

# Abstracts of the talks

ALEXANDER AUE

## **Distinguishing between random walks and changes in the mean**

In this talk we discuss test procedures that detect structural breaks in underlying data sequences. In particular, we wish to discriminate between different reasons for the breaks, such as (1) shifting means, (2) random walk behavior, and (3) constant means but innovations switching from stationarity to difference stationarity. Almost all procedures presently available in the literature are simultaneously sensitive to all three types of alternatives. The test statistics under consideration are based on partial sum functionals of the observations. These CUSUM-type statistics have limit distributions if the mean remains constant and the errors satisfy the central limit theorem, but tend to infinity in the case any of the alternatives (1), (2) or (3) holds. On removing the effect of the shifting mean, however, divergence of the test statistics will only occur under the random walk behavior, which in turn enables statisticians to not only detect structural breaks but also to identify their causes.

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RICHARD A. DAVIS, PETER J. BROCKWELL AND YU YANG

## **Inference for Lévy-driven continuous-time ARMA processes**

Continuous-time ARMA (CARMA) processes with non-negative kernel and driven by non-decreasing Lévy processes constitute a very general class of stationary, non-negative continuous-time processes. In financial econometrics, for example, they have been used to model stochastic volatility (see e.g. Barndorff-Nielsen and Shephard (2001) and Todorov and Tauchen (2006)). In this paper we develop a highly efficient method of estimation for the coefficients of such models, taking advantage of the non-negativity of the driving process. We also show how to reconstruct the background driving Lévy process from a continuously observed realization of the CARMA process and use this result to estimate the increments of the Lévy process itself when closely-spaced observations are available.

## A structure theory for generalized linear dynamic factor models (GDFM's)

GDFM's are used for modelling high-dimensional time series, occurring e.g. in finance or macroeconomic applications. The idea of GDFM's is to combine the idea of (static) generalized factor models as introduced by Chamberlain with the idea of linear dynamic factor models, as described by Brillinger. This contribution is concerned with the construction of a state-space model for the latent variables from the spectral density of the observations. The central result deals with spectral factorization of a singular rational spectral density.

*Key words:* Generalized linear dynamic factor models, realization theory, state space systems, Kalman filtering, singular rational spectral densities, factorization

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PAUL DOUKHAN

## Weak dependence, models and some applications

The talk will present the basic features of weak dependence defined in Doukhan & Louhichi (1999). A book on the subject coauthored with Dedecker, Lang, León, Louhichi and Prieur will appear in the LNS (Springer) in 2006.

Our main aim is to propose several new models of time series and random fields for which this theory applies beyond mixing. Nonlinear, non-Markov stationary models will be proposed.

We shall derive from a Lindeberg type theorem some applications to resampling and functional estimation.

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## **Asymptotic distribution of the maximum likelihood estimate of a change-point under smooth changes**

The problem of estimating an unknown change-point in a sequence of independent random elements defined on a general space is considered. We develop a framework for deriving the asymptotic distribution of the maximum likelihood estimator of the change-point under smooth changes. We found that the consistency result of Ibragimov and Hasminski plays a central role in the development of this asymptotic theory. Furthermore, the estimation methodology of Hinkley for abrupt changes can easily be adapted into the smooth change scenario, a fact not pursued thus far in the literature. The only assumption we require in this study is that the statistical experiment be regular. The smoothness assumption we impose here is quite similar to that found in the literature. The general methodology is then applied in an in-depth way for smooth changes in the mean vector or the covariance matrix for multivariate Gaussian processes. Extensive simulations performed illustrate the closeness of the asymptotic distribution to reasonable sample sizes as well as amounts of changes. Finally, we apply the methodology to estimate the change-point for the realized logarithmic standard deviations in a bivariate financial data from NYSE.

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C. FRANCO AND J-M. ZAKOIAN

## **Testing that some GARCH coefficients are equal to zero**

The asymptotic distribution of the quasi-maximum likelihood (QML) estimator for generalized autoregressive conditional heteroskedastic (GARCH) processes is not standard when the true parameter have zero coefficients. This asymptotic distribution is the projection of a normal vector distribution onto a convex cone. We show that the QML estimator does not converge to its asymptotic distribution locally uniformly. Using these results, we consider the problem of testing that one or several GARCH coefficients are equal to zero. The null distribution and the local asymptotic powers of the Wald, score and quasi-likelihood ratio tests are derived. The one-sided nature of the problem is exploited and asymptotic optimality issues are addressed.

## Nonstationarity-extended local Whittle estimation

This paper extends the classical local Whittle estimation procedure of the memory parameter to fractionally-integrated  $I(d)$  processes for  $d > -3/2$ , covering stationary and nonstationary regions. We introduce the concepts of fully-extended discrete Fourier transform and periodogram. We investigate the properties of our Fully-Extended Local Whittle (FELW) estimator, which is applicable not only for the traditional cases but also for nonlinear and non-Gaussian processes. For a wide class of processes, we show that the estimator is consistent and we derive its asymptotic expansion. In addition, when the generating process is linear, we show that the estimator satisfies the same normal CLT as in the stationary case. The performance of the estimator is illustrated by a simulation.

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EDIT GOMBAY

## Change detection in autoregressive time series

Autoregressive time series models of order  $p$  have  $p + 2$  parameters, the mean, the variance of the white noise and the  $p$  autoregressive parameters. Change in any of these over time is a sign of disturbance that is important to detect. The methods of this paper can test for change in any one of these  $p + 2$  parameters, or in any collection of them. They are available in forms that make one-sided tests possible; furthermore, they can be used to test for temporary change. The test statistics are based on the efficient score vector. The large sample properties of the change-point estimator are also explored.

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HAO YU

## Test for symmetry of innovation distributions in GARCH models

In this talk I will introduce Nikitin's symmetric test based on integration of empirical processes. This test will be used to test for symmetry of innovation distributions in GARCH models. Whether it can be used to test GARCH against asymmetric GARCH will be investigated.

## Augmented GARCH sequences, dependence and asymptotics

Since the introduction of the ARCH model by Robert Engle numerous extensions have been considered, including GARCH, AGARCH, EGARCH, etc. Duan defined the so-called augmented GARCH process which unifies most of the models occurring in the literature. For statistical inference it is important to study the asymptotics of these processes and thus we need to understand their dependence structure. Typically one tries to verify mixing or other well known dependence measures, which are in general not easy to get and often require very restrictive moment or smoothness conditions. In this talk we show that augmented GARCH sequences can be approximated very well by  $m$ -dependent processes. Employing the theory of independent r.v.'s allows us to deduce very sharp and sometimes optimal results. The methods can be extended to a huge class of stationary processes.

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MARIE HUŠKOVÁ

## Detection of changes in autoregressive time series models

The talk concerns procedures for detection of changes in autoregressive time series models with a possible change in the regression parameters in both non-sequential and sequential setup.

In the *non-sequential (retrospective)* setup all data are available at the beginning. Possible test statistics for detection of a change will be discussed together with their asymptotic properties. Approximations to the related critical values for change-point tests are obtained through various bootstrapping methods. A small simulation study illustrates that the bootstrap provides better approximation than the original asymptotic tests. It is based on joint work with C. Kirch, Z. Prášková and J. Steinebach.

In the *sequential setup* we assume that data arrives sequentially and training (historical) data with no change are available. Two classes of test procedures will be developed and their asymptotic properties will be presented and discussed. Asymptotic results are checked on a small simulation study. It is based on joint work with A. Koubková.

PIOTR KOKOSZKA

## Tests of independence for functional observations

The last two decades have seen the emergence of new technology allowing the collection and storage of time series of finely sampled records. Data of this type can be conveniently viewed as functional (curve) observations. Most statistical procedures of functional data analysis rely on the assumption of independent identically distributed functional observations, which requires careful verification in observational data derived from time series. We propose a  $\chi^2$  test for independence and identical distribution of functional observations and a test for lack of linear functional dependence. Asymptotic theory based on functional principal component expansions and Hilbert space techniques is discussed. The tests are shown to have good empirical size and power. Their application is illustrated on data sets derived from credit card sales activity and geomagnetic records.

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REG KULPERGER

## Discrete time series and option pricing

Options are often written on stocks or other indices. Index data is recorded at daily closing of the markets, although intraday market or index prices may be available.

We consider prediction of option prices based on models constructed for the index daily closing prices. This is applied to the S&P 500 data for the period of January 4, 1988 to January 3, 2004, and to European call options on this index. Such models are incomplete market models and thus have infinitely many risk neutral measures.

We use models of the GARCH type. These are interesting since they are conditionally location scale shift models, with predictable conditional mean and variance. Thus they can be fit to data, and with some model assessment. The driving noise may be Gaussian or non-Gaussian.

The risk neutral measure needs to be chosen according to some economic argument. We consider various economic choices. These usually coincide when the driving noise is Gaussian but differ when the driving noise is not Gaussian. The empirical analysis suggests that the driving noise is not Gaussian.

The conditional Esscher transform seems to be a good choice when comparing the option prediction based on either mean absolute or mean squared error criteria.

This is joint work with Alex Badescu.

## Inference on the time of break

The asymptotic distribution of the estimator of the break point in a linear regression model depends on the unknown underlying distribution of data and thus it is not available for inference purposes. To circumvent this drawback, the paper proposes a bootstrap procedure that is valid for linear stationary processes. The approach is based on a specific type of deconvolution. It has the advantage of avoiding the artificial technical assumption that the size of break shrinks to zero as the sample size increases, which, despite yielding distribution-free asymptotics, may not always be seen as acceptable.

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REMIGIJUS LEIPUS

## Time series aggregation, disaggregation and long memory

In this talk we consider the aggregation scheme introduced in the paper of Granger (1980), where it was shown that aggregation of i.i.d. AR(1) processes with given beta-type distributed random coefficient can produce long memory time series. On the other hand, Dacunha–Castelle and Oppenheim (2001) stated the following problem: to characterize the class of long memory processes which can be obtained by the aggregation of short memory models with random coefficients. We call the latter problem a *disaggregation problem*. In particular, we study the problem of finding the individual random coefficient AR(1) processes (if they exist) which produce the given class of long memory processes. Using the form of AR(1) models producing the simple time series (e.g. classical FARIMA model) we show that one can solve the disaggregation problem for more complex long memory stationary sequences. The questions related to aggregation and disaggregation of time series such as estimation of the AR coefficient's density, its consistency, asymptotic normality, etc. are discussed.

## Testing for threshold moving average with conditional heteroscedasticity

The recent paper by Ling and Tong (2005) considered a quasi-likelihood ratio test for the threshold in moving average models with i.i.d. errors. This article generalizes their results to the case with GARCH errors and a new quasi-likelihood ratio test is derived. The generalization is not direct, since the techniques developed for TMA models heavily depend on the property of  $p$ -dependence which is no longer satisfied by the time series models with conditional heteroscedasticity. The new test statistic in this article is shown to converge weakly to a functional of a centered Gaussian process under the null hypothesis of no threshold and it is also proved the test has nontrivial asymptotic power under local alternatives. Monte Carlo experiments demonstrate the necessity of our test when a moving average time series has a time varying conditional variance. As a further support, two real data examples are also reported.

*Key words and phrases:* Conditional heteroscedasticity; Gaussian process; likelihood ratio test; MA-GARCH model; Threshold MA-GARCH model.

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BENEDIKT M. PÖTSCHER AND HANNES LEEB

## Sparse estimators and the oracle property, or the return of Hodges' estimator

We point out some pitfalls related to the concept of an oracle property as used in Fan and Li (2001, 2002, 2004) which are reminiscent of the well-known pitfalls related to Hodges' estimator. The oracle property is often a consequence of sparsity of an estimator. We show that any estimator satisfying a sparsity property has maximal risk that diverges to infinity whenever the loss function is unbounded. For ease of presentation the result is set in the framework of a linear regression model, but generalizes far beyond that setting. In a Monte Carlo study we also assess the extent of the problem in finite samples for the smoothly clipped absolute deviation (SCAD) estimator introduced in Fan and Li (2001). We find that this estimator can perform rather poorly in finite samples and that its worst-case performance relative to maximum likelihood deteriorates with increasing sample size.

*AMS Subject Classifications:* Primary 62J07, 62C99; secondary 62E20, 62F10, 62F12.

*Key words:* oracle property, sparsity, penalized maximum likelihood, penalized least squares, Hodges' estimator, SCAD, Lasso, Bridge estimator, hard-thresholding, maximal risk, maximal absolute bias, non-uniform limits.



## **The stock markets of Europe: globalization or European integration?**

A non-stationary analysis of the evolution of the relationship between various levels of aggregation of returns (sectorial, national, continental and international) of the major European financial markets during the last three decades is performed. The aggregated returns are modeled as independent vectors with a time-changing unconditional covariance structure.

The methodological frame is that of non-parametric regression with non-random, equidistant design points, where the regression function is the evolving unconditional covariance matrix.

The modeling choice reflects our assumption of the existence of four independent factors (an international, an European, a specific national and a specific sectorial factor) that drive the dynamics of the multivariate vector of aggregated returns. The time-changing proportions of the variance of sectorial returns explained by the national, the European and the international factors reflect the evolution of the market relations and are used to evaluate the integration process possibly at work inside the European economic space. We find that in all the financial markets we analyzed, the proportion of the sectorial variance explained by the national factor decreased in the last 10-15 years. We also find that this decrease has been matched by an increase in the proportion explained by the international factor. Differences in the amplitude of this movements can be noticed in different markets. We do not find evidence for an increase in the co-movements of the financial indexes at European level.

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JOSEF G. STEINEBACH

## **Monitoring risk in the Sparre Andersen ruin model**

In this lecture, we discuss the possibility of monitoring the risk of an insurance portfolio under the Sparre Andersen ruin model. A class of sequential procedures is suggested, which are based on test statistics detecting possible changes of the adjustment coefficient in the underlying model. The stopping times are chosen in such a way that the procedures have an (asymptotic) false alarm rate  $\alpha$  (small) and (asymptotic) power one.

## The increment ratio test for long memory

We introduce a new statistic written as a sum of certain ratios of second order increments of partial sum process  $S_n = \sum_{t=1}^n X_t$  of observations, which we call the Increment Ratio (IR) statistic. The IR statistic can be used for testing non-parametric hypotheses for  $d$ -integrated ( $-1/2 < d < 3/2$ ) behavior of time series  $X_t$ , including short memory ( $d = 0$ ), (stationary) long-memory ( $0 < d < 1/2$ ) and unit roots ( $d = 1$ ). If  $S_n$  behaves asymptotically as an (integrated) fractional Brownian motion with parameter  $H = d + 1/2$ , the IR statistic converges to a monotone function  $\Lambda(d)$  of  $d \in (-1/2, 3/2)$  as both the sample size  $N$  and the window parameter  $m$  increase so that  $N/m \rightarrow \infty$ . For Gaussian observations  $X_t$ , we obtain a rate of decay of the bias  $EIR - \Lambda(d)$  and a central limit theorem  $(N/m)^{1/2}(IR - EIR) \rightarrow \mathcal{N}(0, \sigma^2(d))$ , in the region  $-1/2 < d < 5/4$ . Graphs of the functions  $\Lambda(d)$  and  $\sigma(d)$  are included. A simulation study shows that the IR test for short memory ( $d = 0$ ) against stationary long-memory alternatives ( $0 < d < 1/2$ ) has good size and power properties and is robust against changes in mean, slowly varying trends and nonstationarities. We apply this statistic to sequences of squares of returns on financial assets and obtain a nuanced picture of the presence of long-memory in asset price volatility.

The talk is based on a joint paper with Gilles Teyssière (Centre for Finance, Göteborg University) and Marijus Vaičiulis (Institute of mathematics and informatics, Vilnius), to appear in *J. Multivariate Anal.* (2007).

TIMO TERÄSVIRTA AND ANNASTIINA SILVENNOINEN

## Modelling multivariate autoregressive conditional heteroskedasticity with the double smooth transition conditional correlation GARCH model

We propose a multivariate GARCH model with a time-varying correlation structure. The new Double Smooth Transition Conditional Correlation (DSTCC-) GARCH model extends the Smooth Transition Conditional Correlation (STCC-) GARCH model of Silvennoinen and Teräsvirta (2005) by including another variable according to which the correlations change smoothly between states of constant correlations. A Lagrange multiplier test is derived for testing the constancy of correlations against the DSTCC-GARCH model and another one for testing for another transition in the STCC-GARCH framework. Other specification tests, with the aim of contributing to the model building process, are considered as well. Analytical expressions for the test statistics and the required derivatives of the log-likelihood function are provided. There are two empirical examples. The model is fitted to a set of daily world stock index returns, and the second application is a bivariate DSTCC-GARCH model for daily returns of US stock and bond futures.

## Long-range dependence and multiple change-points in multivariate time series

We present a framework for multivariate long-range dependent volatility processes suitable for modelling multiple series of asset price volatility. Since change-points are present in volatility series, we consider an alternative framework for detecting multiple change-points in multivariate time series. We assume that the covariance structure of the series changes abruptly at some unknown common change-point times. The proposed adaptive method is able to detect changes in multivariate i.i.d., weakly and strongly dependent series. This adaptive method outperforms the Schwarz criteria, mainly for the case of weakly dependent data. We consider applications to multivariate series of stock prices returns and series generated by an artificial financial market.

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QIWEI YAO

## Estimating GARCH models: when to use what?

The class of GARCH models has proved particularly valuable in modelling highly volatile time series. These include financial data, which can be particularly heavy tailed. It is well understood now that the tail heaviness of the innovation distribution plays an important role in determining the relative performance of the two competing estimation methods, namely the maximum quasilielihood estimator based on a Gaussian likelihood (GMLE) and the log-transform based least absolute deviations estimator (LADE). A practically relevant question is when to use what. We provide in this paper a solution to this question. By interpreting the LADE as a version of the maximum quasilielihood estimator under the likelihood derived from assuming hypothetically that the log squared innovations obey a Laplace distribution, we outline a selection procedure based on some goodness-of-fit type statistics. The methods are illustrated with both simulated and real data sets. Although we deal with the estimation for GARCH models only, the basic idea may be applied to address the estimation procedure selection problem in a general regression setting.

PAOLO ZAFFARONI

## **Whittle estimation of exponential volatility models**

The strong consistency and asymptotic normality of the Whittle estimate of the parameters in a class of exponential volatility processes are established. Among many models of interest, this class includes one-shock models, such as the EGARCH model of Nelson (1991), and two-shock models, such as the SV model of Taylor (1986). The variable of interest might not have finite fractional moment of any order and so, in particular, finite variance is not imposed. We allow for a wide range of degrees of persistence of shocks to conditional variance, allowing for both short and long memory. A detailed Monte-Carlo exercise shows the small-sample properties of the estimator. We present an empirical application using the Standard & Poor's 500 composite stock index.

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JEAN-MICHEL ZAKOIAN, CHRISTIAN FRANCQ AND SVETLANA MAKAROVA

## **A class of stochastic unit-root bilinear processes**

A class of stochastic unit-root bilinear processes, allowing for GARCH-type effects with asymmetries, is studied. The volatility is not bounded away from zero and is minimum for non zero innovations. Necessary and sufficient conditions for the strict and second-order stationarity of the error process are given. The strictly stationary solution is shown to be strongly mixing under mild additional assumptions. It follows that in this model, the standard (non-stochastic) unit-root tests are asymptotically valid. It is shown that the quasi-maximum likelihood estimator is generally inconsistent. The asymptotic properties of weighted least-squares estimators are established.

## Structural change tools for currency regime classification

The so-called Frankel–Wei regression model (Haldane and Hall 1991; Frankel and Wei 1994) is the popular workhorse for *de facto* currency regime classification, i.e., for determining whether a certain currency is pegged to one or more other currencies. Typically, central banks only provide limited (or wrong) information about the currency regime in operation and about changes of it. Therefore, practitioners routinely use rolling regressions to track the evolution of the currency regime in operation. To embed these techniques into an inferential framework for currency regime classification, several tools from the structural change literature are adapted to Frankel–Wei regressions. More precisely, we suggest tools for assessing the stability of a Frankel–Wei regression in historical data (*testing*) and in incoming data (*monitoring*) and for determining the breakpoints of shifts in the currency regime (*dating*).

To illustrate how the tools can be applied in practice, we investigate the Chinese currency regime after China gave up on a fixed exchange rate to the US dollar (USD) on 2005-07-21. The People’s Bank of China announced that the CNY would no longer be pegged to the USD but to a basket of currencies so that the CNY exchange rate would be improved with greater flexibility. Shah, Zeileis, and Patnaik (2005) found that – contrary to these announcements – in the first months after the change a plain USD peg (with extremely limited currency flexibility) is still in operation. Here, we investigate whether this currency regime evolved since, finding some instability pertaining mainly to the currency flexibility.

*Keywords:* structural change test, monitoring, dating, breakpoints, China, CNY.

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## **Easily verifiable conditions for weak convergence of stochastic processes**

When considering weak convergence of stochastic processes on the real line and, particularly, on the unit interval, Davydov (1996) suggested a new set of simple yet general conditions that proved to be particularly useful in applications. Furthermore, Davydov (1996) presented arguments showing that there are even simpler conditions if the processes can be decomposed into differences of two non-decreasing processes. Subsequently, Davydov and Zitikis (2006) extended the aforementioned Davydov's results to multi-parameter stochastic processes. During the talk we shall discuss these results, especially keeping in mind their potential uses.

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# Posters

ZSUZSANNA HORVÁTH

## Ratio tests for change point detection

We propose new tests to detect a change in the mean of a time series. Like many existing tests, the new ones are based on the CUSUM process. Existing CUSUM tests require an estimator of a scale parameter to make them asymptotically distribution free under the no change null hypothesis. Even if the observations are independent, the estimation of the scale parameter is not simple since the estimator for the scale parameter should be at least consistent under the null as well as under the alternative. The situation is much more complicated in case of dependent data, where the empirical spectral density at 0 is used to scale the CUSUM process. To circumvent these difficulties, new tests are proposed which are ratios of CUSUM functionals. We provide three tests to detect changes in the mean of dependent observations without estimating the asymptotic variance. We demonstrate the applicability of our method to detect a change in the mean when the errors are AR(1) and GARCH(1,1) sequences. This is based on joint work with Lajos Horváth (University of Utah, USA) and Marie Hušková (Charles University, Prague).

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PHILIPP MAYER, S. KINDERMANN, H. ALBRECHER AND H. W. ENGL

## Identification of the local speed function in a Lévy model for option pricing

We propose a non-parametric stable calibration method based on Tikhonov regularization for the local speed function in a local Lévy model. The jump term in this model introduces an integral operator into the classic Black-Scholes partial differential equation such that the associated model calibration to observed option prices can be treated as a parameter identification problem for a partial integro-differential equation. This problem is shown to be ill-posed and thus requires regularization. It is proven that nonlinear Tikhonov regularization is a stable and convergent method for this problem. Furthermore, convergence rate results are established under an abstract source condition.

MATTHEW L. REIMHERR

## Estimation of the reaction time to a change in linear models

In this paper we consider a change-point test in the parameters of a linear model. We briefly discuss a sequential test based on the CUSUM of the residuals introduced by Chu et al. (*Econometrica* 1996) and later examined by Horváth et al. (*J. Stat. Planning Inf.* 2004) and Aue et al. (*Econometrics J.* 2006). We are concerned with deriving an asymptotic distribution for the stopping time under the alternative hypothesis. Horváth et al. (*J. Stat. Planning Inf.* 2004) and Aue et al. (*Econometrics J.* 2006) showed that under certain assumptions the test procedure would terminate in finite time under the alternative hypothesis with probability one. We extend those results and derive the exact order of the stopping time. Our assumptions will allow the error terms to be independent and identically distributed as well as a variety of dependent processes. We also assume that the explanatory variables are realizations of a stationary process. This paper is based on a joint work with A. Aue (Clemson University) and L. Horváth (University of Utah).

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JOHANNES SCHAUER

## Asymptotics of permutation and bootstrap statistics for stable samples

Permutation and bootstrap statistics are effective tools for constructing critical values and improving the speed of convergence in various statistical procedures. In this paper we investigate the behavior of these statistics in case of an i.i.d. sample with a stable distribution. We show that the normalized partial sums of the permuted or bootstrapped sample converge weakly, but the limit distributions, instead of a stable limit expected naively, are random distributions depending on the actual sample used. We give simple series representations of the random limits. This paper is based on joint work with A. Aue, I. Berkes and L. Horváth.



## **Asymptotic normality of the quasi maximum likelihood estimator for multidimensional conditionally heteroscedastic processes**

This poster presents a work done in association with J.-M. Bardet. The consistence and the asymptotic normality of the Pseudo Maximum Likelihood estimator are given for new infinite memory models. These non-Markov and multidimensional heteroscedastic models have been introduced recently by Doukhan & Wintenberger (2007). The gain of generality in the modeling is balanced by restrictive assumptions. In particular a moment of order  $> 2$  is needed for the consistence of the estimator. We compare our approach with the one of Straumann (2006).