT) required to define the dependences among the risks, (so to develop a multivariate analysis), in the case of only qualitative data and with Bernoulli random variables for the risk frequency. This way can get an integrated vision of the risks.
It has been reached to calculate the conditional probabilities matrix for the case at one, two and three parents (generalized to the case with more than three parents), using only the partial correlations, the values of marginal probability of parents and children nodes and on the fact that the Markov property allows the local study of the model.
For finding such solutions the fundamental idea has been to understand how the correlations are linked with the incremental ratios or the derivatives of the child's probability in function of the father's probability. This choice is due to the fact that parent and child interact through the values of conditional probabilities and also that the derivatives are directly linked to such probabilities and therefore to the degree of interaction between the two nodes and so also with the correlation. For the case of two independent parents, i.e., the system is:

$$\begin{aligned}
f(x,z) &= (\alpha_1 - \alpha_2 - \alpha_3 + \alpha_4)xz + (\alpha_2 - \alpha_4)x \\
&\quad +(\alpha_3 - \alpha_4)z + \alpha_4 = y \\
\frac{\partial f}{\partial x} &= (\alpha_1 - \alpha_2 - \alpha_3 + \alpha_4)z + (\alpha_2 - \alpha_4) \\
&= \frac{(\rho_{AF})(M_{AF})}{x(1-x)} \\
\frac{\partial f}{\partial z} &= (\alpha_1 - \alpha_2 - \alpha_3 + \alpha_4)z + (\alpha_3 - \alpha_4) \\
&= \frac{(\rho_{BF})(M_{BF})}{z(1-z)} \\
\frac{\partial^2 f}{\partial x \partial z} &= \frac{\partial^2 f}{\partial z \partial x} = (\alpha_1 - \alpha_2 - \alpha_3 + \alpha_4) \\
&= \frac{(\rho_{ABF})(M_{ABF})}{x(1-x)z(1-z)} \\
\alpha_1 + \alpha_5 &= 1 \\
\alpha_2 + \alpha_6 &= 1 \\
\alpha_3 + \alpha_7 &= 1 \\
\alpha_4 + \alpha_8 &= 1
\end{aligned}$$

Where with $\alpha_i$ are indicated the conditioned probabilities, with x and z the marginal probabilities of the parents (A and B) and with y the child probability (F). For the correlations, instead, it has been pointed out with AF the partial correlation between parent A and child F, with BF that between parent B and child F and with ABF the global correlation.
The values for the M parameters are:

$$M_{AF} = \sqrt{x(1-x)y(1-y)};$$

$$M_{BF} = \sqrt{z(1-z)y(1-y)};$$

$$M_{ABF} = \sqrt{x(1-x)z(1-z)y(1-y)};$$

Besides, since only the partial correlations have been given so the global ones are set by using the mutual information as index:

$$I[X,Y] = H(X) + H(Y) - H(X,Y);$$

Where with H are indicated the entropies (defined in statistic terms) for the nodes and for the local network studied, therefore for the exposed system are:

$$I[A,F] = (H(A) + H(F) - H(A,F)) \propto \rho_{AF};$$

$$I[B,F] = (H(B) + H(F) - H(B,F)) \propto \rho_{BF};$$

$$I[A,B,F] = (H(A)+H(B)+H(F)-H(A,B,F)) \propto \rho_{ABF};$$

Such a method has been applied to a project of enterprise risk management for the integration of the risks involved in the construction of Messina's strait bridge.
Defined the net with which the risks are linked together, a following development would be that of identifying various sets of risks (sceneries), to appraise their joined distribution of the frequencies $P_N(n)$ (calculable by the BN implemented), to estimate the distribution for the impact $F_X(x)$ (through the experts or the historical data) and then the distribution of losses $H_L(x)$:

$$H_L(x) = \begin{cases} \sum_{i=0}^{2} P_N(n) \times F_X^n(x) & x > 0 \\ P_N(0) & x = 0 \end{cases}$$

Where Fn(x) is the convolution product of F(x) with itself n-times.

The function H, in general, cannot analytically be calculated and therefore techniques of numerical simulation as Monte Carlo methods are implemented to calculate the loss distribution, [4,5,7,8].

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## Risk measures with non-Gaussian fluctuations.

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Reliable calculations of financial risk require that the fat-tailed nature of prices changes is included in risk measures. To this end, a non-Gaussian approach to financial risk management is presented[1], modeling the power-law tails of the returns distribution in terms of a Student-$t$ (or Tsallis) distribution [2,3]. Non-Gaussian closed-form solutions for Value-at-Risk and Expected Shortfall are obtained and standard formulae known in the literature under the normality assumption are recovered as a special case. The implications of the approach for risk management are demonstrated through an empirical analysis of financial time series from the Italian stock market. Detailed comparisons with the results of widely used procedures of quantitative finance [4], such as parametric normal approach, RiskMetrics methodology and historical simulation, as well as with previous findings in the econophysics literature [5,6], are shown and commented. Particular attention is paid to quantify the size of the errors affecting the risk measures obtained according to different methodologies.

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## The Growth of Business Firms: Theoretical Framework.

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We introduce a model of proportional growth to explain the distribution $Pg(g)$ of business-firm growth rates. The model predicts that $Pg(g)$ is exponential in the central part and depicts an asymptotic power-law behavior in the tails with an exponent equal to 3. Because of data limitations, previous studies in this field have been focusing exclusively on the Laplace shape of the body of the distribution. In this article, we test the model at different levels of aggregation in the economy, from products to firms to countries, and we find that the predictions of the model agree with empirical growth distributions and size-variance relationships.

## Scale-free nature of financial systems.

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There is a growing interest in the field of econophysics about the recent developments in networks.
It has been realized that many phenomena and social relations can be modeled through a network where agents represent the vertices and their relationships represent the edges. Strikingly enough these networks have in all the cases some constant statistical properties. In particular all of them seem to be characterised by a scale-free distribution of the number of edges per vertex (degree).
In this contribution we want to present the activity done in this field by our group on stock shareholding networks, stock price correlation network and interbank loan network.
We also present a possible explanation for the onset of scale-invariance in such financial systems.

## Information-theoretical measure for long-range correlated time series.

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We propose an information-theoretical measure, the Shannon entropy, for the clusters emerging from the self-organized critical dynamics described by a fractional Brownian motion. We calculate the Shannon entropy, $S(L)$, for the probability distribution functions $P(L)$ where $L$ is a characteristic size, denoting the diameter $\ell$, the lifetime $\tau$ or the area $\mathcal{A}$ of the clusters. We find that $S(L)$ can be written as the sum of two terms. The first term, varying as $\log L$, accounts for the mechanism of information exchange in the fully developed stationary self-organized critical regime. The second term, varying as the logarithm of the scaling function $\mathcal{F}(L/n)$, accounts for the dissipative effects.

## Econophysics of income distributions: A kinetic model with saving propensity.

B.K. Chakrabarti
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We will review the ideal gas-like models of trading markets, incorporating savings. Numerical results for both uniform and distributed savings will be discussed and compared with observations. Recent theoretical developments on the will be reported. Some of the well-publicised criticisms of the model will be considered addressed.

## Timescales and agent-based models of financial markets.

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I will discuss the relationship between the Minority Game [1] and information exploitation modelling in financial markets. Then the issue of heterogeneous timescales in MGs will be addressed: learning rates, score memory, strategy correlation [2]. The talk will end with a discussion on a model of speculation, where the agents open, wait and close their positions explicitely [3].

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[3] D. Challet, submitted to JEBO, preprint physics/0502140 (2005).

## Heterogeneous agents are responsible for the Pareto tail.

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The 'ideal-gas' like models of wealth distribution [1] in trading markets have been thoroughly investigated. In

such models, agents with identical saving propensity produce a Gamma function like distribution of wealth [2]. The role of heterogeneous agents in the emergence of the Pareto tail [3] has been identified; the system self-organizes to a power law distribution of wealth as soon as agents have a quenched distribution of savings. We also discuss the detailed numerical results and the formulation of a master equation for the trading process and its solution [4].
Recent analyses suggest strong evidence in favor of heterogenity in producing the power law in the wealth distribution [5]. It is possible to extract savings parameters from empirical data from a community of agents with similar savings pattern. These parameters from different communities can then be used in the 'ideal-gas' model framework and one can have a case for obtaining wealth distributions in a heterogeneous society exactly similar to what is observed in the real data. We find strong arguements in favor of these savings-wealth models in explaining the observed shapes of the empirical wealth distribution data and the subsequent emergence of social inequality (see article by T. Lux in [1]).

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## The collision of masses and technical indicators.

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Lately appeared in literature the idea to establish an analogy between prices and masses impacted by other masses proposing a taxonomy of impacts or expectations. We have four expectations: the first one is a blow without penetration and without reduction of the body mass; the second one is a blow without penetration but with reduction of the body mass; the third one is a blow that penetrates and stays in the body and the last one is a blow that goes thru the body without affecting the body mass [1]. The purpose of this paper is to take the previous viewpoint into account to analyze the technical indicators which relate to anticipation, volatility, tendency, market strength, support and resistance and the way these indicators are used. The indicators that we are going to study are the following ones: The Relative Strength Index Technical Indicator (RSI), Bollinger Bands Technical Indicator (BB), Money Flow Index (MFI), The Moving Average Technical Indicator (MA), Moving Average Convergence/Divergence (MACD), The Stochastic Oscillator Technical Indicator, The Momentum Technical Indicator, Commodity Channel Index Technical Indicator (CCI), Parabolic SAR Technical Indicator (SAR) and Envelopes Technical Indicator.

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## Critical dynamics and global persistence exponent on Taiwan financial market.

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We investigated the critical dynamics on the daily Taiwan stock exchange index (TSE) from 1971 to 2005, and the 5-min intraday data from 1996 to 2005. A global persistence exponent $\theta_p$ was defined for non-equilibrium critical phenomena [1,4], and describing dynamic behavior in an economic index[2]. In recent numerical analysis studies of literatures, it is illustrated that the persistence probability has a universal scaling form $P(t) \sim t^{-\theta_p}$[3]. In this work, we analyzed persistence properties of universal scaling behavior on Taiwan financial market, and also calculated the global persistence exponent $\theta_p$. We found our analytical results in good agreement with the same universality.

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# Evaluating short-term financial risk in the electricity market by applying feed-forward ANN and its BP algorithm.

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Usually the definition of risk relates with the uncertain loss. The classical decision-making theory described the risk as the uncertainty of the result, for its application to the competitive markets is the uncertainty of payoffs acquired by the market participants. Especially in the short-term electricity markets in which the real time prices change very frequently, the market participants assume great risk in terms of the profit and loss, so the price uncertainty is highly related to the risk. VaR index is popular method for risk management in electricity market, and Monte-Carlo method is usually used in modeling. In this respect, use the variance of probability distribution as the risk index is improper. This paper considers only the loss part as the risk in the expected result. The risk index incorporates two meanings, one is the possibility of the loss and the other is the magnitude order. The risk is evaluated with the product of the probability and the expected loss value and the modification factor that is used to account for the risk vulnerability. The expression is:

$$R = E(\zeta^{-1})[1 + k\sigma(\zeta^{-1})] \quad (1)$$

where $R$ is the measurement of risk, $\zeta^{-1}$ and $E(\zeta^{-1})$ are respectively the discrete variables and the average values of loss sequences, $\sigma(\zeta^{-1})$ is the average variance and $[1 + k\sigma(\zeta^{-1})]$ is the modification factor.

The feed-forward neural network model is adopted to forecast the value of $E(\zeta^{-1})$ and $\sigma(\zeta^{-1})$, and then the risk value $R$ is evaluated.

The feed-forward neural network, as an efficient tool to solve the nonlinear problem, is trained by the gradient method with the optimal path. It is proved that any nonlinear functions can be approached with high level accuracy and the very complicated problems, such as in cluster and identification area, can be treated using the three-layer-feed-forward neural network with S-function.

The structure of feed-forward three-layered neural network is viewed in figure 1 with $n$ input nodes, $m$ output nodes and $N$ hidden nodes. The math model is as following: Where $Y_k$ is the $k_{th}$-dimension component of net output vector, in the risk forecast $k = 2$, which represent $E(\zeta^{-1})$ and $\sigma(\zeta^{-1})$; $x_i$ is the $i_{th}$-dimension component of the net input vector, and the dimension is decided by the great impact factors to the price, so the load congestion waste available residual capability and random variable lead that $n$ is five; $\alpha_{ij}$ is the weight from $i$ input node to $j$ hidden node; $\beta_{jk}$ is the weight from $j$ hidden node to $k$ output node; $\alpha_{0j}$ is the threshold value of $j$ hidden node. $\beta_{ok}$ is the threshold value of $k$ output node; $h_j$ is the response function of $j$ hidden node, and it is the sigma function:

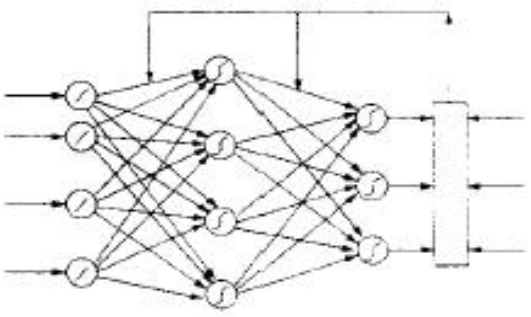

Fig.1 Three Feed-Forward ANN.

$$h_j = \frac{1}{1 + \exp(-\nu_j)} \quad (2)$$

where $\nu_j = \sum_{i=1}^{n} \alpha_{ij} x_i + \alpha_{0j}$.

Although it is testified that any given function can be approached by three-layer-feed-forward neural network, there is no general rule applied to the selection of the number of the hidden nodes. Due to the great fluctuation of price, the network structure should not be fixed and should be modified with the changes of the sampled data, as a consequence to increase or decrease the hidden nodes.

For the consideration of the changes of the network structure, the state variables and the discrete control variables are included in such neural network model that is difficult to be solved. Generally the decomposition technique is used to optimize the control variables and the state variables separately. In this paper, a new approach is proposed for such neural network model. First, the control variables are optimized using the gradient method, next the number of hidden node can be determined, then the weights can be calculated by the BP algorithm. The case study is made by a practical system, and it is indicated, that proposed method is effective to determine the hidden units of three layer Feed-Forward neural networks in evaluating short-term financial risk in the electricity market.

## Models describing the certification market forecast.

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The aim of this work is to analyse differents models describing the certification market forecast, both in traditional and in emerging markets. Based on the assumption that any product follows a typical S-curved life cycle, several methods for describing patterns of growth and decline in biological popolations and individual organisms, represented by a "S-curve tool", are analysed. The study starts with the analysis simplest case of the logistic Verhulst-Pearl equation, finishing with the more complex West, Brown and Enquist (WBE) model. For this method the rate of growth of a population is a non linear function of the population size. The historical data are retrieved from the ISO Survey of ISO 9001:2000 and ISO 14001 Certificates made in differents countries of the whole world. They are subdivised in External data (ISO Survey) and Internal data (MIB/Flash reports). By comparing the seven methods analysed, the WBE model yields the best interpolation, giving the minimal value of quantities such as the root mean square error, mean absolute error and mean absolute percentage error. Furthermore, the WBE method calculates the simulated future trends in the Certification market with respect to the carrying capacity, typical of the limited population growth. The WBE model describes correctly the markets in expansion (emerging countries, i.e., Far East), while some cautions are to be taken as concerns satured markets (e.g. Europe). Finally it describes well both External and Internal data, taking into account that, for the two different sets of data, the carrying capacity is calculated in differents ways.

## Phase transitions in portfolio optimization

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Portfolio optimization problems can be often reduced to linear programming, for which extremely fast algorithms exist. It can happen, as it is the case of optimization under the Expected Shortfall measure of risk, that the problem does not alway admit a finite solution [1]. More precisely, the feasibility of the corresponding linear programming problem depends on the external parameters. Focusing on the particular case of the Expected Shortfall [2], we determine the phase diagram of the related portfolio optimization problem by means of a replica approach. We will also show that the analytical approach we use here is suitable for dealing with more general problems.

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## Market power and collusive behavior in an artificial power exchange.

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Since early nineties, worldwide production and distribution of electricity has been characterized by a progressive liberalization. The state-owned monopolistic production of electricity has been substituted by organized power exchanges. Power exchanges are markets which aggregate the effective supply and demand of electricity. Spot-price markets are usually Day Ahead Market and are requested in order to provide an indication for the hourly unit commitment. This first session of the complex daily energy market collects and orders all the offers, determining the market price by matching the cumulative demand and supply curves for every hour of the day after according to a merit order rule. Subsequent market sessions operate in order to guarantee the feasibility and the security of this plan. The electric market is usually characterized by a reduced number of competitors, thus oligopolistic scenario may arise. Understanding how electricity prices depend on behavior of the suppliers and on production costs has become particularly important. Main goal is to increase the overall market efficiency, trying to study, to develop and to apply different market mechanisms. Auction design is the standard domain for commodity markets and the properties of different auction mechanism must be studied and determined correctly before their appliance. In this work, the nature of the clearing mechanism is investigated comparing two different methods, i.e., discriminatory and uniform auctions. The theoretical framework used to perform the analysis is the theory of learning in games. The demand is considered inelastic and sellers use learning algorithms to understand proper strategies for increasing their profits. The auction mechanism is

modeled in two different duopolistic scenarios, i.e., a low demand situation, where a single seller can clear all the demand, and a high demand condition, where all sellers are requested involved in the clearing. Moreover, heterogeneity in the cost function is considered.

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## $\kappa$-generalized statistics in personal income distribution.

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The distribution function $y_{\{\kappa\}}(x) = \exp_{\{\kappa\}}(-\beta x^{\alpha})$, being $\exp_{\{\kappa\}}(x) = \left(\sqrt{1+\kappa^2 x^2} + \kappa x\right)^{\frac{1}{\kappa}}$ the $\kappa$-exponential function [1–3], with $\alpha > 0$, $\beta > 0$ and $0 \leq \kappa < 1$, is considered in order to analyze the data on personal income distribution for USA and some EU nations [4–6]. The above defined distribution is a continuous one-parameter deformation of the stretched exponential function $y_{\{0\}}(x) = \exp(-\beta x^{\alpha})$—which recovers in the limit $\kappa \to 0$—behaving in very different way in the $x \to 0$ and $x \to \infty$ regions. Its bulk is very close to the stretched exponential one, $y_{\{0\}}(x)$, while its tail decays following the Pareto power-law, *i.e.* $(2\kappa\beta)^{-\frac{1}{\kappa}} x^{-\frac{\alpha}{\kappa}}$. This makes the $\kappa$-generalized distribution function $y_{\{\kappa\}}(x)$ particularly suitable to describe simultaneously the income distribution among both the richest part and the vast majority of the population, generally fitting different curves. A high quality agreement is found between our theoretical model and the observational data on personal income over their entire range.

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## The price of risk in insurance.

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Insurance is one of the means invented by society to protect itself from the economic consequences of risk incurred in daily activities. By defining risk as the uncertainty of a current decision or situation, one can calculate a price for that risk. From early in the history of the industry, insurers have used mathematical models based on probability theory to evaluate risk and to price their policies accordingly.
In recent years, deregulation and an increase number of catastrophes have forced the industry to rethink its approach to risk and the way in which it creates economic value. With the help of computers, it is now possible to use realistic risk models through which insurers can price policies and evaluate the performance of their portfolios. Starting from a simple example, we show the different components used to compute the price of risk. This example allows us to explain the central role played by capital in insurance. We discuss the different risk measures used to determine risk based capital (RBC) and define the necessary conditions required to gain a coherent measure of risk. Using this technique, we present a capital allocation method based on an estimation of the probability distribution of the profits of an entire portfolio. Finally, we show how, by using copula to model the dependence between risks, it is possible to compute the price of a particular risk in the context of an entire portfolio and how this relates to the way financial markets price risk.

## Vanishing price predictability in a simulated limit order book.

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With high-frequency data increasingly accessible to scholars, traders intraday activity has become a major subject of research attention in the last few years. Market microstructure was showed to be relevant [1,2] and the most pervasive of all, the limit order book, was investigated more closely, leading to the discovery of new, high-frequency stylised facts [3,4,5]. A few phenomenological and "empirical behavioral" models started to appear [6,7]. We present in this paper an agent-based simulation of artificial stock market implementing a limit order book (continuous double auction), which we check against high-frequency stylised facts. In contradiction with the weak form of the Efficient Market Hypothesis, the book imbalance appears to be a reliable predictor of future price changes, even when the market is exclusively populated with zero-intelligence traders. This level of predictability introduced by the order book is used to devise a trading strategy that consistently outperforms the buy-and-hold strategy on unseen data.
We then introduce in our simulations such smart traders and check whether the level of predictability persists or, as conjectured by the EMH, vanishes when being exploited.

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## Proposal of a new SI base unit for value – An hedonic estimation of the Physical Purchasing Power (PhPP) of money.

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Purchasing power comparisons between currencies are usually based upon consumer baskets. Such baskets are variable phenomena and their use as numeraire (= value measurement unit) confuses a measurement unit with a measurement result and creates inconsistencies. The theoretically correct choice of a numeraire is shown to be the value of a one-time consumable scalar having minimal quality variation and non-zero market price. A good example is the value of the Economist's Big Mac, except for its link with a particular life style. This example can be generalized to any possible life style or, beyond the human domain, to any living organism by using the objective process value of energy as numeraire. This choice allows to propose an invariant SI (= metric) value unit based on the value of Planck energy (1956.1 MJ). Planck units form a natural system of units that is independent of culture or civilization. We propose to name this value unit walras (Wal) in honour of the economist L. Walras. One Wal is also shown to equal the annual cost of physiological energy consumption of a reference person at minimal activity, i.e. an annual minimum cost of life. The study uses official disaggregated Swiss Producer and Consumer Price Index data and estimates the hedonic numeraire price (HNP) and its inverse, the physical purchasing power (PhPP), of the Swiss franc in 2003.

## Money, space, and time.

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The emergence of intrinsically worthless token as "fiat money" is inherently connected with the fact that exchanges are local in space and time. In this paper, a dynamic network model of production and exchange is proposed in which commodities are locally transformed into other sets of commodities according to standard production technologies. The topology of the exchange network imposes the use of fiat money. The exchange process is shown to generate complex oscillations with multiple time-scales. Furthermore, it leads to local concentrations of wealth.

## An analysis of the Italian interbank money market based on graph theory

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Graph theory provides useful tools to analyse systems of heterogeneous interacting agents and to represent their dynamical evolution. We analyse here the microstructure of the Italian Interbank Money Market [1]. We represent the Interbank market as a network [2], analysing the topological properties and their evolution [2],[3]. We propose a model to reproduce the structure of the network, comparing experimental and numerical data [4]. This model provides some insights into the organizational principles of this system.

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## Contagion effects in a chartist-fundamentalist model with time delays.

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The correlation of asset prices across financial markets is one of the stylized facts of financial markets. Asset price correlations can be a source of contagion dynamics across assets and markets leading to the coupling of financial cycles and to the spread of crash dynamics across markets. The chartist-fundamentalist model of speculative markets has been successful in explaining market fluctuations, speculative bubbles and crashes. Varieties of the model combine herding behavior, trend following and feedback effects. In this paper, the extension of such models into multi-asset markets is investigated. Two models of speculative markets are developed to study the effects of feedback mechanisms in financial markets. The models are an extension of the chartist-fundamentalist model in G. Dibeh "Speculative Dynamics in a Time Delay Model of Asset Prices," Physica A 355 (1), 2005, 199-208, which models speculative asset markets using delay-differential equations (DDEs) which allow the modeling of time lags in financial markets. In the first model, a two-asset market is considered. The first market is a chartist-fundamentalist model with a linear DDE exhibiting damped oscillatory motion where the price converges to the fundamental price. The second market is represented by a market index modeled as a log-periodic process as introduced by D. Sornette. The crash market model couples the linear model with the log-periodic market index I(t) through direct coupling. Numerical solutions to the model show that the asset price exhibits significant persistence as a result of the coupling to the log-periodic index. Moreover, an extension that includes endogenous wealth dynamics shows that the chartists clearly benefit from the persistent dynamics induced by the coupling. The chartists' share of wealth follows oscillatory motion with large periods where the chartist's wealth share is maintained at high levels. This lends theoretical support for the empirical fact that speculators are drawn into speculative markets.The second model is a two-asset model represented by a 2-dimensional DDE. Asset one price exhibits limit cycle dynamics while in the second market asset prices follow stable damped oscillations. The price of asset two converges to the fundamental price. The markets are then coupled through a diffusive coupling term. Solutions to the coupled model show that the dynamics of asset two changes fundamentally with the price now exhibiting also a limit cycle. The stable converging dynamics is replaced with limit cycle oscillations around the fundamental. This qualitative change in dynamical behavior shows that coupling and contagion between different markets can lead to the transmission of fluctuations across financial markets.

## Financial correlation based networks.

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In Ref. [1] we introduced a novel method to generate

networks by means of their embedding on hyperbolic surfaces and we showed that the genus (number of surface handles) is a good measure to characterize and constraint the network-complexity. This method can be conveniently used to filter relevant information from complex systems of several interacting elements generating correlation-based skeleton networks. This is a filtering procedure which can be tuned up to any desired level of complexity by controlling the genus of the resulting network. We have shown in Ref.[2] that this procedure determines a family of graphs having the same hierarchical properties of the Minimum Spanning Tree (MST) but comprising a larger number of links and allowing closed loops. The amount of filtered information with respect to the one present in the MST increases by increasing the genus. A substantial step in the amount of additional filtered information is achieved already in the case of planar embedding (genus = 0). In this talk we will introduce this filtering correlation procedure and we will show its application to different financial data sets.

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## On the integrated behaviour of non-stationary volatility in stock markets.

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The persistence of stock price volatility is a well-known stylized fact in the financial literature. Much of the empirical tests of volatility presented in the literature rely on the standard GARCH approach proposed by Bollerslev and Wooldrigde (1992), and often produce evidence that the conditional volatility is not only highly persistent but also asymmetric. This has triggered a large amount of research on asymmetric conditional volatility modeling, and several asymmetric models are now widely used in the empirical literature. However, the stock price volatility may also present some attributes that are typically non-stationary, an issue that requires the consideration of a special class of conditional heteroskedasticity models based on the IGARCH specification proposed by Engle and Bollerslev (1986). Under this specification, there is no need to differenciate the series when they prove to be non-stationary in order to apply the conditional heteroskedasticity models, thus retaining the richness of information contained in the original series.
The main purpose of this paper is to study the relationship of the volatility between several international stock market indexes, namely the S&P 500 (USA), the Nikkei (Japan), the PSI 20 (Portugal), the CAC 40 (France), the DAX 30 (Germany), the FTSE 100 (UK), the IBEX 35 (Spain) and the MIB 30 (Italy), in the context of non-stationarity. We use the daily closing prices of these indexes to perform our tests and to present the empirical results.
A number of models were tested in our work in order to compare the results. We applied Johansen tests (Johansen, 1988) for cointegration between non-stationary variables, as well as tests for weak exogeneity (Johansen and Juselius, 1990). The results were then compared to those obtained by the Granger causality tests in order to get evidence on the strong exogeneity of the variables. Besides, a stochastic integrated conditional heteroskedasticity specification based on IGARCH and FIGARCH (Meddahi and Renault, 2004) models was also attempted in order to capture the likely non-stationary attribute of the series under the context of conditional volatility.
Our empirical results point to the evidence of the existence of integrated behaviour among several stock market indexes of different dimensions. It seems, therefore, that the behaviour of these markets tends to some uniformity in terms of risk, which can be interpreted as the existence of a similar behaviour facing to shocks that may affect the worldwide economy. Whether this is a cause or a consequence of market globalization is an issue that may be stressed in future work.

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## Does detrending matter for output growth-rate distributions? A cross-country empirical investigation.

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The paper investigates the statistical properties of output and industrial production (IP) growth-rate distributions by employing both parametric and non-parametric techniques.

Many empirical contributions (e.g. Bottazzi and Secchi [2,3]; Castaldi and Dosi [6]) have recently pointed out that growth rates follow a Laplace distribution at different levels of aggregation (i.e., at firm-, industry- and country-level). According to this robust empirical regularity, growth patterns tend to be lumpy, displaying relatively frequent 'big' – negative or positive – growth events. At a more theoretical level, the 'stylized fact' points to the decisive role played by heterogeneity and path-dependency in characterizing firm growth dynamics, which in turn impact on aggregate growth processes (see e.g. Castaldi and Dosi [6]).

Following this line of research, we test whether output and IP growth rates can be approximated by a Laplace distribution. Furthermore, we ask whether our results are robust to alternative ways of detrending output and IP series. Indeed, it is well-known that different detrending techniques (e.g. first difference, Hodrick and Prescott [8] and bandpass filters) affect both qualitative and quantitative stylized facts of the business cycle (Canova, [4,5]).

We carry out our analysis fitting growth rates with the Subbotin family of densities (more on that in Bottazzi and Secchi [2,3]). The Subbotin distribution is characterized by three parameters: a shape parameter $b$, a positioning parameter $m$ and a scale parameter $a$. The $b$ parameter gives information about the fatness of the distribution tails: the higher is the parameter, the thinner are the tails. Note that for $b = 1$ the distribution reduces to a Laplace, whereas for $b = 2$ to a Gaussian.

We begin by considering U.S. output growth-rate distributions. We find that the detrending technique employed does affect the distribution of U.S. GDP growth rates. First-differenced growth rates seem to follow a Laplace, bandpass-filtered growth rates appear to distribute according to a Gaussian, whereas the results obtained employing the Hodrick-Prescott (HP) filter are mixed.

We then consider U.S. industrial production growth-rate distributions. This choice allows us to explore a longer time-span and to employ monthly observations. Our empirical results show that IP growth rates distribute according to a Laplace when the first difference filter is employed. In the other cases, $b$ ranges from 1.20 (Christiano and Fitzgerald filter [7]) to 1.74 (Baxter and King filter [1]).

Finally, we perform a cross-country analysis estimating IP growth-rate distributions for twelve developed countries (i.e. Canada, the U.S., Japan, Belgium, Denmark, France, Germany, Italy, Netherlands, Spain, Sweden, and the U.K.). We find that in many countries the IP growth rates obtained from the first difference filter distribute according to a Laplace. The estimates of $b$ range from 1.65 (Canada) to 0.81 (Denmark). With the exception of Canada and the U.S., first difference has always the lowest $b$ among the filters. When data are detrended with the HP filter, the estimates of $b$ ranges from 1.24 (Canada and the U.S.) to 2.37 (Japan). In six out twelve countries, the $b$ estimated from HP filtered data are lower than the ones obtained from bandpass filtered data. Similar results are obtained when the Baxter-King filter is employed. Indeed, estimates go from 1.20 (Spain) to 2.76 (Sweden). In seven countries, the tails of the Subbotin densities are not fatter than the ones of the Gaussian distribution. Christiano-Fitzgerald filtered data distribute according to a Subbotin distribution with $b$ ranging from 1.10 (the U.S.) to 3.95 (Belgium). Moreover, in eight out twelve countries $b > 2$.

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## A quantitative explanation of the distribution of price returns.

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At this point there are a wide variety of models that purport to explain heavy tails and clustered volatility in price formation. Which of these models, if any are correct? I will present a very simple agent based model, which for some stocks provides a good prediction of the magnitude and form of the full return distribution, as well as the distribution of spreads. It is a simple agent based model in which each component can be directly calibrated based on data on order placement. This model supports the conclusion of several other studies that liquidity fluctuations are the dominant immediate cause of volatility.

## Asymmetric conditional volatility in international stock markets.

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Recent studies show that a negative shock in stock prices will generate more volatility than a positive shock of similar magnitude. The aim of this paper is to appraise the hypothesis under which the conditional mean and the conditional variance of stock returns are asymmetric functions of past information. We compare the results for the Portuguese Stock Market Index PSI 20 with six other Stock Market Indices, namely the S&P 500, FTSE 100, DAX 30, CAC 40, ASE 20, and IBEX 35. In order to assess asymmetric volatility we use autoregressive conditional heteroskedasticity specifications known as TARCH and EGARCH. We also test for asymmetry after controlling for the effect of macroeconomic factors on stock market returns using TAR and M-TAR specifications within a VAR framework. Our results show that the conditional variance is an asymmetric function of past innovations raising proportionately more during market declines, a phenomenon known as the leverage effect. However, when we control for the effect of changes in macroeconomic variables, we find no significant evidence of asymmetric behaviour of the stock market returns. There are some signs that the Portuguese Stock Market tends to show somewhat less market efficiency than other markets since the effect of the shocks appear to take a longer time to dissipate.

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## Why has CEO pay increased so much?

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This paper develops a simple competitive model of CEO pay. A large part of the rise in CEO compensation in the US economy is explained without assuming managerial entrenchment, mishandling of options, or theft. CEOs have observable managerial talent and are matched to assets in a competitive assignment model. Under very general assumptions, using results from extreme value theory, the model determines the level of CEO pay across firms and over time, and the pay-sensitivity relations. The model predicts a cross-sectional constant-elasticity relation between pay and firm size. It also predicts that the level of CEO compensation should increase one for one with the average market capitalization of large firms in the economy. Therefore, the six-fold increase of CEO pay between 1980 and 2003 can be fully attributed to the six-fold increase in market capitalization of large US companies. The model can also be used to study other large changes at the top of the income distribution, and offers a benchmark for calibratable corporate finance. We find a minuscule dispersion of CEO talent, which nonetheless justifies large pay differences. The evidence is broadly supportive of our model. The size of large firms explains many of the patterns in CEO pay, across time, across firms and across countries.

## Modeling price impact across stocks.

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We present a theory of the price impact of a trade, a subject that has received a great deal of attention in econophysics. It shows how the price impact varies with the size of the trade, the volatility of the stock, the daily volume traded for the stock.

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## Overlapping generations models, genetic algorithms and Markov processes.

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The overlapping generations model of Diamond (1965) describes the aggregate behaviour of individuals in a two-period economy. Diamond considers an economy consisting of individuals who live for two periods. Hence at any point of time there are two generations, the young and the old. Individuals maximize their utility (arising from their consumption decisions) over their two-period life. The decisions of individuals who save in their youth to finance consumption during retirement give rise to the aggregate behaviour of the economy in this model. For simulation studies of Diamond-type models using a genetic algorithm (GA), the assumption that individuals maximize utility is relaxed. Instead it is assumed individuals use a GA to arrive at their utility decisions. In current terminology we might say that a GA is used to model the adaptive behaviour of a population of boundedly rational agents. In this paper we discuss recent GA studies of Diamond-type overlapping generations models. We describe the Markov chain structure of the system of GA and model. Simulation studies can only suggest results and a mathematical theory is need to confirm them. The central feature of Diamond-type models is that they include intergenerational interactions. These models provide insight into how consumption decisions made by individuals in their youth impact on co-existing older people and also on their consumption when old. Diamond-type overlapping generations models are hence relevant to the area of finance concerned with superannuation and it is important we sort out their structure.

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## Obtaining probability densities of econometric time series with the Wigner distribution.

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Econometric time series are often modeled using random processes. Among the many possible applications, using such models one can estimate the probability that the random process will be constrained within given bounds at a certain time. This fundamental information can be also obtained from the Wigner distribution of the random process. We will show how to do it by considering the random process as the solution of a stochastic differential equation.

## Emergent macroeconomics.

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This paper considers an economy populated by firms, workers/consumers, and banks, who undertake decisions at discrete times on the markets for an homogeneous non-storable consumption good, credit and labor services. Each firm is run by a single manager, and all of them share the following two characteristics. First, they use bounded rational decision rules, in that they choose prices and quantities in an adaptive way by looking at their most recent past. Second, managers may finance their operating costs either from internal funds or by borrowing on the credit market. Asymmetric information generates a constraint on how much a firm can borrow on the equity market (for the sake of simplicity we assume that there is not an equity market).
All the markets are characterized by decentralized search and matching processes. Interaction and adjustment involve dynamics at the individual level and is not a fixed point (it is complex). Macroscopic regularities emerge from the interactions of the agents: microequilibrium is sufficient to have macroequilibrium, but it is not necessary at agent based level, where there are fluctuations, continuous adaptation and adjustement to one another.
Heterogeneous Interacting Agents models do not require that every element is in equilibrium, but rather that the aggregate is quasi-stable, i.e. in "[. . .] a state of macroeconomic equilibrium maintained by a large number of transitions in opposite directions". It is a dynamic network

of many agents acting in parallel, constantly acting and reacting to what the other agents are doing. If there is to be any coherent behavior in the system, it has to arise from competition and cooperation among the agents themselves. The overall behavior of the system is the result of a huge number of decisions made every moment by many individual agents.
Thus, due to the absence of market-clearing mechanisms the economy is characterized by the contemporaneous presence of persistent involuntary unemployment, unsold production and excess individual demand.
The sequence of events occurring in each period runs as follows: Starting from the demand it expects to face, each operating firm determines the amount of output to be produced, the amount of labor to be hired and the amount of credit to be borrowed. Expectations on future demand are updated adaptively. A fully decentralized labor market opens. Firms set their wage bids (actually each of them sets a maximum wage, as a function of its own financial soundness), and post their vacancies on the basis of their labor demand. Workers, in turn, accept a job only if the wage they are offered is higher than their individual "satisficing" wage. A sequential matching procedure determines whether unfilled vacancies and unemployed workers remain after the labor market has closed. If internal financial resources are in short supply for paying wages, firms can borrow on the credit market. Individual demand for credit is a straight line up to a maximum rate she can afford. The supply of loan of each bank is also a straight line above a minimum rate of interest the bank sets as a function of the expected inflation, the rate of discount and the bank financial conditions. The individual supply is proportional to bank's capital. The borrowers' demand are ranked according to firms' financial conditions. After production is completed, the market for goods opens. Firms post their offer price, while consumers are allowed to muddle through searching for a satisfying deal. If a firm ends up with excess supply, it gets rid of the unsold goods at zero costs.
An empirical analysis on European data closes the paper.

## Cross correlations and multifractal properties of ukraine stock market.

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Recently the statistical characterizations of financial markets based on physics concepts and methods attract considerable attentions. The correlation matrix formalism and concept of multifractality are used to study temporal aspects of the Ukraine Stock Market evolution. Random matrix theory (RMT) is carried out using daily returns of 431 stocks extracted from database time series of prices the First Stock Trade System index (www.kinto.com) for the ten-year period 1997-2006. We find that a majority of the eigenvalues of C fall within the RMT bounds for the eigenvalues of random correlation matrices. We test the eigenvalues of C within the RMT bound for universal properties of random matrices and find good agreement with the results for the Gaussian orthogonal ensemble of random matrices—implying a large degree of randomness in the measured cross-correlation coefficients. Further, we find that the distribution of eigenvector components for the eigenvectors corresponding to the eigenvalues outside the RMT bound display systematic deviations from the RMT prediction. We analyze the components of the deviating eigenvectors and find that the largest eigenvalue corresponds to an influence common to all stocks. Our analysis of the remaining deviating eigenvectors shows distinct groups, whose identities correspond to conventionally identified business sectors. Comparison with the Mantegna minimum spanning trees method gives a satisfactory consent. The found out the pseudoeffects related to the artificial unchanging areas of price series come into question
We used two possible procedures of analyzing multifractal properties of a time series. The first one uses the continuous wavelet transform and extracts scaling exponents from the wavelet transform amplitudes over all scales. The second method is the multifractal version of the detrended fluctuation analysis method (MF-DFA). The multifractality of a time series we analysed by means of the difference of values singularity stregth (or Holder exponent) $\alpha_{\max}$ and $\alpha_{\min}$ as a suitable way to characterise multifractality. Singularity spectrum calculated from daily returns using a sliding 250 day time window in discrete steps of $1 \ldots 10$ days. We discovered that changes in the multifractal spectrum display distinctive pattern around significant "drawdowns". Finally, we discuss applications to the construction of crushes precursors at the financial markets.

## Network analysis of the World Trade Web.

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We report an empirical analysis and a theoretical investigation of the topological and dynamical properties of the *World Trade Web* (WTW), the network defined by the in-

ternational import/export trade relationships among all world countries [1,2]. The WTW is a network representation of the global trade activity, where each country is represented by a vertex and the flow of money between two trading countries is represented by a directed weighted link between them. Our analysis is based on a data set reporting the trade flow for all pairs of countries for all years between 1950 and 2000.
The recent advances in network theory allow us to characterize the topology of the WTW quantitatively and to detect structural properties which are of interest for the behaviour of the world economy. We focus on both static and dynamical properties of the WTW; in both cases we find that the properties of the network are strongly related to the *Gross Domestic Product* (GDP) of world countries [1,2,3]. We discuss several aspects of these results and show how the tools of statistical mechanics help us unveil unexpected regularities in the network. The consequences of this analysis for the understanding of the evolution of the global trade activity are discussed.

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## Artificial financial markets with continuous-time random walks.

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We present the framework for the simulation of artificial financial markets on a parallel computer architecture. Synthetic intraday high frequency financial time series are generated by Monte Carlo for all assets traded on a stock exchange and used e.g. for speculative option valuation. The phenomenological model for the time series is a continuous-time random walk [1,2].

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## A cluster-based analysis of some macroeconomic indicators in various time windows.

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A cluster type analysis of the time evolution of some macroeconomic indicators was developed in order to organize observed data into meaningful structures, in particular the time evolution of Gross Domestic Product (GDP), Consumer Price Index (CPI) and Gini Coefficient for the 15 West European countries of the EU before 2004. The method used was the moving average minimum path length, i.e. constructing the MPL clusters starting from an "average" country, introduced for every time window investigated. For different time window sizes the statistical properties of length distributions were analyzed and the "globalization" effect, i.e. the decrease of mean distance was observed in the 5 years time size window when moved over 1994-2005 with a 1 year step. The aims of choosing the above macroeconomic indicators are multifold: firstly, the time evolution of GDP represents in fact the time variation of total wealth, which can not be considered constant especially in the industrialized societies, whose evolution is principally based on the production processes; secondly, the time evolution of CPI allows to take into account the inflationary mechanisms, which lead to non conservation of the total monetary mass and in turns influence the individual wealth; thirdly, the governmental policy exerts a strong influence over both GDP and CPI that results in various wealth distributions. The evidences of large ranges of Gini coefficients and the similarity in hierarchical patterns found in the time evolution of the above macroeconomic indicators open the way for using appropriate theoretical tools in explaining these results, such as the stochastic kinetic equation in the presence of external fields and the multivariate nonextensive linear response theory.

## Multifractal and wavelet analysis of temporal variations of the market stock indexes.

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The purpose of this paper is to carry out an analysis of temporal variations of the market stock indexes of the type as follows: Germany's Xetra Dax index, PE FTSE Eurofirst 300 one, Nikkei 225 S&P500 during the quite long temporal interval (including seven and more years per day, week, month) and to find the corresponding multi-fractal features. Since last decades, many scientists use the new powerful tool based on the wavelet decomposition for analyzing various signals series, including financial ones [1]. At present, the family of analyzing function dubbed wavelets is being increasingly used in problems of pattern recognition, financial analysis; in processing and synthesising various signals; in analysis of images of any kind /1-4/. Wavelets are fundamental building block functions, analogous to the sine and cosine functions. Fourier transform extracts details from the signal frequency, but all information about the location of a particular frequency within the signal is lost. At the expense of their locality the wavelets have advantages over Fourier transform when non-stationary signals are analyzed. Here, we use non-decimated wavelet transform that has temporal resolution at coarser scales and allows to isolate time series of the major components of financial sets a direct way. The dilation and translation of the mother wavelet y(t) generates the wavelet as follows: $\Psi_{j,k} = 2^{j/2}\Psi(2^j t - k)$. The dilation parameter $j$ controls how large the wavelet is, and the translation parameter $k$ controls how the wavelet is shifted along the t-axis. For a suitably chosen mother wavelet $\Psi(t)$, the set $\Psi_{j,k}$ provides an orthogonal basis. The corresponding wavelet expansion of a function is closely related to the discrete wavelet transform of a signal observed at discrete points in time. In practice, the length of the signal, say $n$, is finite and, for our study, the data are available daily, monthly, i.e. the interested function is vector $f = (f(t_1), \ldots, f(t_n))$ with $t_i = i/n$ and $i = 1, \ldots, n$. With these notations, the DWT of a vector $f$ is simply a matrix product $d = W \cdot f$, where $d$ is an $n \times 1$ vector of discrete wavelet coefficients indexed by 2 integers, $d_{jk}$, and $W$ is an orthogonal $n \times n$ matrix associated with the wavelet basis. For computational reasons, it is simpler to perform the wavelet transform on time series of dyadic (power of 2) length. Using a link between wavelets and fractals, we have made calculating the multi-fractal spectrum. The results of analysis are presented for temporal variations of the market stock indexes: Germany's Xetra Dax index, PE FTSE Eurofirst 300 one, Nikkei 225 one, S&P500 one etc.

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## Modeling long-range memory trading activity and volatility.

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There are empirical evidences that the trading activity, the trading volume and the volatility of the financial markets are stochastic variables with the power-law probability distribution function (PDF) and the long-range correlations [1, 2]. Additive-multiplicative stochastic models of the financial mean-reverting processes provide rich spectrum of shapes for PDF, depending on the model parameters [3]. The proposed models, however, usually are characterized only by the short-range time memory. The long-range memory aspect is not accounted in the widespread models [4]. These models based on the empirically fitted parameters fail in reproducing the power-law behavior of the volatility autocorrelation function.
Recently we investigated analytically and numerically the properties of the stochastic multiplicative point processes, derived formula for the power spectrum [5] and related the model with the multiplicative stochastic differential equations [6]. Preliminary comparison of the model with the empirical data of stock market trading activity power spectrum and probability distribution stimulated us to work on the more detailed definition of the model [7]. We will present the stochastic model of the trading activity with the long-range correlations and will investigate its connection to the stochastic modeling of the volatility and returns. The proposed stochastic nonlinear differential equations reproduce the power spectrum and PDF of the trading activity in the financial markets, describe the stochastic interevent time as the modulated Poisson process and can be applicable for modeling of the volatility with the long-range autocorrelation.

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## Complex networks: Self similarity and superhighways.

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Complex networks have been studied extensively due to their relevance to many real systems such as the world-wide web, the Internet, energy landscapes and biological and social networks. A large number of real networks are referred to as "scale-free" because they show a power-law distribution of the number of links per node. It is shown that complex networks can be partitioned into fractals (self-similar) and non-fractal networks. This result is achieved by applying a renormalization procedure that coarse grains the system into boxes containing nodes within a given distance. We identify a power-law relation between the number of boxes needed to cover the network and the size (maximum distance) of the box, defining a finite self-similar fractal exponent. The renormalized networks conserve the scale free property with the same degree exponent. These fundamental properties help to explain the origin of the scale-free nature of complex networks and suggest a common self-organization dynamics. We also suggest a growth model that generates both fractal and non-fractal scale free networks. It is shown that the network fractality is due to hub-hub repulsion and non-fractal networks have no repulsion. We discuss general results for transport in weighted networks with general distribution of weights as well as the finding of superhighways and small roads in such networks.

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## Coherent oscillatory patterns as system equilibrium in a simple congestion game.

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We study a simple symmetrical 2x2 game where two players try to optimize their payoffs in a similar way as drivers optimize their daily routes. There is a difference between an optimum of a single player (a 'Wardrop' or 'Nash equilibrium') and a system optimum. The latter can be received if a symmetry between decisions of both players is broken and one of them decides for a lower profit solution. A time dependent oscillatory decision behaviour can restore the system symmetry when the players are ready to cooperate. Our experimental and computer simulation results confirm occurrence of coherent oscillations in players decisions. The observed cooperation emerges after a transient time that is inversely proportional to single users spontaneous flipping frequencies.

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## Effective memory of the minority game.

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It is known that the memory is relevant [1,2] in the symmetric phase of the minority game [3]. In our previous work [4] we have successfully explained the quasi-periodic behavior of the game in the symmetric phase with the help of the probability theory. Based on this explanation, we are able to determine how the memory affects

the variance of the system in this paper. By using some particular types of fake history such as periodic type and random type, we determine how efficient the memory has been used in the standard game. Furthermore, the analysis on the effective memory strongly supports the result we proposed previously [5] that there are *three* distinct phases in the minority game.

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## Response of agent network to exogenous shock.

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Most of earlier studies in econophysics are about financial market [1,2]. A few is about firm activity, although fundamental understanding, such as derivation of the Pareto law from the detailed balance condition and the Gibrat law, was achieved [3-8]. Quantitative discussion with existing model for firm activity is concentrated on the power index of distribution [9-11]. Furthermore almost no study focuses on business-to-business transaction, although the transaction play important role in actual firm activity [12-16]. On the other hand, it is required to estimate model parameters using from financial and business-to-business transaction data analysis to develop a quantitative model. It is, however, that usable data is restricted to fiscal time series data of short period, e.g. 10 years, due to non-stationarity of economic phenomenon.
Econophysical model of transaction network, where interacting firm agents invest capital and labor rationally in order to maximize its payoff, is studied, based on previously studied industrial sector agent models [17-19]. Here, financial statement data, including various items in income statement, and business-to-business transaction data are focused on, in order to avoid the difficulty of insufficient time series data. With interaction parameters estimated from financial and transaction data analysis, firm activity on a subset of a real transaction network is simulated with exogenous shock, which is defined as sudden change of a macro-economic index. The simulation reproduces past revenue and cost data for each agent quantitatively. Response of firm agents to the given exogenous shock is discussed.

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## Pareto laws caused by Bose-Einstein condensation in the urn model.

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Population of income (or wealth) decreases following power law for the richest 5-10 % of the population. This fact observed by Vilfredo Pareto in 1896 is well-known as *Pareto law*. In this paper, we present a simple model to explain the Pareto law in income distributions [1]. Our model is a kind of the so-called *Monkey-class urn model* [2] in which $N$ urns (might be regarded as *people* in society) share $M = \rho N$ balls (might be regarded as *money*) under global constraint (conservation of total amount of money) : $n_1 + n_2 + \cdots + n_N = M$, where $n_i$ $(i = 1, \cdots, N)$ means the number of balls in the $i$-th urn. Each urn possesses its own energy $E(n_i)$. Then, we evaluate the probability $P(k)$ that an arbitrary urn has $k$ balls by using statistical mechanics of disordered systems. If we choose the energy function as $E(n_i) = \epsilon_i n_i$, where $\epsilon_i$ means energy level of $i$-th urn, obeying some distribution (density of states) $D(\epsilon) \sim \epsilon^{\alpha}$, and it could be regarded as disorders in the systems, we find that below the critical temperature at high density level ($\rho \equiv M/N \gg 1$), Bose-Einstein condensation occurs and most of the urns falls in the lowest energy level $\epsilon = 0$. As the result, the distribution function $P(k)$ changes its scaling behavior from the exponential $\sim k^{-3/2}\,\mathrm{e}^{-k}$-law to the polynomial $\sim k^{-(\alpha+2)}$-Pareto law in large $k$ regime. In this paper, we also show some results for the *Backgammon model* [3,4] and the *Ehrenfest-class urn model* [2], in which each ball can be distinguished from the others, whereas it is impossible in the Monkey-class. We compare the results of our analysis with several studies from empirical data analysis (see e.g. [5] and references therein). The difference between them and its possible explanations are also discussed.

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## Dynamical change of Pareto index in Japanese land prices.

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In the large scale region of wealth, income, profits, assets, sales, the number of employees and etc $(x)$, a cumulative number $N(> x)$ obeys a power-law $N(> x) \propto x^{-\mu}$. This power-law and the exponent $\mu$ are called Pareto's law and Pareto index, respectively. Recently, Fujiwara et al. [1] have explained Pareto's law (and the reflection law) by using the law of detailed balance and Gibrat's law, which are observed in empirical data. The detailed balance is time-reversal symmetry: $x_1 \leftrightarrow x_2$. Here $x_1$ and $x_2$ are two successive incomes, profits, assets, sales and etc. Gibrat's law states that the conditional probability distribution of growth rate is independent of the initial value $x_1$. In the proof, they assume no model and only use these two underlying laws in empirical data. In Ref. [2], it is reported that the Pareto index is also induced from the reflection law.
These findings are important for the progress of econophysics. Above derivations are, however, valid only in the economic equilibrium where the detailed balance holds. As the next step, the dynamics should be established. For this aim, we investigate the dynamical behavior in the large scale region of non-equilibrium systems, by employing data on the assessed value of land in 1983 – 2005 Japan. Because the distribution of Japanese land prices has similar features with one of personal income and company size [3], and the long-term database is readily available. In the non-equilibrium system we have found the quasi-detailed balance, which has the symmetry: $x_1 \leftrightarrow a\, {x_2}^{\theta}$. By using the quasi-detailed balance and Gibrat's law, we have derived Pareto's law with varying Pareto index annually. The parameter $\theta$ corresponds with the ratio of Pareto indices $(\mu_1 + 1)/(\mu_2 + 1)$, and the relation is confirmed in the empirical data nicely [4].
On the other hand, the parameter $a$ corresponds to the ratio of prices. We observe that the change of $a$ induces the change of CPI. As a result, we obtain a dynamical equation which non-equilibrium economic systems should satisfy.

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## Persistence in the socio-econo dynamics of the random bond Ising model in high dimensions.

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We study the persistence phenomenon in a socio-econo dynamics model using computer simulations at a finite temperature on hypercubic lattices in dimensions up to 5. The model includes a social local field which contains magnetization at time $t$. The nearest neighbour quenched interactions are drawn from a binary distribution which is a function of the bond concentration. We determine the decay of the persistence probability in the model. We discuss our results, which indicate the existence of *blocking*, and the consequent implications in the social and economic contexts.

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## Asymmetry and synchronization in stock markets.

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We investigate financial time series by means of socalled inverse statistics giving the distribution of investment times for a fixed pre-described level of the return [1]. We obtain a new set of distributions for the investment times which exhibit well-defined maxima defining the optimal investment horizons [1,2]. It is observed that the market contains an inherent gain-loss asymmetry in the sense that the time span for a typical gain is about twice that of a loss of the same magnitude [2]. Surprisingly, this feature is not present for a single stock, which exhibits complete symmetry between the gain and loss waiting times.
To explain this, we introduce an asymmetric synchronous market model consisting of a number of randomly fluctuating stocks that occasionally synchronize their drawdowns, parameterized by a "fear factor" [3]. The model explains the empirical findings of the market, indicating that synchronization of (symmetric) individual stocks is a fundamental ingredient in understanding the asymmetric stock market index dynamics.

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## A precursor of market crashes.

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In the econophysisists' community, market crashes have also been a hot issue. One of the greatest myths is that market crashes are random, unpredictable events. Can large market crashes be forecast? To answer the quastion we quantitatively investigated the properties of an ensemble of *stock prices* in Japan in a 3-year period to study the warning phenomenon of large market crashes. We selected approximately 1200 large stocks listed and traded on the Tokyo Stock Exchange for over than 20 years, and formed ensembles of daily stock prices in the 3-year period from January 4, 1999 to December 28, 2001, corresponding to the period of Japan's internet bubble and the market crash. We found that the tail of the complementary cumulative distribution function of the ensemble of stock prices in the high value range is well described by a power-law distribution, $P(S > x) \sim x^{-\alpha}$, with an exponent that moves in the range of $1.09 < \alpha < 1.27$. Furthermore, we found that as the power-law exponents $\alpha$ approached *unity*, the internet bubble burst. This suggests that *Zipf's law* for an ensemble of stock prices is a sign of bursts of bubbles.
Then we focus attention on the relative price defined as $X(t) = S(t)/S(0)$, where $S(0)$ is the initial price. We selected approximately 3200 stocks traded on the Japanese Stock Exchange and formed a statistical ensemble of daily relative prices for each trading day in the 3-year period from January 4, 1999 to December 28, 2001, corresponding to the period in which the *internet Bubble* formed and *crashes* in the Japanese stock market. We found that the upper tail of the complementary cumulative distribution function of the ensemble of the relative prices in the high value of the price is well described by a power-law distribution, $P(S > x) \sim x^{-\alpha}$, with an exponent that moves over time. Furthermore, we found that as the power-law exponents $\alpha$ approached *two*, the bubble burst. It is reasonable to assume that when the power-law exponents approached *two*, it indicates the bubble is about to burst. Finally, we investigate the effects of market crash on corporate management by analyzing the data of the financial statements of Japanese companies. We show a mesurement of risk which is defined as the probability of decreas-

ing capital caused by the stock price fluctuations.

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## An interacting-agent model of financial markets from the viewpoint of nonextensive statistical mechanics.

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A number of interacting-agent models proposed recently showed that they can generate some ubiquitous characteristics, for example the clustered volatility and the scaling behaviors of price fluctuations, found for empirical financial data as a result of interactions between agents. It seems reasonable to support that the emergence of realistic scaling laws from the agents' interaction would lend convinced evidence in favor of the *Interacting Agent Hypothesis*. Although the interacting-agent models are advocated as an alternative approach to the *efficient market hypothesis* that is equivalent to the *rational expectation hypothesis* in economics, little attention has been given to the point how probabilistic rules, that an agent switches his opinion, is connected with his expectation formation. Our previous work [1] proposed a new expectation formation hypothesis, that is, *the relative expectation formation hypothesis* corresponding to the interacting-agent hypothesis. The relative expectations formation of interacting-agents has been formularized by using the *minimum average energy principle for Bolztmann-Gibbs entropy*. The aim of this paper is to generalize the formulation of the relative expectation formation from the viewpoint of the nonextensive statistical mechanics. We shall present an interacting-agent model that follows the line of an Ising-like model of financial markets proposed by our previous work [1], and formulate the agents' decision-making on investment as the *maximum entropy principle for Tsallis entropy*, and demonstrate that a equilibrium probability distribution on the agent's investment attitude, which is obtained as the so-called *q-exponential distribution*, is able to be derived from the relative expectations formation. We also show that the interacting-agent model gives a convictive explanation for an universal statistical characteristics of financial data, that is, the power-law tails of the distribution of volatility, measured by the absolute value of relative price changes.

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## Stylized facts in internal return rates on elementary market investment strategies.

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The power law for the decay of the asymptotic tails of the distributions of normalized returns in financial markets, which is one of the paradigms of experimental finance, has been described in terms of the communication networks among market participants and modeled, among other approaches, by the means of spin lattice models [1-4]. While this stylized feature deals with the distribution of relative prices on the session-to-session basis, i.e. the statistics of the quantity $\log(P_{t+1}/P_t)$ defined apriori, it is also worthwhile to examine the stylized facts related to generic investment strategies applied to particular markets. Within this approach, the above mentioned normalized returns exhibit a stylized fact for the "buy now, sell the next session" strategy.
This work deals with the stylized facts for a set of elementary investment strategies classified into two groups. The first group of strategies is defined by the internal return rate (IRR): "buy now, sell when a predefined IRR value is reached". Within the continuous time model, such an approach yields a probability distribution $p(\rho)$ over the single-encounter return-rate density $\rho$. This distribution presents an interesting generalization of the stylized features usually discussed in the case of normalized returns. In particular, by using daily price averages, we have demonstrated a remarkable similarity of $p(\rho)$ distributions across various stock indices.
The second set of stylized facts dealt with here is based on the different role of moving time averages in investment strategies. Elaborating on the comparison of short-term and middle-term market trends, the turning points named as golden cross (an accelerating bearish trend) and the dead cross (an accelerating bullish trend) are known as elementary signals to buy and sell, respectively. Interestingly, the stylized features derived from these signals for the pair of golden cross - dead cross strategies show

a remarkably discrete behavior, which is moreover distinct among particular financial markets (stock indices in this work). By screening across various averaging periods defining the turning point signals, we have discovered quite interesting regular patterns in the behavior of $p(\rho)$ distributions.
This paper presents the stylized facts for the group of single-encounter and dead cross -golden cross strategies (or market transforms), and compares these to the classical stylized facts discussed in the literature. Our extended approach is illustrated by a wealth of real data ranging from the daily stock index averages (TOPIX, S&P 500, FTSE100) to one minute tick data from the Tokyo Stock Exchange Price Index.

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## Size matters: some stylized facts of the market revisited and consequences for fluctuation scaling.

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We reanalyze high resolution data from the New York Stock Exchange and find a monotonous (but not power law) variation of the mean value per trade, the mean number of trades per minute and the mean trading activity with company capitalization. We show that the second moment of the traded value distribution is finite. Consequently, the Hurst exponents for the corresponding time series can be calculated. These are, however, non-universal: The persistence increases with larger capitalization and this results in a logarithmically increasing Hurst exponent. A similar trend is displayed by intertrade time intervals. Finally, we demonstrate that the distribution of the intertrade times is better described by a multiscaling ansatz than by simple gap scaling. The consequences for the recently found fluctuation scaling are discussed.

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## Individual and aggregate behaviour on financial markets.

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It is widely recognized that certain features of financial time series, do not correspond to those that would emerge from standard models of financial markets. For example, the presence of "bubbles" and "herding" behaviour in such markets, seems to be incompatible with the efficient markets hypothesis as well as the idea of rational expectations. The existence of long memory in financial price series which is well documented would not be consistent with standard financial market models. Since these empirical phenomena exist and are important they need to be explained. In particular the preoccupation of many regulatory authorities with the increasing volatility of these markets is closely linked to the phenomena I have mentioned.
As a result a number of us have tried to develop theoretical models, which generate such phenomena.
The purpose of this talk is to present this class of models which have been proposed as an alternative to the more standard models associated with the CAPM paradigm. These models generate data, which, in some configurations, reproduce many of the stylized facts of the empirical series and in particular are capable of generating, "bubbles", "long memory" and "excess volatility". The essential feature of the models is that they involve interaction between the various individual agents in the market. Agents forecast changes in prices and the actions that they take will be based on their forecasts. Their forecasts and their actions may be highly interdependent and it is this that generates the properties we are interested in. The most typical feature of this model is that agents tend to herd on one type of behaviour and then to move together to another. This sort of "herding" behaviour is by no means irrational, since the actions of agents reveal something about the information that the individuals possess.
Such models would not seem to be likely to have equilibria in the standard sense but I will propose a notion of equilibrium which suggests that there is structure in financial time series but no tendency to converge to a long term price or steady state.

## Probability of large movements in financial markets.

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The attempt to continuously and successfully predict the direction of future movements of any asset price can be compared to attempts of inventing the *perpetum mobile*. However, the attempt to characterize and predict the risk (or volatility) may offer significantly better results and therefore the volatility is one of the most-studied phenomena in Econophysics. We have introduced in [1] the concept of low-variability period analysis that, among the other things, complements the analysis of volatility. The low-variability period analysis refers to the length-distribution of consequent time periods where the price changes of the observed asset remain under pre-set threshold. We have shown in [1] and [2] that this technically simple method can extend the traditional multifractal analysis of financial markets. In this paper we focus on the super-universal law derived in [2] - the probability of "silence-breaking". It is shown that just the very presence of a power-law of the length-distribution of low-variability periods leads to a super-universal law that the probability of observing a large movement is inversely proportional to the length of the ongoing low-variability period. We have successfully tested this relationship in a number of financial time series. Given the fact that the low-variability periods are closely related to the volatility, we have also tested the relationship between the probability of silence-breaking, historic and implied volatility of S&P 500 equity index. Finally, we have developed the volatility trading strategy based on the probability of "silence-breaking".

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## The wavelet-based analysis of crisis precursors.

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Critical and crisis appearances of the financial markets constantly in a field of attention of financial analysts and practicians. According to modern theoretical representation the markets are effective and only occurrence of the drama information, catastrophic or shock events (the USA, September, 11, 2001, modifications of the prices for oil - oil shocks 1974, 1990, 2005) can reduce in noticeable (critical) modifications - crashes. Actually, even the most captious researches do not give indisputable conclusions concerning the information on forerunners of approach of critical events. Financial markets are hierarchical multifractality ones in plants where each level can have different weight, connections with other levels, and also characteristic temporal and spatial scales (see, for example [1]). Therefore the problem is reduced to designing such forerunners of catastrophic appearances which would allow to analyze a condition and dynamics of the market with the help of modern methods, to discover typical pictures of precritical conditions. We investigated singularities of wavelet-transformations coefficients and their higher moments (from the second on the fifth), some financial numbers during known crisis appearances: S&P 500, DJ Industrial, MSCI, rates of exchange. A dynamic number of daily values was exposed wavelet to transformation to phase up to, during time and after crisis. Calculations were carried out with the help of MatLab Wavelet Toolbox tools. In work the typical picture which is observed at the various central moments of distribution has been defined. It is established, that behaviour of the fourth moment of factors wavelet-transformations itself similarly to the third moment of distribution. In turn given situation is similar for various share and currency numbers with various crisis appearances. Was, it is established, that before crisis there is an increase of fluctuations which are similar on clasterization of volatility, given defined, display can serve as a forerunner of critical appearances.

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## Stylized facts from a psychology-based agent model.

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We study a class of agent-based market models built upon simple, psychologically-grounded, forms of bounded ra-

tionality. We inflict upon our agents differing tolerances to various sources of 'stress' and when the threshold for any of the stresses is violated the agent switches position (other threshold/inertia models can be found in [1,2]). The primary driving force is the increasing pressure on agents to switch positions as the market price moves away from the one at which they last traded. This 'inaction' stress can also be interpreted as mimicking several other (rational) market effects and, when used alone, results in a base model whose output is identical to those of markets operating under the strongest forms of the Efficient Market Hypotheses (EMH).
However, the introduction of a further source of stress, namely the increasing tension experienced by an agent while holding the minority position, changes the market dynamics considerably via the generation of herding behavior. Numerical simulations demonstrate that all of the most important 'stylized facts' of real-market statistics (including quantitative details such as observed power-law exponents for price-returns and the decay in volatility correlations) are stably reproduced. Furthermore, the reduction to EMH-statistics in the base model allows for the possibility of isolating the effects of other, more subtle, aspects of bounded rationality. One such set of numerical experiments relating to observed asymmetries in price-return data [3] will also be presented.

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## Large deviation principle in economics for a short term forecasting.

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In this paper the Large Deviation Principle is applied to a non stationary non-hardly volatile economic process $Y_t = g(Y_{(\tau\setminus\{t\})}, u_{(\tau)})$, where $\tau = \{t_0, \ldots, t-1, t\}$ and $u_{(\tau)}$ is the growth rate process, under the knowledge of the probability distribution of the intertemporal growth factors $z_t = h(u_t)$.
The main aim is to estimate the short term values of the random variables $\{Y_k\}_{t+1}^{t+n}$ following a probabilistic approach. The Gärtner-Ellis theorem is used to infer the appropriated *good rate function* involved in a short term forecasting framework.

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## Self-organization behavior in a constrained minority game.

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In the standard minority game, every agent switches to his best strategy in hand at each time step. If only a small number of agents are allowed to switch their strategies at each time step, the population variance of the system plunges. The variance reaches a low value and remains steady for a period of time. Then without any sign it starts to rise abruptly to a high value and then decreases smoothly to the previous low value again. The process of an abrupt rise followed by a gentle decrease repeats again and again but without obvious characteristic length as time goes on. The phenomenon is similar to the collapse of a sand pile with sands being added continuously from the top. We define the scale of collapse of the population variance by the difference of the variance before and after an abrupt rise. We then find that the logarithmic plot of the frequency versus scale of the collapses follows a power law.

## Dynamic Financial Analysis: Solvency testing and non-catastrophe losses.

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Dynamic Financial Analysis (DFA) is the most advance modeling process in today's property and casualty

industry-allowing us to develop financial forecasts that integrate the variability and interrelationships of critical factors affecting our results. Through the modeling of DFA, we see the company's relevant random variables is based on the categorization of risks which is generated solvency testing where the financial position of the company is evaluated from the perspective of the customers. The central idea is to quantify in probabilistic terms whether the company will be able to meet its commitments in the future.
I'm exploring this research draft on DFA (Monte Carlo stochastic simulation), which deal with the long time horizons present in insurance and with the combination of models on the liability side, we explicitly considered four sources of randomness: non-catastrophe losses followed by payment patterns. We simulated catastrophes separately due to quite different statistical behavior of non-catastrophe losses. In general the volume of empirical data for non-catastrophe losses is much bigger than for catastrophe losses. Due to the fact that the density function of the gamma distribution decreases exponentially under appropriate choice of parameters it is a distribution serving our purposes sharply.

## Enhanced requirements-based programming for complex model completion.

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R2D2C is a technique to mechanically transform system requirements via provably equivalent models to running code. It was developed at NASA [4] as a general-purpose method to mechanically transform system requirements into a provably equivalent model. This is a central need for ultra-high dependability systems like those developed at NASA for space exploration. The R2D2C approach provides mathematically tractable round-trip engineering for system development, rigorously based on formal modelling and formal reasoning techniques.
Dealing with complex systems, it is of vital importance to be able to gather reasonably complete requirements, which is typically impossible from the very beginning, especially for long running projects. To this aim, we complement R2D2C by model extrapolation via automata learning[1].
The main practical impact of this combined approach is its power to support the systematic *completion* of the requirements, which by their nature are typically very partial and concentrate on the most prominent scenarios. Our technique generalizes these typical requirement skeletons by extrapolation and it indicates by means of automatically generated traces where the requirement specification is too loose and additional information is required.
Central application domains are here the capture of interaction mechanisms in the communication in sensor networks as in the Autonomous Nano Technology Swarm mission (ANTS) [2], the modelling of adaptive and autonomous systems, and the modelling of evolution and emerging behaviour in complex collaborative environments. The underlying models are discrete feedback networks, which are adequate to cover e.g. traffic behaviour on communication and logistic networks, and serve as basis for cost estimation, efficiency computation, cost assignment, and design of reactive business models based on adaptive pricing.

**Example: Communication Systems**
The learning based approaches based on [1] have so far fared quite promisingly for the test-based discovery of models of legacy communication systems, thus outperforming prior approaches based on trace combination [3]. As shown in [5], the test-based model generation by classical automata learning is very expensive. It requires an impractically large number of queries to the system, each of which must be implemented as a system-level test case. Key towards the tractability of observation based model generation are powerful optimizations exploiting different kinds of expert knowledge in order to drastically reduce the number of required queries, and thus the testing effort. Recent studies have brought to a thorough experimental analysis of the second-order effects between such optimizations in order to maximize their combined impact [6], and to the development of a mature toolset for experimentation.
In the specific R2D2C context, we are interested in investigating the possible application of the combined approach to the specification of communication mechanisms used in all of these application domains. This can be completed by a test-based or monitoring-based validation once those systems are operational.

*Note: We hope to obtain clearance to present a concrete case study in time for the conference.*

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## Black Wednesday and collapse of ERM currency peg: An ACE test bed for robust policy design or how to avoid endogenous policy induced systemic failure.

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Here we report an Agent based Computational Economics (ACE) model of a classic example of poor policy design leading to collapse of a system: **Black Wednesday and Collapse of the ERM Currency peg on 19 Sept. 2002**. George Soros made 2bn taking a short position against the Sterling and the Bank of England. He is alleged to have used the Liar or Contrarian Strategy. *Why did Soros win*: Or why did *all* Currency pegs collapse (from Mexico to the Asian ones) at great cost to the tax payer? Firstly, the ACE model shows that what provokes the attacks is the transparent defence: Speculator Sells forward **after** the central bank raises the exchange rate to above the lower bound of the peg. Thirty different simulations using an ACE wind tunnel test of the currency peg with a central bank intervening to raise the exchange and speculator taking a short position shows that the bank cannot win even once viz. ran out of reserves. Flawed Macro economic literature on pre-commitment to transparent strategy caused IMF to support currency pegs and led to the worst policy induced failures of our time. ACE testing may have averted such policy disasters.

## Dynamic instability in a phenomenological model of correlated assets.

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We show that financial correlations exhibit a non-trivial dynamic behavior. We introduce a simple phenomenological model of a multi-asset financial market, which takes into account the impact of portfolio investment on price dynamics. This captures the fact that correlations determine the optimal portfolio but are affected by investment based on it. We show that such a feedback on correlations gives rise to an instability when the volume of investment exceeds a critical value. Close to the critical point the model exhibits dynamical correlations very similar to those observed in real markets. Maximum likelihood estimates of the model's parameter for empirical data indeed confirm this conclusion, thus suggesting that real markets operate close to a dynamically unstable point.

## Stock price fluctuations and the mimetic behaviors of traders.

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The understanding of the market impact, that is the price reaction to a transaction volume, is of a practical importance in order to avoid the risk of paying a large transaction cost, when individual investors or brokerage firms place a large size of order. From many prior works about this subject, it seems to be established that the functional form of the average price impact is monotonically increase and concave. It seems very natural to think that large price changes are caused by large transaction vol-

umes. Farmer et al. has proposed an entirely different story of large price changes[1]. They has argued that large returns are not caused by large orders, while the large gaps between the occupied price levels in the orderbook lead to large price changes in each transaction, and actually showed that the gap distribution closely matches the return distribution, based on the analysis of the orderbook as well as the transaction records on the London Stock Exchange. They have also showed by the experiment of the virtual market orders of a constant size that non-intelligent manner of market order placement reproduces the actual fat tail of return distribution.
If we look at the large returns in the new light, we arrive at the next step of the question, that is, what really causes large gaps. In this presentation, I propose an stochastic model of the order flow in stock markets. If we take the mimetic behavior of traders, when they put limit order, into our model, the fat tail of the distribution of the gap is reproduced. I also analyze the trades and quotes database of the Tokyo Stock Exchange, and point out that the assumption of the independence of the amplitude of returns on the size of transactions cannot fully explain the profile of the average price response[2]. It is important to consider the mimetic behavior of traders at this point too.

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## Market memory and fat tail consequences in risk and option pricing under the expOU stochastic volatility model.

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The geometric Brownian motion is in clear disagreement with real market data [1]. A possible way out to this inconsistency is to assume that the volatility is not a constant but a time-depending random variable. At late eighties different stochastic volatity (SV) models [Brownian motion with random diffusion coefficient] were presented for giving a better price to the options somewhat ignoring their ability to reproduce the real price time series. Recently SV models have been suggested by some physicists as good candidates to account for the so-called stylized facts of speculative markets [2,3,4,5].
We have studied the exponential Ornstein-Uhlenbeck stochastic volatility model [6] and observed that the model shows a multiscale behavior in the volatility autocorrelation [7]. It also exhibits a leverage correlation and a probability profile for the stationary volatility which are consistent with market observations. All these features seem to make the model more complete than other stochastic volatility models also based on a two-dimensional diffusion.
This paper wants to go further on with the expOU model by exploring two aspects of financial markets of practical interest. Using an approximate solution for the return probability density designed to capture the kurtosis and skewness effects we study the resulting option price. We will take parameters estimated from underlying and confront the results with real option prices. In this way, we will be able to relate the market memory estimated from our expOU model with smile and smirk effect in options. The second aspect is related to risk. We will study the survival probability of the stochastic volatility process. The measure can serve us as a measure of risk which have several advantages with respect to VaR measures. We will focuss on the stochastic volatility and check their ability to describe the true behaviour of this market observable.

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## Correlation of worldwide markets' entropies.

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This study reports on coherence or its lack in financial data series from worldwide stock market indices. Previous work on the PSI-20 index [1], provides the motivation for a wider-ranging study, both in a geographical and technical sense, for exploration of several measures of disorder, (entropy). In this work, the focus is on the information contained in the Hurst exponent, as obtained through Detrended Fluctuation Analysis [2].

We propose a new method of studying the Hurst exponent, which includes investigation of both time and scale dependency, [3]. This approach permits recovery of major events, affecting worldwide markets, (such as Sept. 11th 2001) and facilitates examination of the propagation of effects produced across different scales. Such effects may include early awareness, distinctive patterns of recovery, as well as comparative behaviour distinctions in emergent/established markets. The emphasis on time dependence serves to demonstrate the importance of entropy measures as snapshots of market uncertainty, which have their own dynamic.We apply the TSDFA (Time and Scale Detrended Fluctuation Analysis) to a study of the time evolution of each market. Major features may include transition from a developing to a mature state, (International Finance Corporation definition). Comparing the results obtained using TSDFA to all markets, we identify groups that display similar behaviour at any given time. This classification allow us to distinguish perturbations with global or more general effect, (e.g. Asian tiger crash, 9/11, Madrid bomb 2004 and others) from local influences affecting a small set of markets or even a single market only.

Interestingly, in spite of known differences between emerging and established markets, the evidence suggests that, in recent years, entropy measures are convergent across markets studied worldwide. This can be construed as an increasing number of markets achieving or mimicking mature behaviour relatively rapidly, irrespective of their trading capability, which suggests narrowing windows for investors. One plausible explanation for this phenomenon is the progressive globalisation of financial markets (and the increased refinement required perhaps in entropy measures to act as plausible predictors for investment).

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## Markov processes, Hurst exponents, nonlinear diffusion equations, and option pricing.

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We present a large set of scaling solutions of Fokker-Planck partial differential equations where $H \neq 1/2$, showing by direct calculation that a Hurst exponent $H \neq 1/2$, without extra assumptions, does not imply long time correlations like those found in fractional Brownian motion. If a Markov process scales with Hurst exponent $H \neq 1/2$, then it simply means that the process has nonstationary increments. As an example, we generate a class of student-t-like densities from the class of quadratic diffusion coefficients. The Tsallis density is a member of that class. The Tsallis density is usually thought to solve a nonlinear diffusion equation, but instead we explicitly show that it follows from a Markov process generated by a linear Fokker-Planck equation, and therefore from a corresponding Langevin equation. All densities in this class can be superficially disguised to appear as "nonlinear diffusion eqns." Having a Tsallis density with $H \neq 1/2$ therefore does not imply dynamics with correlated signals, e.g., like those of fractional Brownian motion. As an aside, there is no such thing as a "nonlinear Fokker-Planck eqn.", nonlinearity would contradict the Markov process described by a Langevin eqn. We explain in addition why option pricing blows up if fat tails are included, and show that our generalization of the Black-Scholes pde is equivalent to the market Fokker-Planck pde for a special choice of the expected stock interest rate and also describes a Martingale in the risk neutral discounted stock price.

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## Symbolic dynamics and control in a matching labor market model.

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In a recent paper, Levin [8] discusses the set of results presented over the last decade by various prominent physicists which led to the conclusion that black holes seem to be susceptible to chaos. Levin argues that the most realistic description available of a spinning pair of black holes is chaotic motion, and goes on to complain that in physics and cosmology "chaos has not received the attention it deserves in part because the systems studied have been highly idealized". In contrast, in economics we have the interesting fact that even some of the most simple and highly idealized models describing modern economies can easily lead to chaotic dynamics[3].
In this paper we apply the techniques of symbolic dynamics and chaos control to the analysis of a labor market model which shows chaotic behavior and large volatility in employment flows. The possibility that chaotic dynamics may arise in modern labor markets had been totally strange to economics until recently, at least as far as we are aware of. However, in an interesting paper Bhattacharya and Bunzel [1] have found that the discrete time version of the Pissarides-Mortensen matching model, as formulated in [9], can easily lead to chaotic dynamics under standard sets of parameter values. This paper explores this version of the model having two basic objectives in mind: (i) to clarify some open questions raised in the paper of Bhattacharya and Bunzel by providing a rigorous proof of the existence of chaotic dynamics in the model; and (ii) to show that this type of dynamics can be easily controlled by linear feedback techniques — the OGY method — without producing modifications to the original model, apart from locally changing its type of stability. These two techniques may be of significant importance for the study of economic theory and policy, in particular, if complexity becomes more frequently encountered in the models developed to properly describe the behavior of modern economies, and the view of purely exogenous shocks as explaining cycles and volatility looses its large predominance in contemporary economics.

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## Chaotic dynamics in optimal monetary policy with a nonlinear phillips curve.

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Since the early 1990s we have witnessed an increasing consensus in the conduct of modern monetary policy. Goodfriend and King (1997) have labelled this new consensus as "The New Neoclassical Synthesis and the Role of Monetary Policy", while Clarida et al. (1999) called it the "The Science of Monetary Policy: A New Keynesian Perspective". This new framework is a natural extension of the seminal idea developed by Taylor (1993), in which the central bank should conduct monetary policy through an aggressive and publicly known rule with commitment. In fact, this emerging consensus turned upside down the basic prescriptions of monetary and fiscal policies of the old Neoclassical Synthesis of the 60's and 70's, and has led to a standard dynamic general equilibrium model so successful that, as Laurence Ball has recently commented, "the model is so hot that the Keynesians and Classicals fight over who gets credit for it" (2005, 265).
In this paper we extend the standard model by introducing nonlinearity into the Phillips curve. As the lin-

ear Phillips curve in the standard model is clearly at odds with empirical evidence, a similar procedure has already been undertaken in a series papers over the last few years, e.g., Semmler and Zhang (2004), Zhang and Semmler (2003), Nobay and Peel (2000), and Dolado et al. (2004). However, the main results obtained in these papers (mostly based upon continuous time) either are not substantially different from those of the linear case, as the saddle-path stability continues to hold in most of them, or show significant limitations because the particular form of nonlinearity considered leads to inherent difficulties in securing closed form solutions.
In contrast, under the specific form of nonlinearity proposed in our paper (which allows for convexity and concavity and secures closed form solutions), we show that the introduction of a nonlinear Phillips curve into the structure of the standard model in a discrete time and deterministic framework produces radical changes to the major conclusions regarding stability and the efficiency of monetary policy. We should emphasize the following main results: (i) instead of a unique fixed point we end up with multiple equilibria; (ii) instead of saddle–path stability, for different sets of parameter values we may have saddle stability, totally unstable and chaotic fixed points; (iii) for certain degrees of convexity and/or concavity of the Phillips curve, where endogenous fluctuations arise, one is able to encounter some results that seem intuitively correct. Firstly, when the Central Bank pays attention essentially to inflation targeting, the inflation rate has a lower mean and is less volatile; secondly, when the degree of price stickiness is high, the inflation rate displays a larger mean and higher volatility; and thirdly, the higher the target value of the output gap chosen by the Central Bank, the higher is the inflation rate and its volatility. Moreover, the existence of endogenous cycles due to chaotic motion may raise serious questions about whether the old dictum of monetary policy (that the Central Bank should conduct policy with discretion instead of commitment) is not still in the business of monetary policy.

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## Information flow in economy systems, ACP model study.

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Applying any strategy requires knowledge about the state of the system. Unfortunately in the case of economy collecting information is a difficult, expensive and time consuming process. Therefore the information about the system is announced within some well defined intervals, e. g. company reports, inflation data, GDP etc. They describe a market situation in some past. The time delay is specific to the market branch. It can be very short (e.g. stock market offer is updated every minute and this information is immediately available) up to months in the case of agricultural market, when the decisions taken are based on the results from the previous harvest.
The analysis of the information flow delay can be based on the ACP model of spatial evolution of economic systems [1]. The entities can move on a square lattice and when meeting take one of the two following decisions: merge or create a new entity. The decision is based on the system state, which is known with some time delay. Two classes of strategies are considered: with forecast and without forecast. The effect of system's feedback is investigated. The stability conditions are analysed and the question of a governmental control over systematically unstable branches is discussed.

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## Potentials of unbalanced complex kinetics (PUCK) tools of market time series.

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We apply our estimation method of potential force to Yen/Dollar and stock markets. We first introduce an optimal moving average price "$\overline{P}$" and a super moving average price "$\overline{P_M}$" defined by M. Takayasu, et.al.. [1,2] The super moving average $\overline{P_M(t)}$ is a mean from $\overline{P(t-M-1)}$ to $\overline{P(t)}$. Dynamics of the optimal moving average $\overline{P}$ are represented as follows

$$\overline{P(t+1)}-\overline{P(t)} = -\frac{1}{2}\cdot\frac{b(t)}{M-1}\cdot\frac{d}{d\overline{P}}(\overline{P(t)}-\overline{P_M(t)})^2+f(t), \quad (3)$$

where $b(t)$ and $f(t)$ are a coefficient of the potential force and a noise at time $t$. A time unit of the dynamics is 1 tick. We can estimate the market potential in real time using the Eq.(1). We developed a general software called "the PUCK Tool" as shown in Fig.1. The PUCK tool displays news, a price chart of an hour time scale, a time series of potential coefficient $b(t)$, a price chart of 3 minutes time scale, the estimated potential function at the time, and the standard deviation of the future price diffusion modified by the dynamic effect.
The market potential is shown to have spontaneous fluctuations and also it is affected by external factors such as news. For example, the potential changed suddenly from an attractive force $b(t) > 0$ to a repulsive one $b(t) < 0$ on the day of the 9-11 terrorism in 2001. A yen/dollar rate collapsed after the potential change. On October 8, 1998, the yen/dollar rate spontaneously crashed. We can find the potential coefficient $b(t)$ had shown an unstable market before October 8. Therefore, we can predict such market crashes by using the PUCK tools.
The PUCK tools are helpful in a financial policy. For example, we focus on the average of rate change for a yen-selling & dollar-buying intervention in a yen/dollar market. In the case of a repulsive force $b(t) < 0$, the average rate shifts about 0.4 yen/dollar after the intervention. However, when the force is an attractive $b(t) > 0$, the average rate doesn't respond, enough. Therefore, an efficiency of the intervention is good when the market has the repulsive force.
In the workshop, we show many examples and statistical laws of the market potential.

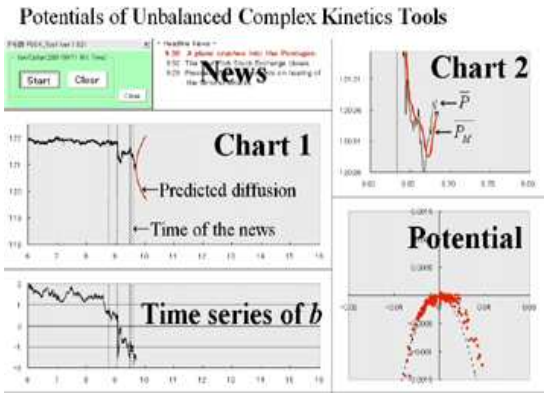

Fig.1 PUCK Tools

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## Mean exit time and survival probability within the CTRW formalism.

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The study of financial market microstructure has been recently the object of intense research. Continuous Time Random Walks (CTRWs) are general models which is able to capture market microstructure, specially that of high frequency data. CTRWs were introduced by Montroll and Weiss in 1965 and have a long history of successful applications to physics, chemistry and geophysics to name a few. To our knowledge, the application of the CTRW to finance is quite recent and its potential has not been fully developed [1-2].
In previous papers [3-4], we computed the mean exit time out of a given region for a set of historical records of asset prices. We detected regularities in the behaviour of this magnitude across the companies. This fact impelled us to develop theoretical models that could explain the observed features of the mean exit time with a good degree of accuracy.
Within the CTRW literature there have been two typical magnitudes under a theoretical study: the mean exit time and the survival probability. We now want to go further from a theoretical point of view based on past observations.

These magnitudes may be easily related to risk control. The link between the value of the mean exit time and the timescale of market fluctuations of a certain size is clear. Therefore, its value may help, for instance, in deciding the optimal horizon for an investment.
However, the mean exit time is only a statistic of a distribution with even bigger interest: the survival probability, the probability that after some elapsed time a process remains inside a given region without having crossed its boundaries. This quantity may outperform the standard "Value at Risk" (VaR) method for two reasons: it will be based on market probabilities different than the unrealistic Gaussian distributions, and it will ensure (within the desired quintile) that the market value of the portfolio will not leave the safe zone.

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## Topology of foreign exchange markets using hierarchical structure methods.

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This paper uses hierarchical techniques to extract an international price influence topological map for 44 major currencies.
The structure of asset price movements within the market are extracted by use of synchronous correlation coefficient matrices of daily difference of log prices to quantify the ultrametric pricing distance between currencies. Two techniques of hierarchical structure theory are used to analyse the ultrametric distance matrices. The first technique is the creation of a minimal spanning tree. The second technique used is the creation of an ultrametric hierarchical tree. We find that these two generate a defined and robust scale free network with meaningful taxonomy, which is fundamentally different from that obtained from stock market topology. The topology is shown to be robust with respect to method, to time horizon and is stable during market crises. This topology gives a guide to determining the underlying economic or regional causal relationships for individual currencies and will prove useful to understanding the dynamics of exchange rate price determination as part of a complex network.

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## Uses of free random variables for random matrix analysis of financial correlation matrices.

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Using the powerful technique of Free Random Variables we present a new and straightforward derivation of spectral properties of several estimators of the financial correlation matrices for correlated Wishart random matrix models. Next we show how to unravel these estimators for various types of asset and/or time correlated models, including distance–dependent correlation matrices and exponentially weighted moving average. Then we generalize presented results for the case of the data exhibiting heavy tails, obtaining several new results for multivariate analysis of Lévy random matrices. The presented formalism

is very general, and directly applicable for the cases of other known probability distributions.

## Relative efficiency in financial markets.

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We investigate the relative market efficiency for adiverse financial market data, using the Approximate entropy(ApEn) method for a quantification of a complexity, an irregularity and unpredictability in the time series. We investigate the global foreign exchange market indices in 26 countries from 1984 to 1998. We find that the ApEn for the Asian FX market except the Japan is smaller than those for the European FX market. We also investigate the individual stock in the $S\&P500$ and the KOSPI stock market from 1993 to 2003. The Averaged ApEn from the $S\&P500$ stock market is shown to be larger than one from the KOSPI stock market. Notably, we find that the ApEn value from the financial market, which has the market crisis are decrease during the market crisis.

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## Peculiar gain-loss asymmetry for emerging stock markets.

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Stock indices for some European emerging markets are analyzed via an investment horizon approach. Gain-loss asymmetry, originally found for American Dow Jones index, is observed. It happens however, that this asymmetry has completely different character for emerging markets as compared to established ones. Austrian ATX index and Dow Jones has been studied for comparison. When mean waiting time 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 situation is just the opposite. We propose a measure of gain-loss asymmetry and try to provide an interpretation to this unexpected result.

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## Different risk measures and portfolio optimization.

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Various risk types and their measures are introduced, investigated, and compared. It is shown that (and how) their choice influences a portfolio optimization process and its outcome. Some illustrative examples from Warsaw Stock Exchange are provided.

## Many-agent models in economic and social sciences.

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We review some statistical models of economic and social systems inspired by microscopic molecular models [1] and discuss their stochastic interpretation. We consider the application of these models to some examples of social systems, e.g. wealth exchange in economic models [2, 3]. The shape of the resulting stationary distribution depends on a small number of key parameters of the system,

that define and diversify the agent profiles. We show how these parameters can be tuned in order to reproduce real data and discuss their dynamical meaning.

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## Medium and small scale analysis of financial data.

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A stochastic analysis of financial data is presented. Evidence is given that the log return $R(\tau)$ upon different time scales $\tau$ can be described as a Markov process evolving in $\tau$. Thus the $\tau$-dependence of the probability density functions (pdf) $p(R,\tau)$ on the time scale $\tau$ can be described by a Fokker-Planck equation, a generalized diffusion equation for $p(R,\tau)$. With such a stochastic approach the general joint pdf for arbitrarily many different time scales $\tau_i$ can be described providing a non-equilibrium thermodynamical description of the complexity of the data. Beside the direct calculation of the coefficients from the data a new method is shown how this coefficients can be obtained. This new method utilizes an optimization process based on conditional probability densities, computed directly from the data, yielding coefficients for an effective Fokker-Planck equation. It is shown that the solutions of the resulting Fokker-Planck equation describe the empirical pdfs correctly, including the pronounced fat tails. For very small timescales (typically smaller than several minutes) this Markov process description is no longer valid indicating a different stochastic behaviour for very small timescales. A method is introduced in order to analyse the shape evolution of the highly non Gaussian pdfs with time scale parameter $\tau$ in this domain. We demonstrate that for individual stocks a small timescale regime exists, that exhibits a profound different evolution of shape in the timescale $\tau$. This regime seems to be universal for individual stocks and based on a distinct relation of consecutive increments on small timescales.

## The impact of heterogeneous trading rules on the limit order book and order flows.

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In the last few years several order driven microscopic models have been introduced to explain the statistical properties of asset prices. In this paper we develop a model of an order-driven market where traders set bids and asks and post market or limit orders according to exogenously fixed rules. The model developed here extends the earlier one of Chiarella and Iori [1] in several important aspects, in particular agents have heterogenous time horizons and can submit orders of sizes larger than one, determined by utility maximisation. The model seeks to capture a number of features suggested by recent empirical analysis of limit order data, such as fat-tailed distribution of limit order placement from current bid/ask; fat-tailed distribution of order execution-time; fat-tailed distribution of orders stored in the order book; long memory in the signs (buy or sell) of trades.
We analyze the impact of chartist and fundamentalist strategies on the determination of both the placement level and the placement size, on the shape of the book, the distribution of orders at different prices, and the distribution of their execution time. We compare the results of model simulations with real market data.

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## Roughness and finite size effect in the NYSE stock-price fluctuations.

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We consider the roughness properties of NYSE (New York Stock Exchange) stock-price fuctuations. The statistical

properties of the data are relatively homogeneous within the same day but the large jumps between different days prevent the extension of the analysis to large times. This leads to intrinsic finite size effects which alter the apparent Hurst (H) exponent. We show, by analytical methods, that finite size effects always lead to an enhancement of H [1]. We then consider the effect of fat tails on the analysis of the roughness and show that the finite size effects are strongly enhanced by the fat tails. The non stationarity of the stock price dynamics also enhances the finite size effects which, in principle, can become important even in the asymptotic regime. We then compute the Hurst exponent for a set of stocks of the NYSE and argue that the interpretation of the value of H is highly ambiguous in view of the above results. Finally we propose an alternative determination of the roughness in terms of the fluctuations from moving averages with variable characteristic times. This permits to eliminate most of the previous problems and to characterize the roughness in useful way. In particular this approach corresponds to the automatic elimination of trends at any scale [2].

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## Kelly criterion revisited: optimal bets.

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When John L. Kelly was working for Bell Labs, he observed analogies between calculation of the optimal player's stake who enters in a gambling game and the effective transmission of information in a noisy communication channel. During the last half century the strategy which was proposed by Kelly becomes very popular among gamblers inspired many authors of articles and books. The original paper dates from 1956 and is hardly available. Therefore, with the AT&T consent, it has been recently reproduced in LaTeX. Today, strategies based on Kelly criterion are successfully adopted in financial markets, blackjack and even horse races. Kelly's approach allows for an interesting financial interpretation of the Boltzmann-Shannon entropy. We analyze this topic and the reasons why the use of the Kelly criterion, which is to maximize the expected value of the logarithm of wealth, gives an economic advantage over different strategies. We explore the projective symmetry for a scientific explanation of this fact. We analyse bookmaker's bets and show that this is a generalization of model described by Kelly. Does the Kelly criterion unambigously specify the winning strategy? In the thermodynamic limit the maximization of the mean logarithm of the profit rate still leaves the freedom of adopting different strategies. Because of calulational dificulties, only the limit case of extreme profit can be given in a concise analytical form. Kelly's association suggests a method of describing effectiveness of agents investing in the financial market in thermodynamical terms.

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## Fractionally integrated process with asymmetric distributions for transition economics.

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We investigate European transition economics and show that for their financial indices majority of the time series are power-law correlated both serially and in the magnitudes [1]. Regarding serial correlations, the results in this study suggest that we can divide stock markets into two groups: markets with strong power-law correlations (e.g. Russia), and markets with no or only a weak form of power-law dependence (e.g. Poland). We apply phase-randomization procedure on the time series in order to investigate possible nonlinearity in the financial data. After phase-randomization procedure is applied, we show that magnitude correlations completely vanish in the data. To model the scaling behavior found in the empirical data, we propose a process exhibiting the same scaling properties[1-3]. The process is defined with only one scaling parameter. We extend the process by introducing asymmetry in the probability distributions, where asymmetry is controlled by only one extra parameter. We show that commonly employed processes do not exhibit the scaling properties found in the data.

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## Non-parametric extraction of implied asset price distributions.

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The statistical distribution of market prices can give clues to the underlying mechanism driving them. The conventional assumption of Brownian motion and associated Gaussian distribution has known shortcomings, notably for assessing risk of financial loss. Particularly useful information lies in the market prices of options contracts. Options can be priced in terms of a discounted expectation with respect to the price probability distribution - the risk neutral density (RND) function. In recent years, there has been much interest in the recovery of the complete RND. Market participants use it for investment decisions. For risk management, knowledge of the entire RND provides more information for Value-at-Risk calculations than implied volatility alone [1].
Extracting the RND is well defined in principle, but is very sensitive to errors in practice. Typically, RNDs are deduced from option prices by making a distributional assumption, or relying on implied volatility [2]. We present a fully non-parametric method for extracting such risk-neutral densities from observed option prices. The aim is to obtain a continuous, smooth, monotonic, and convex pricing function that is twice differentiable. Thus, irregularities such as negative probabilities that afflict many existing RND estimation techniques are reduced. Our method employs neural networks to obtain a smooth pricing function, and a central finite difference approximation to the second derivative to extract the required gradients. This novel technique was successfully applied for the first time to a large set of FTSE 100 daily European exercise (ESX) put options data and also to the corresponding set of American exercise (SEI) put options. The results of paired t-tests showed significant differences between RNDs extracted from European and American option data, reflecting the distorting impact of early exercise possibility for the latter. In particular, the results for skewness and kurtosis suggested different shapes for the RNDs implied by the two types of put options. However, both ESX and SEI data gave an unbiased estimate of the realised FTSE 100 closing prices on the expiration date of the options. We confirmed that estimates of volatility from the RNDs from both types of option gave unbiased estimates of the actually realised volatilities at expiration.

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## Wealth distributions: a review of models and empirical data.

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We review briefly approaches aimed at understanding the distribution of money in society since the first studies by Pareto at the end of the 19th century. Data for UK income distributions over the period 1992 to 2002 is examined in detail and compared with the log normal, Boltzmann and generalized Lotka-Volterra distribution functions. We conclude that it is possible to describe the entire income distribution from the low to medium income range through to the Pareto power law region with a single function of the Lotka Volterra type. It is not necessary to invoke different mechanism for these two different regions. We comment on values observed for the Pareto exponent both in this study and by others in recent years. Some observations relating to possible improvements required within the model will be discussed.

## On the maximum drawdown during speculative bubbles.

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The importance of large drawdowns is well known in port-

folio management problems. This paper aims to explore within a probability framework [1, 4, 5, 6] the behavior of maximum drawdown of stock market indices during periods of speculative bubbles due to endogenous causes. The theory of speculative bubbles has been enhanced during the last years by the models describing systems close to some rupture point [3, 7] that evidence the role of log-periodic functions as they emerge from a discrete scaling invariance hypothesis. Huge data analyses support theoretical results by providing empirical evidence. In [2] a wide comparative analysis over market indices is performed, and in [3] the drawdowns are examined. This papers starts from comparative analyses of the self similarity properties of stock market indices modeled through the above theory and therefore shows how to apply probability results in order to estimate the probability of the occurrence of drawdowns.

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## Asset price dynamics in a financial market with heterogeneous trading strategies and time delays.

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In this paper we present a continuous time dynamical model of heterogeneous agents interacting in a financial market where transactions are cleared by a market maker. The market is composed of fundamentalist, trend following and contrarian agents who process information from the market with different time delays. Each class of investors is characterized by path dependent risk aversion. We also allow for the possibility of evolutionary switching between trend following and contrarian strategies. We find that the system shows periodic, quasi-periodic and chaotic dynamics as well as synchronization between technical traders. Furthermore, the model is able to generate time series of returns that exhibit statistical properties similar to those of the S&P500 index, which is characterized by excess kurtosis, volatility clustering and long memory.

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## Frequency analysis of tick quotes on foreign exchange markets and agent-based model.

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The recent accumulation of high frequency financial data due to development and spread of information technologies has sparked considerable interest among researchers [1,2]. Many researchers expect that they bring new finding and insights to finance and physics [3,4]. On the other hand agent-based models as complex systems are attracting significant interest across a broad range of disciplines.

Many agent-based models to explain behaviors of financial markets are proposed [5,8,6,7]. The agent-based models are expected to be an alternative to phenomenological models that duplicate mimic market price fluctuations. Specifically it seems to be worth to consider the explanation capability of the agent-based models for causality.
In this presentation we show results of frequency analysis of tick quotes on foreign exchange markets and propose a simple agent-based model in order to explain the observed behaviors of market participants in the markets [9,10]. As results of frequency analysis for high frequency financial data periodic behaviors of the market participants are observed. Moreover they appear and disappear depending on observation periods. In order to confirm them in detail we calculate spectrograms of the number of tick quotes per unit time (market activity).
The agent-based model which consists of market participants to decide three kinds of investment attitudes is proposed to explain this periodic behavior of market participants. In this model the agents perceive information in environment, which are separated into exogenous factor (news about events) and endogenous factor (news about market fluctuations) and decide their actions based on them. They have two thresholds to decide three kinds of investment attitudes, namely, buying, selling, and waiting.
From numerical simulation it is demonstrated the market participants behave periodically even thought a periodical subthreshold exogenous signal not to influence their decision-making directly exists. The stochastic difference equation for the market activity are derived approximately and it explains the periodic behaviors of market participants. Furthermore it is clarified that the periodic behaviors of the market activity are dependent on uncertainty of their decision-marking.
We conclude that appearance and disappearance of periodic behaviors observed in the market activity can be explained if there exists a weak periodic exogenous signal. The frequency analysis of the market activity is expected to bring deep understanding and insights of financial markets.

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## How long does a trader wait until the next price change? –Queueing theoretical approach–

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We introduce a queueing theoretical approach to financial time series analysis. As one of the applications of the queueing theoretical approach, we here analyze the average waiting time (AWT), which is defined as the mean time for a trader to wait until the next price change from any time point when they want to check the price, for example when they login to their computer systems. In order to evaluate the AWT, we use what we call Renewal-reward theorem which is well-known in the field of queueing theory. The theorem implies that the AWT is written in terms of first and second moments of the distribution of time intervals between price changes. Thus, the AWT can be calculated by the theorem, if we have the explicit form for the distribution. In this talk, we analyze the AWT of the Sony bank USD/JPY rate both theoretically and empirically using the theorem. The Sony bank rate is the foreign exchange rate that Sony bank offers to their customers on their online FX trading service. If the market rate changes by more than 0.1 yen, the Sony bank rate is updated to the market rate. Our data set is $\sim$ 31,000 data for the period of September 2002 to May 2004. We find that the theorem is a good agreement with empirical evidence. One of the authors (N.S.) showed previously [1] that time intervals of Sony bank USD/JPY rate are well approximated by a Weibull distribution. The theorem gives that the AWT of the fitted Weibull distribution is $\sim$ 44 minutes, which is close to empirical value of the AWT $\sim$ 49 minutes. However, if we assume an exponential distribution describes a Poisson arrival process, the theorem shows that the AWT is equal to the average time interval between price changes $\sim$ 21 minutes [2], which is less than half of empirical evidence. This fact is a justification for non-exponential time intervals of the Sony bank USD/JPY rate as shown in [1] and consistent with recent empirical studies of high frequency financial data

[3,4]. The empirical evidence also shows that we actually need to wait more than twice the average interval between price changes.

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## Growth and inequality processes: equilibrium and non equilibrium models in Physics and Economics.

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This presentation reviews models that have been developed in order to explain growth and inequality including:

Eleonora Bennati's perfect gas model

John Angle's one parameter inequality process

"Gibrat's" law of proportional effects

– "Sedulo curavi humanas actiones non ridere, non lugere, neque detestari, sed intelligere" Baruch Spinoza, Tractatus Politicus, (Opera Posthuma), Amsterdam, 1677.

## Two-power law behavior in the personal income distribution.

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It is widely observed that economical systems, and more in general complex systems, are characterized by power-law distributions. Quite often, these distributions show a changing of the slope in the tail so that, more appropriately, they are multi-power-law distributions. For instance, personal income distributions exhibit such a slope changing for high income, giving origin to the well-know Pareto region. We present a method to derive analytically a two-power-law function starting from a single power-law distribution recently obtained, in the frameworks of the generalized statistical mechanics, by employing an optimizing method applied to the Sharma-Taneja-Mittal information measure. In order to test the predictability of the method we fitted the cumulative distribution of total personal income of several countries, obtaining a good agreement for a wide range of data values.

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## Long-term memory in the Irish market (ISEQ): evidence from wavelet analysis.

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Researchers have used many different methods to detect the possibility of long-term dependence (long memory) in stock market returns, but evidence is in general mixed. In this paper, three different tests, (namely Rescaled Range (R/S), its modified form, and the semi-parametric method (GPH)), in addition to a new approach using the discrete wavelet transform, (DWT), have been applied to the daily returns of five Irish Stock Exchange (ISEQ) indices. These methods have also been applied to the volatility measures (namely absolute and squared returns). The aim is to investigate the existence of long-term memory properties. The indices are Overall, Financial, General, Small Cap and ITEQ and the results of these approaches show that there is no evidence of long-range dependence in the returns themselves, while there is strong evidence for such dependence in the squared and absolute returns. Moreover, the discrete wavelet transform (DWT) provides additional insight on the series breakdown. In particular, in comparison to other methods, the benefit of the wavelet transform is that it provides a way to study the sensitivity of the series to increases in amplitude of fluctuations as well as changes in frequency. Finally, based on results for these methods, in particular, those for DWT of raw (or original), squared and absolute returns, it can be concluded that there is strong indication for persistence in the volatilities of the emerging stock market returns for the Irish data.

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## Geometry of financial markets – Towards information theory model of markets.

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Most of parameters used to describe states and dynamics of financial market depends on proportions of the appropriate variables rather than on their actual values. Therefore, projective geometry seems to be the correct language to describe the theater of financial activities. We suppose that the object of interest of agents, called here baskets, form a vector space over the reals. A portfolio is defined as an equivalence class of baskets containing assets in the same proportions. Therefore portfolios form a projective space. Cross ratios being invariants of projective maps form key structures in the proposed model. Quotation with respect to an asset $\Xi$ (ie in units of $\Xi$) are given by linear maps. Among various types of metrics that have financial interpretation, the min-max metrics on the space of quotations can be introduced. This metrics has an interesting interpretation in terms of profit rates of return. It can be generalized so that to incorporate a new numerical parameter (called temperature, cf [1,2]) that describes agent's lack of knowledge about the state of the market. In a dual way, a metrics on the space of market quotation is defined. In addition, one can define an interesting metric structure on the space of protfolios/quotation that is invariant with respect to hyperbolic (Lorentz) symmetries of the space of portfolios. The introduced formalism opens new interesting and possibly fruitful fields of research.

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## Complexity Emergence in Economics: theory and applications.

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I will review some generic mechanisms responsible for the generic emergence of collective adaptive phenomena in a wide range of economics applications.
In particular I will explain theoretically and illustrate phenomenologically the role of discrete auto-catalytic agents and discrete asynchronous interactions in the emergence of economic complex phenomena.

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## Complex economic systems structural organization modelling.

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One of the well-known results of the theory of management is the fact, that multi-stage hierarchical organization of management is unstable. Hence, the ideas expressed in a number of works by Don Tapscott (see, for example, [1]) on advantages of network organization of businesses over vertically integrated ones is clear. While studying the basic tendencies of business organization in the conditions of globalization, computerization and internetization of the society and the results of the financial activities of the well-known companies, the authors arrive at the conclusion, that such companies, as IBM, Boeing, Mercedes-Benz and some others companies have not been engaged in their traditional business for a long time. Their partner networks performs this function instead of them. The companies themselves perform the function of system integrators.
The Tapscott's idea finds its confirmation within the framework of a new powerful direction of the development of the modern interdisciplinary science – the theory of the complex networks (CN) [2]. CN-s are multifractal objects, the loss of multifractality being the indicator of the system transition from more complex state into more simple state. We tested the multifractal properties of the data using the wavelet transform modulus maxima approach in order to analyze scaling properties of our company. Comparative analysis of the singularity spectrum$f(\alpha)$, namely, the difference between maximum and minimum values of $\alpha$ ($\Delta = \alpha_{\max} - \alpha_{\min}$) shows that IBM company is considerably more fractal in comparison with Apple Computer. Really, for it the value of $\Delta$ is equal to 0.3, while for the vertically integrated company Apple it only makes 0.06 – 5 times less. The comparison of other companies shows that this dependence is of general character. Taking into consideration the fact that network organization of business has become dominant in the last 5-10 years, we carried out research for the selected companies in the earliest possible period of time which was determined by the availability of data in the Internet, or by historically later beginning of stock trade of computer companies. A singularity spectrum of the first group of companies turned out to be considerably narrower, or shifted toward the smaller values of $\alpha$ in the pre-network period. The latter means that dynamic series were antipersistant**.** That is, these companies‘ management was rigidly controlled while the impact of market mechanisms was minimized. In the second group of companies if even the situation did changed it did not change for the better. In addition, we discuss applications to the construction of portfolios of stock that have a stable ratio of risk to return.

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## Importance of positive feedbacks and over-confidence in a self-fulfilling Ising model of financial markets.

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We study a model of financial price dynamics resulting from the collective aggregate decisions of agents. This model incorporates imitation, the impact of external news and private information. It has the structure of a dynamical Ising model in which agents have two opinions (buy or sell) with coupling coefficients which evolve in time with a memory of how past news have explained realized market returns. We study two versions of the model, which differ on how the agents interpret the predictive power of news. We show that the stylized facts of financial markets are reproduced only when agents are over-confident and mis-attribute the success of news to predict return to herding effects, thereby providing positive feedbacks leading to the model functioning close to the critical point. Our model exhibits a rich multifractal structure characterized by a continuous spectrum of exponents of the power law relaxation of endogenous bursts of volatility, in good agreement with previous analytical predictions obtained with the multifractal random walk model and with empirical facts.

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## Hitting time distributions in financial markets.

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We analyze the hitting time distributions of stock price returns in different time windows, characterized by different levels of noise present in the market. The study has been performed on two sets of data from US markets. The first one is composed by daily price of 1071 stocks trade for the 12-year period 1987-1998, the second one is composed by high frequency data for 100 stocks for the 4-year period 1995-1998. We compare the probability distribution obtained by our empirical analysis with those obtained from different models for stock market evolution. Specifically by focusing on the statistical properties of the hitting times to reach a barrier or a given threshold, we compare the probability density function (PDF) of three models, namely the geometric Brownian motion, the GARCH model and the Heston model with that obtained from real market data. We will present also some results of a generalized Heston model.

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## The growth of business firms: theoretical framework and empirical evidence.

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Gibrat, building upon the work of the astronomer Jacobus Kapteyn, assumed the expected value of the growth rate of a business firm's size to be proportional to the current size of the firm, the so called "Law of Proportionate Effect". Several models of proportional growth have been subsequently introduced in economics in order to explain the growth of business firms. Herbert A. Simon and co-author extended Gibrat's model by introducing an entry process according to which firm numbers rise over time. In Simon's framework, the market consists of a sequence of many independent "opportunities" which arise over time, each of size unity. Models in this tradition have been challenged by many researchers who found that the firm growth distribution is not Gaussian but displays a tent shape [1].
We introduce a general framework that provides an unifying explanation for the growth of business firms based on the number and size distribution of their elementary constituent components [2]. Specifically, we present a model of proportional growth in both the number of units *and* their size, and we draw some general implications on the mechanisms which sustain business firm growth. According to the model, the probability density function (PDF) of growth rates is Laplace in the center with power law tails decaying as $P(g) \sim g^{-\zeta}$ where $\zeta = 3$.
Due to data limitations, previous studies in this field have been focusing exclusively on the Laplace shape of the body of the distribution. Thanks to a new economic database on the size and growth of firms and products, we are able to characterize the shape of the entire growth rates distribution.
We test our model by analyzing different levels of aggregation of economic systems, from the micro level of products to the macro level of industrial sectors and national economies. We find that the model accurately predicts the shape of the PDF of growth rate at all levels of aggregation.

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## Opinion dynamics: How can one influence the social network?

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The opinions of people have been modelled through one or several integers or real nunbers; in the simplest case each person has just one opinion (yes or now) on one question. Voter or Axelrod models are examples from last century, while in this century the model of Krause and Hegselmann, of Deffuant et al, and of Sznajd became fashionable. We check how a single person can influence the opinions of the rest of the population, a question known as damage spreading in physics but going back to Stuart Kauffman in genetics. Also the hierarchical opinions of the terrorism model of Castillo-Chavez and Song are checked in this aspect. Many of these simulations are made on Barabasi-Albert networks, but also the reciprocity variant of ethnologist Schnegg will be presented.

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## Recurrence quantification analysis and state space divergence reconstruction for financial time series analysis.

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The application of Recurrence `Quantification` Analysis (RQA) [1] and State space divergence reconstruction [2] for the analysis of `financial` time series in terms of thresholds detection, cross-correlation [3] and forecasting [4-5] is illustrated using high-frequency as well as daily time series. The results indicate that these techniques, able to deal with non-stationarity in the time series, are able to help in the understanding of the complex dynamics hidden on `financial` markets. Furthermore, a possible on-line trading strategy will be illustrated and the results with high frequency foreign exchange time series with and without transition costs shown.

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## Econophysics of interest rates and the role of monetary policy.

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This paper presents empirical evidence using recently developed techniques in econophysics suggesting that the degree of long-range dependence in interest rates depends on the conduct of monetary policy. We study the term structure of interest rates for the US and find evidence that global Hurst exponents change dramatically according to Chairman Tenure in the Federal Reserve Board and also with changes in the conduct of monetary policy. In the period from 1960's until the monetarist experiment in the beginning of the 1980's interest rates had a significant long-range dependence behavior. However, in the recent period, in the second part of the Volcker tenure and in the Greenspan tenure, interest rates do not present long-range dependence behavior. These empirical findings cast some light on the origins of long-range dependence behavior in financial assets.

## Multifractality in interest rates and monetary policy.

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This paper studies the dynamics of Brazilian interest rates for short-term maturities. Brazil has one of the highest interest rates (both in nominal and real terms) in the world and has changed monetary policy recently. The paper employs recently developed techniques in the econophysics literature and tests for long-range dependence and multifractality in the term structure of these interest rates for the last decade. Empirical results suggest that the degree of multifractality has changed over time due to changes in monetary policy. Therefore, we show that it is possible to identify monetary arrangements using these techniques from econophysics.

## Analysis of consumer purchasing data.

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We analyze high-precision daily records of sales of home electronics. We firstly estimate the effect of calendar. By summing up the total sales for each day of the week we can easily confirm that the sales on Sunday or Saturday are nearly 3 times larger than those on a weekday.
Then, after normalizing this calendar effect we introduce the best moving average that minimizes residuary terms. It is found that simple moving average with time scales about 2 weeks makes the sum of square of residues minimal and its autocorrelation vanishes immediately.
We observe the statistics of fluctuations around the best moving average and found that the theoretical estimate of Poisson processes fits nicely with the real data. This result indicates that human action of purchase of consumer goods can be modeled by a Poisson process with the characteristic time scale about two weeks.

## Physical meaning of potential forces observed in the markets.

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By comparing moving averages of various time scales we can estimate potential forces working in the markets directly from the data [1]. I will review the method and check its validity.
For pure random walks the statistics of the estimated force follows a nearly Gaussian as shown in Fig.1. For real data the distribution is quite different from this theoretical case, which clearly demonstrates the validity of our analysis. Theoretically it can be shown that such random walk in a moving potential function realizes in the situation that each track of random walk produces either attractive or repulsive forces. From the viewpoint of physics this type of history-dependent random walk is a new type that automatically has similar properties with market price fluctuations.
In most cases the observed potential functions are nearly symmetric and in such cases we can only predict the speed of diffusion. However, there are cases that the potential function becomes asymmetric when we can predict the averaged direction of price changes.

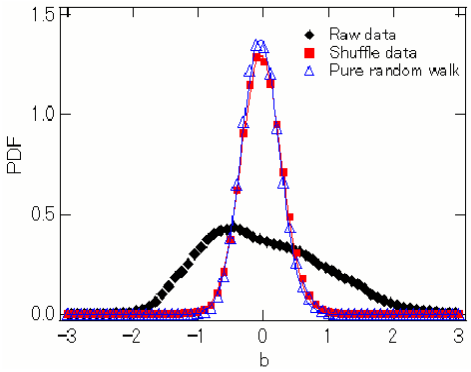


Fig.1 The distribution of the coefficient of the potential force. Simple random cases follow nearly Gaussian.

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## Volatility of stock market index of different economies.

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The volatility, introduced by H. E. Stanley and co-workers [Physica A 245 (1997) 441], of stock market index from 1997 to 2004 is studied for countries from three subgroups of economies classified by the International Monetary Fund: developing Asian countries, newly industrialized Asian economies and major advanced economies. For all markets, the volatility for small time windows is well-fitted by a lognormal probability density in the central part. The developing Asian countries have the largest lognormal shape parameters, except Chinas SSEC and Indias SENSEX. The shape parameters for these two developing countries are closer to those for the newly industrialized Asian economies; in particular, the shape parameter for Chinas SSEC is close to the one for Hong Kongs HSI. The shape parameters for the newly industrialized Asian economies are in between those for the developing Asian countries and major advanced economies, consistent with the results [Physica A 324 (2003) 183] for the generalized Hurst exponent for the second-order moment of the increments of natural-log(index).

## Periodic attractors of random truncator maps.

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This paper introduces the *truncator* map as a dynamical system on the space of configurations of an interacting particle system. We represent the symbolic dynamics generated by this system as a non-commutative algebra and classify its periodic orbits using properties of endomorphisms of the resulting algebraic structure. A stochastic model is constructed on these endomorphisms, which leads us to the classification of the distribution of periodic orbits for random truncator maps. This framework is applied to investigate the periodic transitions of Bornholdt's spin market model.
In particular, let $\Omega = [-1,1]^N$ for some positive dimension $N$ and consider a set $\{S_j\}_{j=1}^M$ of mutually exclusive and exhaustive subsets of $\Omega$. A typical example will be the generalized quadrants, i.e.

$$S_j = \left\{ x \in \Omega \,|sgn(x_i) = \alpha_i,\ 1 \le i \le N \text{ and } \sum_{i=1}^{N} \alpha_i 2^i = 4j + 2 - 2^{N+1} \right\},$$

where the unique set of $\{\alpha_i\}$ denotes the binary decomposition of the integer $j \le M$.
Given a mapping $f : \Omega \longrightarrow \Omega$, we define the *truncator* map as the following discrete dynamical system:

$$x(n+1)_i = x(n)_i sgn\left(f\left(x(n)\right)_i\right). \tag{4}$$

In this paper we specialize to the case of *shuffling* maps, i.e. $f$ which can be expressed as a set of invertible operators $A_j$ associated with each component $S_j$ of $\Omega$.
Specifically, consider the finite group $G = \{1, 2, \ldots, M\}$ endowed with an operation $\circ$ such that, for every $g \in G$, $g \circ g = 1$. This group is naturally isomorphic to the cyclic product group $\mathcal{Z}_2 \times \mathcal{Z}_2 \times \ldots \times \mathcal{Z}_2$ of $M$ factors, which can be represented as a modulo multiplication group $M_n$ for some large enough $n$ such that $\phi(n) = M$, where $\phi$ is the Euler totient function. In this setting, assign an invertible operator $A_j$ to each component $S_j$ of $\Omega$, with the property that $A_j(S_i) = S_{i \circ j}$. The associated *shuffling* map is given by a mapping $\varphi : G \longrightarrow G$ such that $f|_{S_i} = A_{\varphi(i)}$. Using this notation, the resulting truncator dynamics can be described as

$$x(n+1) = \sum_{i=1}^{M} A_{\varphi(i)}\left(x(n)\right) \mathbf{1}_{S_i}\left(x(n)\right). \tag{5}$$

These dynamics arise in a variety of settings. We were driven to study the truncator dynamics because they represent the frozen phase limit ($\beta \to \infty$) of a class of interacting particle systems describing economic interactions and opinion formation [1,8]. In this setting, the points $x$ represent configurations of a spin network and the shuffling map represents the interaction Hamiltonian that describes the influence of local and global effects to the flipping of individual spins.

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## Analysis of stochastic evolution.

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Many studies in Economics and other disciplines have been reporting distributions following power-law behavior (i.e distributions of incomes (Pareto's law), city sizes (Zipf's law), frequencies of words in long sequences of text etc)[1]. This widespread observed regularity has been explained in many ways: GLV equations, self-organized criticality and highly optimized tolerance [2,3,4]. The evolution of the phenomena exhibiting power-law behavior is often considered to involve a varying, but size independent, proportional growth rate, which mathematically can be modeled by geometric Brownian motion $dX_t = r_t X_t dt + \alpha X_t W_t$ where $W_t$ is white noise or the increment of a Wiener process. It is the primary purpose of this article to study both the upper tail and lower tail of the distribution following the geometric Brownian motion and to correlate this study with recent results showing the emergence of power-law behavior from heterogeneous interacting agents [5]. The result is the appearance of similar properties across a wide range of applications.

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[3] X. Gabaix, *Zipfs law for cities: an explanation* in Quarterly Journal of Economics **114** (1999), 739-767.
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## Long term market structure from cointegration maps.

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We employ the Bayesian framework [1] to define a cointegration [2] distance between two assets. We also address the question of cointegration transitivity within the same framework. For clustering and visualization of pairwise relationships in a set of assets we calculate a distance matrix and introduce a map based on the Sorting Points Into Neighboorhoods (SPIN) technique [3], which has been previously used to analyse large data sets from DNA arrays. We compare the correlation and cointegration maps in four data sets: stock indices, US interest rates, foreign exchange and GDPs. We advocate cointegration maps as a suitable tool to study the market structure at macroeconomic time scales.

[1] E.T. Jaynes, G.L. Bretthorst, Probability theory: the logic of science, CUP (2003).
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[3] D. Tsafrir et al., Bioinformatics **21** 102005 (2005), 2301-2308.

## Valuation of stochastic interest rate securities with time dependent variance.

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We consider the problem of valuation of interest rate securities. We show how to generalize the results of Cox, Ingersoll and Ross to the case where the stochastic evolution of the interest rate involves time dependent coefficients and the payoff is arbitrary. We solve this problem in terms of the propagator for the heat operator with a potential.

## Analysis of the Japanese government intervention on the domestic piglets production market.

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Before the oil crisis in 1974 the prices and the number of produced piglets in Japan fluctuated with large amplitude and this created problems to farmers who were unable to plan their future production as well as to the customers who were uncertain about the prices in the near future. As a reaction of the instability of the imports after 1974 the Japanese government introduced various regulation measures in order to make the Japanese economy more adaptive. Here we discuss the results of the measures concerning the piglets production market [1]. The discussion is based on the analysis of the time series for the piglet prices and piglet production numbers by the means of the methods of the nonlinear time series analysis [2,3]. We show that the regulation politics was very successful and has lead to decreasing unpredictability of the prices and to a smoothing of the piglet production.

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## Extracting the exponential behaviors in the market data.

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Market prices sometimes show exponential growth or decay in cases of bubbles or crashes. If we can find such dynamical behaviors from the real time market data, we will be able to avoid big market confusion caused by the large fluctuations. In this paper we present our general approach of extracting exponential behaviors for any given time series data.
Our algorithm is based on a weighted-moving-average or the autoregressive model in the non-stationary parameter range. First we fix the observation time-scale and find the best-fit exponential trend in each piece of data. Next, we subtract the exponential contribution and approximate the residual fluctuation by the standard AR model. Then, we check the statistical validity of this set of approximations and repeat the process for various observation time-scales.We will argue at what time-scale the real price fluctuation shows the non-stationary dynamical behaviors most clearly.

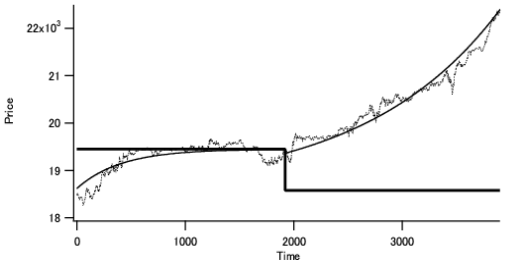


Fig.1 An examples of given data(dots), exponential trends (line), and the basic prices of the divergences and the convergences (heavy line).

[1] T. Ohnishi, T. Mizuno, K. Aihara, M. Takayasu, and H. Takayasu, Proceedings of Practical Fruits of Econophysics (edited by H. Takayasu, Springer, 62-66, 2005).
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[3] M. Takayasu, T. Mizuno, and H. Takayasu, Preparing.

## Distribution of log-returns in the Heston model obtained by subordination to the fluctuating number of trades.

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It is well known that the probability distribution $P_t(x)$ of log-returns $x$ after a time lag $t$ is not Gaussian. These deviations are often associated with the power-law tails. However, the central part of the distribution is also strongly non-Gaussian and typically has the double-exponential (Laplace) shape for short $t$ [1]. (This is also true for hydrodynamic turbulence in physics [2].) In Ref. [1], we quantitatively fitted the evolution of the stock market data for $P_t(x)$ from the double-exponential (Laplace) distribution to the Gaussian distribution with the increase of $t$ using the solution [3] of the Heston model with stochastic volatility. Here we show that the Heston model can be represented by a Gaussian process subordinated to a stochastic integrated variance $V_t = \int_0^t \sigma_{t'}^2 \, dt'$, where $\sigma_t$ is the instantaneous volatility, and derive the probability distribution $P_t(V_t)$ [4]. We conjecture that the integrated variance $V_t$ can be identified with the number of trades $N_t$ during the time interval $t$. We show that the distribution of log-returns after $N$ trades is approximately Gaussian, but the probability distribution $P_t(N)$ is given by a non-trivial function derived from the Heston model, thus giving a non-trivial $P_t(x)$. We analyze the high-frequency stock-market data and find that this conjecture indeed works reasonably well for mesoscopic time lags $t$ from about an hour to a month [4]. Subordination can be also interpreted as a continuous-time random walk with stochastic mapping from time $t$ to the number of trades $N_t$ occurring during the time $t$.

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[3] A. Drăgulescu and V. M. Yakovenko, Quantitative Finance **2** (2002), 443.
[4] A. C. Silva, Ph. D. Thesis (2005), arXiv:physics/0507022.

## Characterization of foreign exchange market using the threshold-dealer-model.

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Generalizing the threshold-dealer-model [1], we introduce a new model which widely implements empirical laws in the markets such as the distribution of price difference, long term memory of volatility, statistical property of transaction intervals and abnormal diffusion in short time scales.

We explain the basic properties of the model and show the way of tuning parameters to fit with foreign exchange market data. It becomes clear that the parameters are not constant but modulate in long time scale. As a result of our analysis we can predict various hidden parameters of the market such as the ratio of market followers and contrarians which is the key parameter of market stability.

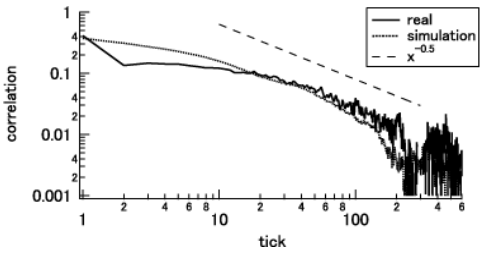


Fig.1 It shows the long term memory of volatility. Both the real data and the simulation result follow power-law.

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## Scaling and memory in intraday volatility return intervals in stock markets.

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We study the return interval, tau, between price volatilities that are above a certain threshold $q$ for 31 intraday data sets, including the Standard and Poor's 500 index and the 30 stocks that form the Dow Jones Industrial index. For different threshold $q$, the probability density function $P_q(\tau)$ scales with the mean interval $< \tau >$ as $P_q(\tau) = \tau^{-1} f(\tau/ < \tau >)$, similar to that found in daily volatilities. Since the intraday records have significantly more data points compared to the daily records, we could probe for much higher thresholds $q$ and still obtain good statistics. We find that the scaling function $f(x)$ is consistent for all 31 intraday data sets in various time resolutions, and the function is well-approximated by the stretched exponential, $f(x)\ exp[-a\, x^{\gamma}]$, with $\gamma = 0.38 + / - 0.05$ and $a = 3.9 + / - 0.5$, which indicates the existence of correlations. We analyze the conditional probability distribution $P_q(\tau|\tau_0)$ for tau following a certain interval $\tau_0$, and find that $P_q(\tau|\tau_0)$ depends on $\tau_0$, which demonstrates memory in intraday return intervals. We also find that the mean conditional interval $< \tau|\tau_0 >$ increases with $\tau_0$, consistent with the memory found for $P_q(\tau|\tau_0)$. Moreover, we find that return interval records, in addition to having short-term correlations as demonstrated by $P_q(\tau|\tau_0)$, have long-term correlations with correlation exponents similar to that of volatility records.

## The matrix rate of return.

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The goal of capital investments is maximise of profits and a possible losses minimisation. Investors diversify investment risk by forming a complex basket. The description of evolution of this multidimensional capital has to respect both a quantitative changes of individual elements and flows between them. This assumption leads to generalisation of the interest rate calculation to matrix rate. In this paper we give the definitions of the matrix rates of return which do not depend on choice of base describing a baskets and we give theirs economic interpretation. The proposed approach leads to capital flow description in terms of differential and difference equations. Matrix rate of return describes baskets of arbitrary type and extends portfolio analysis to the complex variable domain. This allows for simultaneous analysis of evolution of complex baskets in both continuous and discrete time models.

## Heterogeneity of trading at the London stock exchange.

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In this paper we examine the influence of agent heterogeneity on some aspects of the trading process, both on a limit order market and a block market. This is possible by analysing a unique data set from the London Stock Exchange (LSE) which contains agent codes associated with each order and transaction for both markets used at the LSE (a limit order book and a block market). The research takes on several directions.
We first analyse the heterogeneity in the daily volumes agents transact and its influence on prices: From the data it is possible to infer the total transacted daily volume for each agent. We examine how the inequalities in this agent volume composition influence prices. We investigate the differences in trading and price reaction when there is a large agent (one that traded a large fraction of the daily volume) transacting with a number of small ones, a large agent transacting with a large counterpart, and small agents transacting with other small agents.
Next we examine the structure of networks resulting from trading. We construct a network for each day by linking two traders that made a transaction during that day and contrast the networks resulting from limit order book trading and block market trading.
We also investigate the aspects in which an agent's individual market impact differs from other agents' impacts. By being able to track an agent, we can construct his/her individual impact function (both as a function of volume and time delay from the trade). We then investigate if there are simple explanatory variables for the variation in market impact such as average trade size, total volume, etc.
Finally, we construct a simple measure of an agent's "strategy" by looking at hourly time intervals and recording whether the agent was a net buyer or a net seller in that time period. We investigate the correlations in such strategies for all agents through an analysis of eigenvalues of the correlation matrix. Last, we show that pairwise correlations in strategies persist over a period of time (in this case two months).

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