Economics 2142
Time Series Analysis

Fall 2006
Rustam Ibragimov and James Stock

Meeting time and location: Tue., Thu., 8:30-10 a.m., Littauer M-15

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Course Description
The course provides a survey of modern time series econometrics. Topics covered will include univariate models, vector autoregressions, frequency domain methods, models for and inference in persistent time series, structural breaks and applications of functional central limit theory and martingale convergence results in econometrics. The empirical applications in the course will draw primarily from finance and macroeconomics. If time allows, additional topics such as forecasting, inference for heavy-tailed time series and the inroduction to copula-based processes will be covered.

Grading
The final grade will be based on two problem sets (25% on each) and a final research paper (50% weight). The problem sets will emphasize different aspects of the course, including theory and estimation procedures we discuss in class. Collaboration with other students on problem sets is encouraged, however, the problem sets should be written independently. The final research paper can be either theoretical or empirical and should make a new contribution to the literature on a topic related to those covered in the class. Some of the topics will be suggested in class. Unless given explicit permission otherwise, the paper should be sole authored.

Textbooks and Readings
The primary text is Hamilton (1994). The books by Campbell, Lo and MacKinlay (1997) and Hayashi (2000) are recommended as useful references. Most of the readings for the later parts of the course are journal articles. The course overviews a large literature, so not all topics are treated in the same depth and only a few references listed under a topic will be covered. The other papers are additional references for those who wish to study specific topics in greater details. The lectures will be self-contained.

Campbell, J. Y., Lo, A. W. and MacKinlay, A. C. (1997). *The econometrics of financial markets*. Princeton: Princeton University Press.

Hamilton, J. D. (1994). *Time series analysis*. Princeton: Princeton University Press.

Hayashi, F. (2000). *Econometrics*. Princeton: Princeton University Press.

Supplemental texts

Brillinger, D. R. (2001). *Times series analysis: Data analysis and theory*. Reprint of the 1981 edition. Philadelphia: Society for Industrial and Applied Mathematics (SIAM).

Brockwell, P. J. and Davis, R. A. (1991). *Time series: theory and methods*. Second edition. New York: Springer-Verlag.

Cochrane, J. H. (2005). *Asset pricing*. Revised Edition. Princeton: Princeton University Press.

Davidson, J. (1994). *Stochastic limit theory*. New York: The Clarendon Press, Oxford University Press.

Engle. R. F. and McFadden, D. L. (eds.) (1994). *Handbook of econometrics*. Vol. IV. Amsterdam: Elsevier.

Fuller, W. A. (1996). *Introduction to statistical time series*. Second Edition. New York: John Wiley & Sons.

Hall, P. and Heyde, C. C. (1980). *Martingale limit theory and its application*. New York-London: Academic Press.

Harvey, A. C. (1993). *Time series models*. Second edition. Cambridge: MIT Press.

Hatanaka, M. (1996). *Time-series-based econometrics: unit roots and co-integrations*. Oxford: Oxford University Press.

Lütkepohl, H. (2005). *New introduction to multiple time series analysis*. Berlin: *Springer-Verlag*.

Course Outline

Asterisked references are more important to the course.

1. Introduction to stationary time series

Empirical properties of economic and financial time series, notation, stationary processes, lags, Wold decomposition, ARIMA processes, Beveridge-Nelson decomposition, introduction to vector autoregressions, model selection and information criteria, central limit theory for stationary time series, and basic functional central limit theory and applications to structural breaks and unit root tests.

*Hamilton, Chs. 1-5, 7, 10, 11, Sections 17.1-17.3 and Ch. 22.

*Hayashi, Ch. 2.

*Beveridge, S. and Nelson, C. R. (1981). A new approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the 'business cycle'. *Journal of Monetary Economics* **7**, 151-174.

Brockwell and Davis, Chs. 1, 3, Sect. 5.7.

*Hall and Heyde, Chs. 3, 4, and 5 and the Appendix.

*Hamilton, J. D. (1989). A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica* **57**, 357-384.

*Harvey, Chs. 1, 2.1-2.5, and 6.

*Lütkepohl, H. (2005), Ch. 16.

*Geweke, J. and R. Meese (1981). Estimating Regression Models of Finite but Unknown Order. *International Economic Review* **22**, 55-70.

2. Asymptotics I: Fuctional central limit theory for time series and initial applications

*Hamilton, Sections 17.1-17.3

*Stock, J. H. (1994). Unit roots and trend breaks in econometrics. *Handbook of Econometrics*, Vol. IV, 2740-2841 (sections 1-4).

*Dickey, D.A., and Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association* **74**, 427-431.

*Andrews, D. W. K. (1993). Tests for parameter instability and structural change with unknown change-point. *Econometrica* **61**, 821-856. Corrigendum: *Econometrica* **71**, 395-397.

3. Linear time series models with latent variables and the Kalman filter

Harvey, Ch. 4 and Section 5.1-5.4.

*Hamilton, Ch. 13.

4. The spectrum

*Hamilton, Ch. 6.

Brillinger, Chs. 3-5.

Brockwell and Davis, Chs. 6 and 10.

Harvey, Ch. 3.

Berk, K. N. (1974). Consistent autoregressive spectral estimates. *Annals of Statistics* **2**, 489-502.

5. Heteroskedasticity and autocorrelation consistent (HAC) variance estimation

*Andrews, D. W .K. (1991). Heteroskedasticity and autocorrelation consistent covariance matrix estimation. *Econometrica* **59**, 817-858.

Andrews, D. W. K. and Monahan, J. C. (1992). An improved heteroskedasticity and autocorrelation consistent covariance matrix estimator. *Econometrica* **60**, 953-966.

den Haan, W.J. and Levin, A. (1997). A practitioner's guide to robust covariance matrix estimation. In Maddala, G. S. and Rao, C. R. (Eds). *Handbook of Statistics* **15**, Ch. 12, 291-341.

*Hamiton, Ch. 10.

Kiefer, N. and Vogelsang, T. (2002). Heteroskedasticity-autocorrelation robust testing using bandwidth equal to sample size. *Econometric Theory* **18**, 1350-1366.

Newey, W. K. and West, K. D. (1987). A simple positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. *Econometrica* **55**, 703-708.

6. Generalized method of moments (classical theory)

*Cohrane (2001), Chs. 1, 2 and 10-16.

*Hall, A. R. (2005). Generalized method of moments. Oxford: Oxford University Press, Chs. 1-6.

*Hamilton, Ch. 14.

*Hayashi, Ch. 3.

*Hansen, L.P. and Singleton, K. (1982). Generalized instrumental variable estimation of nonlinear rational expectation models. *Econometrica* **50**, 1269-1286. Errata: *Econometrica* **52**, 267-268.

Hansen, L.P., Heaton, J. and Yaron, A. (1996). Finite sample properties of some alternative GMM estimators. *Journal of Business and Economic Statistics* **14**, 262-280.

*Newey, W.K. and McFadden, D. (1994). Large sample estimation and hypothesis testing. *Handbook of Econometrics*, Vol. IV, 2113-2247.

7. Structural VARs

*Blanchard, O. J. and Quah, D. (1989). Dynamic effects of aggregate demand and supply disturbances. *American Economic Review* **79**, 655-673.

King, R. G., Plosser, C. I., Stock, J. H. and Watson, M. W. (1991). Stochastic trends and economic fluctuations. *American Economic Review* **81**, 819-840.

*Lütkepohl, H. (2005), Part I, especially Chs. 3, 7.

Sims, C.A. (1980). Macroeconomics and reality. *Econometrica* 48, pp 1-48.

Stock, J. H. and Watson, M. W. (2001). Vector autoregressions. *Journal of Economic Perspectives* **15**, 101 – 116.

*Watson, M.W. (1994). Vector autoregressions and cointegration. *Handbook of Econometrics*, Vol. **IV**, 2844-2915 (Section 3).

Wright, J. H. (2000). Confidence intervals for univariate impulse responses with a near unit root. *Journal of Business and Economic Statistics* **18**, 368 – 373.

8. Asymptotics II: Functional central limit theory for time series, convergence to stochastic integrals, martingale convergence methods and their time series applications

*Beveridge, S. and Nelson, C. R. (1981). A new approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the 'business cycle'. *Journal of Monetary Economics* **7**, 151-174.

*Hamilton, Ch. 17.

Hall and Heyde, Chs. 3, 4, and 5 and the Appendix.

*Ibragimov, R. and Phillips, P. C. B. (2004). Regression asymptotics using martingale convergence methods, *Cowles Foundation Discussion Paper* 1473. Available at *http://cowles.econ.yale.edu/P/cd/d14b/d1473.pdf*

Jacod, J. and Shiryaev, A. N. (2003). Limit theorems for stochastic processes. 2nd edition. Springer-Verlag, Berlin. Chs. I, III, VI, and IX.

* Phillips, P.C.B. and Solo, V. (1992). Asymptotics for Linear Processes. *Annals of Statistics* **20**, 971-1001.

Prigent, J.-L. (2003). Weak convergence of financial markets. Berlin: Springer-Verlag. Sections 1.1-1.4, 3.1 and 3.3.

*Stock, J. H. (1994). Unit roots and trend breaks in econometrics. *Handbook of Econometrics*, Vol. IV, 2740-2841 (sections 1-4).

9. Structural breaks

Andrews, D. W. K. and Fair, R. C. (1988). Inference in nonlinear econometric models with structural change. *Review of Economic Studies* **55**, 615-640.

Andrews, D.W.K. and Ploberger, W. (1994). Optimal tests when a nuisance parameter is present only under the alternative. *Econometrica* **62**, 1383-1414.

Bai, J. (1997). Estimation of a change point in multiple regression models. *Review of Economics and Statistics* **79**, 551-563.

Bai, J. S. (1997). Estimating multiple breaks one at a time. *Econometric Theory* **13**, 315-352.

Bai, J. and Perron, P. (1998). Estimating and testing linear models with multiple structural changes. *Econometrica* **66**, 47-78.

Bai, J., Lumsdaine, R. L. and Stock, J. H. (1998). Testing for and dating common breaks in multivariate time series. *Review of Economic Studies* **65**, 395-432.

Chow, G. C. (1960). Tests of equality between sets of coefficients in two linear regressions. *Econometrica* 28, 591-605.

Hall, A. R. (2005). Generalized method of moments. Oxford: Oxford University Press, Ch. 5.

*Hamilton (1994), Ch. 22.

Hamilton, J. (1993). Estimation, inference, and forecasting of time series subject to changes in regime. In G. S. Maddala, C. R. Rao, and H. D. Vinod, eds., *Handbook of Statistics* **11**. New York, North-Holland, Ch. 9, pp. 231-260.

*Hansen, B. E. (2001). The new econometrics of structural change: dating breaks in U.S. labor productivity. *Journal of Economic Perspectives* **15**, 117-128.

Nyblom, J. (1989). Testing for the constancy of parameters over time. *Journal of the American Statistical Association* **84**, 223-230.

*Perron, P. (1989). The great crash, the oil price shock, and the unit root hypothesis. *Econometrica* **57**, 1361-1401

Zivot, E. and Andrews, D. W. K. (1992). Further evidence on the great crash, the oil price shock, and the unit root hypothesis. *Journal of Business and Economic Statistics* **10**, 251-270.

10. Modeling of an inference in persistent time series

10a. Tests for random walks and martingaleness

*Campbell, B. and Dufour, J. M. (1995). Exact nonparametric orthogonality and random walk tests. *Review of Economics and Statistics* **77**, 1-16.

*Campbell, Lo and MacKinlay, Ch. 2.

Ibragimov, R. and Brown, D. (2005). Sign tests for dependent observations. *Harvard Institute of Economic Research Discussion Paper No. 2099.* Available at *http://post.economics.harvard.edu/hier/2006papers/HIER2099.pdf*

Lo A. W. and MacKinlay, A. C. (1995). *A Non-Random Walk Down Wall Street*. Princeton University Press.

*Lo, A. W. and MacKinlay, A. C. (1988). Stock market prices do not follow random walks: evidence from a simple specification test. *Review of Financial Studies* **1**, 41-66.

Lo, A. W. and MacKinlay, A. C. (1989). The size and power of the variance ratio test in finite samples: a Monte Carlo investigation. *Journal of*

Econometrics **40**, 203-238.

*Richardson, M. and Stock, J. H. (1989). Drawing inferences from statistics based on multiyear asset returns. *Journal of Financial Economics* **25**, 323-348.

10b. Univariate unit roots and near unit root problem

*Hamilton, Ch. 17

Elliott, G., Rothenberg, T. J. and Stock, J. H. (1996). Efficient tests for an autoregressive unit root. *Econometrica* **64**, 813-836.

*Ibragimov, R. and Phillips, P. C. B. (2004). Regression asymptotics using martingale convergence methods, *Cowles Foundation Discussion Paper* 1473. Available at *http://cowles.econ.yale.edu/P/cd/d14b/d1473.pdf*

Phillips, P. C. B. (1988). Regression theory for near-integrated time series. *Econometrica* **56**, 1021-1043.

Phillips, P. C. B. and Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika* **75**, 355-346.

Rothenberg, T. J. and Stock J. H. (1997). Inference in a nearly integrated autoregressive model with nonnormal innovations. *Journal of Econometrics* **80**, 269-286.

*Stock, J. H. (1994). Unit roots and trend breaks in econometrics. *Handbook of Econometrics*, Vol. IV, 2740-2841 (sections 1-4).

10c. Persistent regressors

Amihud Y. and Hurvich, C. M. (2004). Predictive regressions: A reduced-bias estimation method. *Journal of Financial and Quatitative Analysis* 39, 813-841.

Bekaert, G. and Hodrick, R. J. (2001). Expectations hypotheses test. *Journal of Finance* **56**, 1357-94.

*Campbell, J. Y. and Yogo, M. (2006). Efficient tests of stock return predictability. *Journal of Financial Economics* **81**, 27-60.

*Cavanagh C. L., Elliott, G. and Stock, J. H. (1995). Inference in models with nearly integrated regressors. *Econometric Theory* **11**, 1131-1147.

Lewellen J. (2004). Predicting returns with financial ratios. *Journal of Financial Economics* **74,** 209-235.

***Stambaugh, R. F. (1999). Predictive regressions. *Journal of Financial Economics* **54**, 375-421.

Torous W., Valkanov R. and Yan, S. (2004). On predicting stock returns with nearly integrated explanatory variables. *Journal of Business* **77,** 937-966.

10d. Long memory and fractional integration

Baillie, R. T. (1996). Long memory processes and fractional integration in econometrics. *Journal of Econometrics* **73**, 5-59.

Beran, J. (1994). *Statistics for long-memory processes.* New York, Chapman & Hall.

*Campbell, Lo and MacKinlay, Section 2.6

Diebold, F. and Inoue, A. (2001). Long memory and regime switching. *Journal of Econometrics* **105**, 131-159.

Hosking, J. P. M. (1996). Asymptotic distributions of the sample mean, autocovariances, and autocorrelation of long-memory time series. *Journal of Econometrics* **73**, 261-284.

*Lo, A. (1991). Long term memory in stock market prices. *Econometrica* **59**, 1279-1313.

*Perron, P. and Qu, Z. (2004). An analytical evaluation of the log-periodogram estimate in the presence of level shifts and its implications for stock returns volatility. *Working paper, Boston University and University of Illinois at Urbana-Champaign.* Available at *http://econ.bu.edu/perron/papers/lm-shifts.pdf*

*Phillips, P. C. B. (1999). Unit root log periodogram regression. *Cowles Foundation Discussion Paper 1243.* Available at *http://cowles.econ.yale.edu/P/cd/d12a/d1244.pdf*

Robinson, P. M. (Ed.) (2003). *Time series with long memory*. Oxford: Oxford University Press.

10e. Multivariate unit roots and cointegration

*Campbell, J. Y. and Shiller, R. (1988). The dividend-price ratio and expectations of future dividend and discount factors. *Review of Financial Studies* **1**, 195-228.

*Engle, R. F. and Granger, C. W. J. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica* **55**, 521-576.

*Hamilton (1994), Ch. 19.

Lütkepohl, Chs. 7 and 8.

Stock, J. H. (1987). Asymptotic properties of least squares estimators of cointegrating vectors. *Econometrica* **55**, 1035-1056.

Stock, J. H. and Watson, M. W. (1993). A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica* **61**, 783-820.

*Watson, M.W. (1994). Vector autoregressions and cointegration. *Handbook of Econometrics*, v. IV, 2844-2915 (sections 1 and 2).

10f. Unit roots and cointegration in panels

Bai, J. S. and Ng, S. (2004). A panic attack on unit roots and cointegration. *Econometrica* **72**, 1127-1177.

Chang, Y. (2002). Nonlinear IV unit root tests in panels with cross-sectional dependency. *Journal of Econometrics* **110**, 261-292.

Chang, Y. (2004). Taking a New Contour: A Novel Approach to Panel Unit Root Tests. *Working paper, Rice University.* Available at http://www.ruf.rice.edu/~econ/papers/2004papers/05chang.pdf

Phillips, P. C. B. and Moon, H. R. (1999). Linear regression limit theory for nonstationary panel data. *Econometrica* **67**, 1057-1111.

11. Stochastic volatility and ARCH/GARCH models

*Bollerslev, T., Engle, R. F. and Nelson, D. B. (1994). ARCH models. In *Handbook of Econometrics*, Vol. IV, 2959-3038.

*Campbell, Lo and MacKinlay, Ch. 12.

*Hamilton, Ch. 21.

*Davis, R. A. and Mikosch, T. (1998). The sample autocorrelations of heavy-tailed processes with applications to ARCH. *Annals of Statistics* **26**, 2049-2080.

Engle, R. F. (2002). New frontiers for ARCH models. *Journal of Applied Econometrics* **17**, 425-446.

*Kim, S., Shephard, N. and Chib, S. (1998). Stochastic volatility: Likelihood inference and comparison with ARCH models. *Review of Economic Studies* **65**, 361-393.

Mikosch, T. and Starica, C. (2000). Limit theory for the sample autocorrelations and extremes of a GARCH(1, 1) process. *Annals of Statistics* **28**, 1427--1451.

Prigent, J.-L. (2003). Weak convergence of financial markets. Berlin: Springer-Verlag. Section 3.3.

Poon, S.-H. and Granger, C. W. J. (2003). Forecasting volatility in financial markets: A review, *Journal of Economic Literature* **41**, 478-539.

12. Inference in continuous time models

12a. Introduction to continuous-time stochastic processes and stochastic calculus

Durrett, R. (1996). *Stohastic calculus. A practical introduction.* CRC Press, Boca Raton, FL.

Karatzas, I. and Shreve, S. (1991). *Brownian motion and stochastic calculus.* Springer-Verlag, New York.

Karatzas, I. (1997). *Lectures on the Mathematics of Finance*, American Math Soc., Providence, RI.

12b. Estimation procedures and applications

*Ait-Sahalia, Y. (2002). Telling from discrete data whether the underlying continuous-time model is a diffusion. *Journal of Finance* **57**, 2075-2112.

Ait-Sahalia, Y. (2002). Maximum-likelihood estimation of discretely-sampled diffusions: A closed-form approximation approach. *Econometrica* **70**, 223-262.

*Andersen, T. G., Bollerslev and Diebold, F. X. (2002). Parametric and nonparametric volatility measurement. In: *Handbook of Financial Econometrics* (Aït-Sahalia, Y. and Hansen, L. P., Eds), Amsterdam: North Holland. Available at *http://home.uchicago.edu/~lhansen/abd_handbook_101304.pdf*

Andersen, T. G., Bollerslev, T. Diebold, F. X. and Labys, P. (2003). Modeling and forecasting realized volatility. *Econometrica* **71**, 579-625.

*Barndorff-Nielsen, O. E. and Shephard, N. (2004). Econometric analysis of realized covariation: High frequency based covariance, regression, and correlation in financial economics. *Econometrica* **72**, 885-925.

Barndorff-Nielsen, O. E. and Shephard, N. (2005). How accurate is the asymptotic approximation to the distribution of realised volatility? in *Identification and Inference for Econometric Models. A Festschrift for Tom Rothenberg*, (edited by Donald W.K. Andrews and James H. Stock), Cambridge University Press, 2005, 306—331. Available at h*ttp://www.nuff.ox.ac.uk/economics/papers/2001/w16/tom.pdf*

*Bandi, F. M. and Phillips, P. C. B. (2002). Nonstationary continuous-time processes. In: *Handbook of Financial Econometrics* (Aït-Sahalia,

Y. and Hansen, L. P., Eds), Amsterdam: North Holland. Available at *http://home.uchicago.edu/~lhansen/bandi.pdf*

*Bates, D.S. (1996). Testing option pricing models. In: Maddala, G.S., Rao, R. (Eds.), Handbook of Statistics **14**, Elsevier, Amsterdam, 567–611.

*Campbell, Lo and MacKinlay, Sections 9.1, 9.2, 9.3.

Lo, A. W. (1988). Maximum likelihood estimation of generalized Ito processes with discretely sampled data. *Econometric Theory* **4**, 231-524.

13. Inrtoduction to simulation-based methods in time series analysis

13a. Markov Chain Monte Carlo (MCMC)

Chernozhukov, V. and Hong, H. (2003). An MCMC approach to classical estimation. *Journal of Econometrics* **115**, 293-346.

***Chib, S. and Greenberg, E. (1996). Markov chain Monte Carlo simulation methods in econometrics. *Econometric Theory* **12**, 409-431.

*Chib, S. (2001). Markov chain Monte Carlo methods: computation and inference. In: Heckman, J.J., Leamer, E. (Eds.), Handbook of Econometrics, Vol. 5. North-Holland, Amestradam, 3564–3634 (Chapter 5).

Chib, S., Nardari, F. and Shephard (2002). Markov chain Monte Carlo methods for stochastic volatility models. *Journal of Econometrics* **108**, 281-316.

Cogley, T. and Sargent, T. J. (2002). Evolving post-world war IIUS inflation dynamics. *NBER Macroeconomics Annual* **16**, 331-373 (with discussion).

Cogley, T. and Sargent, T. J. Drifts and volatilities: monetary policies and outcomes in the post WWII US. *Review of Economic Dynamics* **8**, 262-302.

13b. Boostrap for time series

Andrews, D. W. K. (2002). Higher-order improvements of a computationally attractive k-step bootstrap for extremum estimators. *Econometrica* **70**, 119-162.

Andrews D. W. K. (2004). The block-block bootstrap: Improved asymptotic refinements. *Econometrica* **72**, 673-700.

*Bühlmann, P. (2002). Bootstraps for time series. *Statistical Science* **17**, 52-72.

Götze, F. and Künsch, H. R. (1996). Second-order correctness of the blockwise bootstrap for stationary observations. *Annals of Statistics* **24**, 1914-1933.

Hall, P. (1992). *The Bootstrap and Edgeworth Expansion.* Springer-Verlag, New York.

*Hall, P. and Horowitz, J. L. (1996). Bootstrap critical values for tests based on generalized-method-of-moments estimators. *Econometrica* **64**, 891-916.

Künsch, H. R. (1989). The jackknife and the bootstrap for general stationary observations. *Annals of Statistics* **17**, 1217-1241.

Lahiri, S. N. (1999). Theoretical comparisons of block bootstrap methods. *Annals of Statistics* **27**, 386-404.

Nze, P. A. and Doukhan, P. (2004). Weak dependence: Models and applications to econometrics. *Econometric Theory* **20**, 995-1045.

13c. Monte Carlo tests

Dufour, J.-M. and Kiviet, J. F. (1998). Exact inference methods for first-order autoregressive distributed lag models. *Econometrica* **66**, 79-104.

*Dufour, J.-M. (2006). Monte Carlo tests with nuisance parameters : A general approach to finite-sample inference and nonstandard asymptotics in econometrics. *Journal of Econometrics* **133,** 443-477.

Durbin J. and Koopman S. J. (1997). Monte Carlo maximum likelihood estimation for non-Gaussian state space models. *Biometrika* **84**, 669-684.

Additional topics

14. Forecasting

*Hamilton, Ch. 4.

Poon, S.-H. and Granger, C. W. J. (2003). Forecasting volatility in financial markets: A review, *Journal of Economic Literature* **41**, 478-539.

*Stock, J. H. and Watson, W. (2006). Forecasting with many predictors. In: Elliott, G., Granger, C. W. J. and Timmermann, A. G. (Eds). *The Handbook of Economic Forecasting* **1**. Elsevier, Amsterdam, 515-554.

15. Inference in heavy-tailed time series and robustness

15a. Stylized facts and empirical properties of financial time series. Implications for economic decisions

*Cont, R. (2001). Empirical properties of asset returns: stylized facts and statistical issues. *Quantitative Finance* **1**, 223-236. Available at *http://www-stat.wharton.upenn.edu/~steele/Resources/FTSResources/StylizedFacts/Cont2001.pdf*

Gabaix, X., Gopikrishnan, P., Plerou, V. and Stanley, H. E. (2003). A theory of power-law distributions in financial market fluctuations. *Nature* **423**, 267-270.

*Ibragimov, R. (2004). On the robustness of economic models to heavy-tailedness assumptions. *Working paper,* Yale University. Available at *http://post.economics.harvard.edu/faculty/ibragimov/Papers/HeavyTails.pdf*

Loretan, M. and Phillips, P. C. B. (1994). Testing the covariance stationarity of heavy-tailed time series. *Journal of Empirical Finance* **1**, 211-248. Available at *http://cowles.econ.yale.edu/P/cp/p08b/p0866.pdf*

15b. Asymptotics and tail index estimation

*Davis, R. A. and Mikosch, T. (1998). The sample autocorrelations of heavy-tailed processes with applications to ARCH. *Annals of Statistics* **26**, 2049-2080.

De Vany, A. S. and Walls, W. D. (2004). Motion picture profit, the stable paretian hypothesis and the curse of the superstar'. *Journal of Economic Dynamics and Control* **28**, 1035-1057.

Embrechts, P., Klupperberg, C. and Mikosch, T. (1997). *Modelling extremal events for insurance and finance.* Springer, New York.

*Gabaix, X. and Ibragimov, R. (2005). *LOG(RANK*-1/2): A simple way to improve the OLS estimation of tail exponents. *Working paper, Massachusetts Institute of Technology and Harvard University.* Available at *http://post.economics.harvard.edu/faculty/ibragimov/Papers/LogLog.pdf*

Hill, B. M. (1975). Simple general approach to inference about tail of a distribution. *Annals of Statistics* **3**, 1163-1174.

Huisman, R., Koedijk, K. G. , Kool, C. J. M. and Palm, F. (2001). Tail-index estimates in small samples. *Journal of Business & Economic Statistics* **19,** 208-216.

Loretan, M. and Phillips, P. C. B. (1994). *Opt. cit.*

McCulloch, J. H. (1997). Measuring tail thickness to estimate the stable index alpha: A critique. *Journal of Business and Economic Statistics* **15**, 74-81.

Mikosch, T. and Starica, C. (2000). Limit theory for the sample autocorrelations and extremes of a GARCH(1, 1) process. *Annals of Statistics* **28**, 1427--1451.

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