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EURANDOM Workshop

Nolinear Stochastic Models in Finance

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On April 26th-28th the Financial Stochastics group of EURANDOM held its first international conference on non-linear modelling of asset returns. Due to micro market structure imperfection, incompleteness of securities markets and information asymmetries, the complex market view of asset markets is only a first order approximation. Furthermore, asset markets have risk characteristics that are incompatible with the standard normal distribution view of financial asset returns. Typically one observes volatility bunching and heavy tailed conditional and unconditional innovations. Moreover, many derivative prices are non-linear functions of other asset prices. Hence the interest in non-linear modelling in asset pricing for theoretical and empirical researchers. The aim of the conference was to bring together both theoretical oriented and empirically oriented researchers who focus on these non-linearities in financial modelling. This goal was realised in numbers (27 participants from 8 countries) and in quality of content. We mention some of the issues concerned. In the talk on interest rate derivatives, for example, it was argued that the log normal model can't be used simultaneously for the LIBOR and SWAP markets, since this leads to an arbitrage possibility. Hence, the empirical researcher has to modify his specifications to make the pricing on the two markets mutually compatible. Several presentations concerned specific cases of market incompleteness, i.e. the case that one cannot price a financial derivative through a combination of other assets. Economic theory in such cases can only specify a range of possible prices and it is both of theoretical and empirical interest to see how prices behave in such intervals of indeterminacy. Another stream of papers focussed on the auto-correlation structure of the absolute returns, which signifies the dependence in the well-observed clusters of market turbulence and quiescence. A hotly debated issue was whether the dependency structure dies out slowly and gives rise to long memory, or whether this is a spurious result stemming from instabilities in the parameters of the volatility process.

What one come away with from the conference is that after the initial success of the option pricing formula based on the presumption of exponential Brownian motion, derivative pricing and its empirical analysis is currently in a state of flux. This gives a lot of opportunities for researchers both in the empirical and theoretical analysis of asset pricing.

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Non linear stochastic models in finance (in alphabetical order) **April 26-28, 1999**

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Programme of the workshop
Non linear stochastic models in finance April 26-28, 1999

Date	Time	Speaker	Title
Monday,	10.00 - 10.30		**Registration / Coffie**
26 / 4	10.30 - 11.15	Barndorff-Nielssen, O	Turbulence and Finance
	11.20 - 12.05	Schumacher, H	Pricing and hedging in an interval model
	12.15 - 14.00		**Lunch Break**
	13.00 - 14.00		**Meeting of the Steering Committee Financial Stochastics**
	14.00 - 14.45	Cont, R	Feedback effects and endogenous non-linearity in speculative markets
	14.50 - 15.35	Drost, F	A Jump-Diffusion Model for Exchange Rates in a Target Zone
	15.40 - 16.00		**Tea/Coffee Break**
	16.00 - 16.45	Frey, R	Nonlinear filtering techniques for estimation and risk-management in partially observed stochastic volatility models
	16.50 - 17.35	Shephard, N	Dynamics of trade-by-trade price movements : decompositions and models
Tuesday, 27 / 4	09.30 - 10.15	Davis, R	Limit Theory for Sample Correlations of Some Nonlinear Time Series Models including GARCH and Stochastic Volatility Models
	10.20 - 10.35		**Tea/Coffee Break**
	10.35 - 11.20	Giraitis, L	Stationary moderate and long - memory ARCH type models
	11.25 - 12.10	Starica, C	Change of structure in financial time series, long range dependence and the GARCH model
	12.15 - 14.00		**Lunch Break**
	14.00 - 14.45	Werker, B	The Pricing of Volatility Risk: An Empirical Analysis
	14.50 - 15.35	Haan, L. de	Optimality in estimating extreme quantiles
	15.40 - 16.00		**Tea/Coffee Break**
	16.00 - 17.30	**Discussion**	Where is financial mathematics heading to?
	18.30		**Conference Dinner**
Wednesday, 28 / 4	09.30 - 10.15	Wu, C	A case study in insider trading
	10.20 - 10.35		**Tea/Coffee Break**
	10.35 - 11.20	Jong, F. de	Libor and Swap Market Models for the Pricing of Interest Rate Derivatives: An Empirical Comparison
	11.25 - 12.10	Kallianpur, G	Asset Pricing with Stochastic Volatility
	12.15 - 14.00		**Lunch**

Turbulence and Finance

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Similarities and differences between stylized empirical facts from turbulence studies on the one hand and the field of finance on the other will be discussed, as a basis for considerations on realistic modelling of observational series from the two fields.

Feedback effects and endogenous non-linearity in speculative markets

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We present a simple stylized model of the feedback effect of market's anticipations of price movements in a speculative market with finite elasticity of demand. We show that taking feedback effects into account leads to a non-linear evolution equation for asset prices which can generate spontaneous "crashes" even in the absence of any exogenous large shocks.

Limit Theory for Sample Correlations of Some Nonlinear Time Series Models Including GARCH and Stochastic Volatility Models

Richard A. Davis

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(Joint work with Thomas Mikosch)

In deriving limit theory for the sample autocorrelation function (ACF) of a time series with either infinite fourth moment or infinite second moment, two conditions are typically imposed. The first is a regular variation condition that requires the finite dimensional distributions to be jointly regularly varying. The second is a mixing condition specifying the rate and nature at which events become asymptotically independent. It can be shown that a large class of nonlinear time series models, including those arising from a stochastic recurrence equation such as GARCH, and stochastic volatility models (SV) satisfy these conditions. Interestingly, the behavior of the sample ACF for GARCH and SV models are vastly different. Comparisons with the sample ACF of heavy tailed-linear processes will also be described.

A Jump-Diffusion Model for Exchange Rates in a Target Zone

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(Joint work with Frank De Jong and Bas J. M. Werker)

We propose a simple jump-diffusion model for an exchange rate target zone. The model captures most stylized facts from the existing target zone models while remaining analytically tractable. The model is based on a modified two-limit version of the Cox, Ingersoll, and Ross (1985) model. In the model the exchange rate is kept within the band because the variance decreases as the exchange rate approaches the upper or lower limits of the band. We also consider an extension of the model with parity adjustments, which are modeled as Poisson jumps. Estimation of the model is by GMM based on conditional moments. We derive prices of currency options in our model, assuming that realignment jump risk is idiosyncratic. Throughout, we apply the theory to EMS exchange rate data. We show that, after the EMS crisis of 1993, currencies remain in an implicit target zone that is narrower than the officially announced target zones.

Nonlinear filtering techniques for estimation and risk-management in partially observed stochastic volatility models

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(Joint work with W. Runggaldier)

We consider asset price models with stochastic volatility where the current value of the volatility can be observed only partially. This lack of information may arise from discrete observation of the asset price process, so that the volatility cannot be "backed out" from the observation of the quadratic variation of the asset price. Alternatively we consider models where the asset price process is given as exponential martingale of some doubly stochastic Poisson process We provide limit results for large jump-intensity and small jump-variance relating these models to standard continuous-time stochastic volatility models. We show how efficient nonlinear filtering techniques can be employed to estimate the parameters of the unknown volatility process and present results from a simulation study. Finally we discuss how our approach can be used for the computation of risk-minimizing hedging strategies.

Stationary moderate and long - memory ARCH type models

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A broad class of non-negative ARCH type models is discussed. Sufficient conditions for the existence of a stationary solution are established and an explicit representation of the solution as a Volterra type series is found. It is show, that the covariance function can decay slowly like a power function, falling just short of the long memory structure, or in the case of modified ARCH type models powerlike arbitrary slowly. The Central Limit Theorem and the convergence of the corresponding normalized partial sums to the fractional Brownian motion are established.

Optimality in estimating extreme quantiles

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(Joint work with Ana Ferreira [Lisbon]
and Liang Peng [Canberra])

When estimating a quantile out-of-the-sample one has to decide how many extreme order statistics one uses for the estimation procedure: too few means loss of accuracy, too many means introduction of a bias. Up to now the choice has been done on intuitive grounds. We present an asymptotically optimal adaptive choice of the number of extreme order statistics involved.

Libor and Swap Market Models for the Pricing of Interest Rate Derivatives: An Empirical Comparison

Frank de Jong

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(Joint work with Joost Driessen, KUB and Antoon Pelsser, ABN-AMRO)

In this paper we empirically analyze and compare the Libor and Swap Market Models, developed by Brace, Gatarek and Musiela (1997) and Jamshidian (1998), using prices of US caplets and swaptions for 1995 and 1996. A Libor Market Model can directly be estimated from observed prices of caplets, whereas a Swap Market Model is directly fitted to a certain set of swaption prices. For both one-factor and two-factor models it is analyzed how well they price caplets and swaptions. We show that models that are chosen to exactly match derivative prices are overfitted, and that the Libor Market Models lead to a better a fit than the Swap Market Models. A one-factor Libor Market Model that exhibits mean-reversion gives a reasonable fit of the derivative prices, and adding a second factor only decreases pricing errors to a small extent. Still, regression tests reveal that all models are statistically rejected, and the pricing errors are correlated with the shape of the term structure of interest rates.

Asset Pricing with Stochastic Volatility

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(Joint work with J. Xiong)

We study the asset pricing problem when the volatility is random. First, we derive a PDE for the risk-minimizing price of any contingent claim. Secondly,we assume that the volatility process sigma_sub_t is observed through an observation process Y_sub_t subject to random error. A price formula and a PDE are thenderived regarding the stock price process and the observation process as parameters. Finally, we take the stock price process alone as the observation process and estimate the volatility process in terms of S. In this way we obtain a related complete market and any contingent claim is then priced by an arbitrage argument instead of by risk-minimizing.

Pricing and hedging in an interval model
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(Joint work with Berend Roorda and Jacob Engwerda)

As an extension of the standard Cox-Ross-Rubinstein binomial model for option pricing, we consider a model in which the relative change of the price of the underlying during one time step is only restricted to lie in a certain interval. Such a model is incomplete, but it is still possible to give upper and lower bounds for option prices. These upper and lower bounds can be related to particular hedging strategies. Every price in the interval between the bounds can be given an interpretation as the expected value of the option value at expiry under some martingale measure on the collection of allowed trajectories. Each hedging strategy produces a certain interval of possible outcomes, and by defining a preference function for intervals it becomes possible to look for optimal hedging policies. Optimal policies are in general different from the standard delta hedge.

Dynamics of trade-by-trade price movements : decompositions and models
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(Joint work with Tina H. Rydberg)

In this paper we introduce a decomposition of the joint distribution of price changes of assets recorded trade-by-trade. Our decomposition means that we can model the dynamics of price changes using quite simple and interpretable models which are easily extended in a great number of directions, including using durations and volume as explanatory variables. Thus we provide an econometric basis for empirical work on micro market structure using time series of transaction data.

We use maximum likelihood estimation and testing methods to assess the fit of the model to a year of IBM stock price data taken from the New York Stock Exchange.

Keywords: Activity, autologistic, conditional independence, decomposition, directions, durations, forecasting, GLARMA, logarithmic distribution, prediction decomposition, size, transactions data.

Change of structure in financial time series,long range dependence and the GARCH model
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(Joint work with T. Mikosch)

Functionals of a two--parameter integrated periodogram have been used for a long time for detecting changes in the spectral distribution of a stationary sequence. The bases for these results are functional central limit theorems for the integrated periodogram having as limit a Gaussian field. In the case of GARCH(p,q) processes a statistic closely related to the integrated periodogram can be used for the purpose of change detection in the model. We derive a central limit theorem for this statistic under the hypothesis of a GARCH(p,q) sequence with a finite 4th moment.

When applied to real--life time series our method gives clear evidence of the fast pace of change in the data. One of the straightforward conclusions of our study is the infeasibility of modelling long return series with one GARCH model. The parameters of the model must be updated and we propose a method to detect when the update is needed.

Our study supports the hypothesis of global non--stationarity of the return time series. We bring forth both theoretical and empirical evidence that the long range dependence (LRD) type behaviour of the sample ACF and the periodogram of absolute return series documented in the econometrics literature could be due to the impact of non-stationarity on these statistical instruments.

Contrary to the common-hold belief that the LRD characteristic carries meaningful information about the price generating process, we show that the LRD behaviour could be just an artifact due to structural changes in the data. The effect that the switch to a different regime has on the sample ACF and the periodogram is theoretically explained and empirically documented using time series that were the object of LRD modelling efforts (S&P500, DEM/USD FX) in various publications.

The Pricing of Volatility Risk: An Empirical Analysis
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It is well-known that empirically relevant models for stock > (and many other) prices incorporate stochastic volatility. It is also > known that these stochastic volatility models usually describe > financial markets that are incomplete in terms of the underlyi asset,

> even when specified in continuous time. Formally, these models allow > for many possible equivalent martingale measures and, hence, > derivatives can generally not be priced uniquely by arbitrage > arguments alone. Using actual derivatives prices, i.e., prices as > observed in the market, additional information about the empirically > relevant equivalent martingale measures might be obtained. The > present paper operationalizes this. We use a convenient way to > represent all possible equivalent martingale measur in financial > markets. The idea is to split up the pricing problem of derivatives > under stochastic volatility into two steps. The first step is solving > a closely related determin n the second step, a weighted average of > the first step op price of volatility risk. We investigate whether > this price is zer price, by confronting the theoretical with actually > observed prices.

A case study in insider trading

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Gaussian processes generated by certain linear transformations of two Gaussian martingales are studied. This class of transformations is motivated by the Kyle-Back financial equilibrium model with heterogeneous information. We discuss the structure of insider strategies which remain inconspicuous in the sense that the resulting cumulative demand is again a Brownian motion.

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