Journal of Econometrics 181 (2014) 1–2

Contents lists available at ScienceDirect

Journal of Econometrics

journal homepage: www.elsevier.com/locate/jeconom

Guest editorial

Editors' introduction: Heavy tails and stable Paretian distributions in econometrics

This special issue is a collection of selected theoretical papers, some of which were presented at the 2005 Deutsche Bundesbank Fall Conference on "Heavy tails and stable Paretian distributions in finance and macroeconomics", as well as some other related contributions in this field. This conference was held in celebration of the 80th birthday of Professor Benoît B. Mandelbrot and took place at the Training Centre of the Deutsche Bundesbank in Eltville, Germany, from 10 to 12 November 2005. Another special issue containing more empirical papers from the conference was published in the Journal of Empirical Finance (17(2), March 2010). Sadly, Professor Benoît B. Mandelbrot passed away on 14 October 2010 in Cambridge (Massachusetts).

Since the influential works of Mandelbrot (1963), the stable generalization of the Gaussian distribution, known as stable Paretian distribution, together with other probability laws with heavy-tailed and skewed distributions, has often been considered a more realistic distributional assumption for economic, especially financial data. In recognition of the empirical relevance of heavy-tailed distributions for economic and financial modeling, a special volume entitled "Latest developments on heavy-tailed distributions" was recently published in the Journal of Econometrics (Vol. 172, 2013). In this regard, our volume, which comprises six papers, can be considered a sequel to the published one.

One of the requirements for using stable Paretian distributions is to precisely estimate the four characteristic parameters for the stable Paretian distributions, especially the tail-thickness and skewness parameters. There are several methods for estimating the tail parameter, but only a few methods for estimating skewness. In particular, it appears much more difficult to pin down the skewness parameter than it is for the tail parameter. Reliable inference on the skewness parameter has empirical relevance because most economic and financial data exhibit skewness in their changes and returns, which may be related to agents' risk aversion and leverage effects. In "Exact confidence sets and goodness-of-fit methods for stable distributions", Beaulieu, Dufour and Khalaf propose new methods for testing and building confidence sets on tail-thickness and skewness parameters by combining two basic approaches. First, they consider extensions of the Kolmogorov–Smirnov, Shapiro–Wilk and Filliben goodness-of-fit criteria as well as the quantile-based statistics proposed by McCulloch (1986) in order to better capture tail behavior. Second, in view of the complexity of the distributional theory for the statistics considered (both in finite samples and asymptotically), they control the levels of the tests and confidence sets by using the technique of Monte Carlo tests (Dufour, 2006). Neither maximum-likelihood estimation nor any of the other usual methods have this advantage because their inference is usually based on asymptotic distributions which can differ greatly from those for finite samples. The proposed methods yield exact inference in finite samples and more precise estimation of the relevant parameters, especially for the skewness parameter. In contrast with conventional wisdom, reliable inference is obtained with sample sizes as small as 25.

Distributional properties of estimators and statistical inference in econometrics depend crucially on the distributional assumptions in the underlying model, and many authors have focused on this topic in the econometric literature. Phillips and Loretan (1991), for example, investigate the properties of the Durbin–Watson statistic in the presence of stable Paretian noise; Mittnik et al. (1998) study the limiting distribution of the χ^2-statistic as degrees of freedom tend to infinity and provide simulated empirical distributions for finite degrees of freedom. The paper "On the properties of the coefficient of determination in regression models with infinite variance variables" by Kurz-Kim and Loretan examines the asymptotic properties of the coefficient of determination in models with stable Paretian random variables. They show that the coefficient of determination in regression models with stable Paretian variables does not converge to a constant (which is the case for the Gaussian distribution) but has a non-degenerate distribution on the entire [0, 1] interval. Their empirical application exemplifies a possible consequence of this crucial difference of statistical inference between the Gaussian and the Paretian case. They point out that the conclusion on the empirical performance of the conventional static capital asset pricing model by Fama and French (1992) turns out not to be based on the statistical foundations.

The paper "On the robustness of location estimators in models of firm growth under heavy-tailedness" by Ibgagimov exemplifies an economic application of the heavy-tailed distributions, especially stable Paretian distributions. He investigates the dynamics of firms' growth process, and their interplay with the heavy-tails of signals they receive about their consumers. By doing this, he extends the model of demand-driven innovation and spatial competition over time in Jovanovic and Rob (1987) and divides the consumers' signals into two categories, light-tailed and heavy-tailed, with respect to the existence of a finite first moment. He shows that the firms' growth patterns depend crucially on the degree of heavy-tails of consumers' signals and on the choice of estimators employed by the firms to make inferences about their markets. If the first moment of the underlying distribution for consumers' signals is assumed to exist, the firms' output levels exhibit positive persistence so that large firms have an advantage over their smaller counterparts. However, once non-existence of the first moment is assumed the result will be reciprocal so that smaller firms will be more likely to become larger ones in the next period.

In "The asymptotic co-difference and co-variation of log-fractional stable noise" Levy and Taqqu study the asymptotic

0304-4076/$ – see front matter
http://dx.doi.org/10.1016/j.jeconom.2013.11.006

properties of the co-difference and co-variation for heavy-tailed log-fractional stable noise processes. The co-difference and co-variation are new dependence measures when the underlying processes do not have a finite second moment, which is the case for the stable Paretian distributions. Among the infinite-variance stable processes, log-fractional stable noise is particularly interesting. This is because such processes can be used to generally model positive dependences between the past and future in long memory processes, which is typically the case in economic and financial applications. One of the main results of this paper is that the log-fractional stable noise processes exhibit long range dependence with power law decay and, therefore, provide a natural way to combine heavy-tails for marginal distributions with long-range dependence. As is expected for estimators and statistical inference in the presence of stable Paretian distributions, the asymptotic properties of the two introduced measures depend crucially on the tail-thickness of the underlying processes.

The paper "Extreme-quantile tracking for financial time series" by Chavez-Demoulin, Embrechts and Sardy develops an Extreme-Value-Theory-based model widening the Peaks-Over-Threshold approach beyond stationary time series. The nonparametric Peaks-Over-Threshold method proposed in this paper is an important extension of the classical Peaks-Over-Threshold model to situations where the non-stationarity is induced by regime switches. For data related to economic crises, like the dot-com bubble or subprime crisis, a single underlying causal, regime-switching event may not always be detectable. For that purpose, they propose a nonparametric method to smooth extreme values based on total variation distance. Owing to the good segmentation properties of this ℓ_1-based smoother, their method is able to distinguish rapid changes of regime which would have been over-smoothed by classical methods, such as spline or kernel-based methods. Comparing and contrasting the new method to existing ones on financial market data shows that the proposed method provides a realistic model for the sometimes abrupt changes in the extremal behavior of financial time series. Extreme-Value-Theory-based modeling of financial time series has been challenged from the outset. Economists have stressed the need to incorporate regime-switch modeling as an important component to any statistical methodology aiming to estimate extreme risk measures. Back-testing results for nonparametric Peaks-Over-Threshold confirm a rather precise and adaptive estimation procedure for high-quantile-based risk measures (Value-at-Risk, Expected-Shortfall) for financial time series. Moreover, it is possible to derive credible regions, which provide financial analysts with a valuable measure of uncertainty. The proposed method can be applied to other time series data for which high quantiles need to be tracked.

The paper "Exponential stock models driven by tempered stable processes" by Küchler and Tappe investigates stock models driven by the tempered stable processes. The tempered stable processes constitute a rich class of stochastic processes with jumps, in particular a large number of small jumps. This kind of jump process is appropriate for modeling the impact of sudden, unexpected news, such as interventions by central banks or credit events. As financial models driven by jump processes are typically incomplete, they provide a systematic analysis of the existence of equivalent martingale measures, under which the model remains analytically tractable. In a case study, they estimate the model parameters from historical values of the German stock index using the method of moments, compute option prices and implied volatility surfaces by means of their pricing formulae, and compare it with the Black–Scholes model. The application of the tempered stable distribution for economic and financial data is rather motivated by the criticism that the empirical index of stability increases as the frequency of observation rises, which is inconsistent with a stable model of the returns—as pointed out, for example, by Akgiray and Booth (1988). Theoretically, one can argue that empirical data, especially financial returns, do not satisfy the requirement of this distributional convolution, because they are non-correlated but not independent. However, the tempered stable distribution seems to be more applicable to empirical analysis and, hence, is becoming more and more popular for modeling not only financial markets, but also macroeconomic uncertainty.

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Available online 26 November 2013

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