

Econometrics IV: Time Series Econometrics

Course Outline 2015

This is a one semester version of what was originally a two-course sequence in time series econometrics that comprises Econ 553a and Econ 557b. The course provides an introduction to time series methods in econometrics covering stationary series, aspects of trend behavior, detrending mechanisms and their properties, unit root theory, cointegrated system approaches, realized volatility and quarticity, Wold and BN decompositions, model selection, nonlinear nonstationary models and methods, spatial density asymptotics, and long memory modeling. Both time-domain and frequency-domain methods are discussed, and Bayesian as well as classical approaches are included. The treatment relies on asymptotic theory for linear processes, martingales and martingale approximations. We overview a large literature and not all topics are treated in the same depth. Theory, computations and some empirical applications are discussed. Classes are sometimes divided into two parts, one dealing with theory and the other with empirics.

No specific text is recommended. The most recent text is Martin, Hurn and Harris (2012), which provides good general coverage at the introductory level in an approach that is oriented towards implementation offering abundant illustrations that are (uniquely) complete with computer code in Gauss, Matlab and R. Hamilton's (1994)¹ book, Fuller (1996) and Gouriéroux and Monfort (1997) are useful references. Hamilton's coverage is broad and relevant to econometrics, the book is easy to read and it includes much introductory material, but is now dated. Fuller's book provides an accessible statistical treatment of the subject, is a useful revision of an earlier (1976) edition, and was the first text to discuss unit root theory. Gouriéroux and Monfort (1997) is a translation of an excellent French textbook of time series that covers a wide literature from an econometric perspective. Lutkepohl and Kratzig (2004) is a textbook of applied time series econometrics that emphasizes practicalities and covers methods that are popular in empirical economic applications. Brockwell and Davis (1991, with subsequent editions) is a very successful time series text that is commonly used in North American graduate statistics courses. This book is more technical than the above texts and stresses univariate models, but is well expository, covers most of the traditional stationary time series topics and comes with some computer software. Lutkepohl's (1993) book and his newer (2005) text provide excellent coverage and exposition of VAR and Bayesian VAR modelling methods, together with some small scale practical applications to macro data. Hall and Heyde (1980) is a beautifully written classic on martingale limit theory that continues to reward careful reading. Billingsley (1999) is the second edition of a highly influential treatise on weak convergence that first appeared in 1968. Davidson (1994) is a good general reference source on limit theory for econometrics including functional laws, emphasizing mixing and weak dependence. Van de Vaart (1998) is a useful overview of asymptotic methods in statistics, including some empirical process methods. Taniguchi and Kakizawa (2000) give a modern treatment of time series asymptotics from a stochastic process perspective and include some useful special topics like large deviation expansions, saddlepoint approximations and higher order asymptotics. White (2002) provides much useful background and its first edition (1984) was notable for its general treatment of asymptotic covariance matrix estimation. Two useful new entries with advanced material are Giraitis et al (2014), which covers large sample inference methods for long memory data, and Wang's (2015) monograph on limit theory for nonlinear cointegrating regressions.

¹ See Section 0 in the Reading Guide below for general references.

A take home examination will be given at the end of the course. Students have the option of attempting a solution to the problems in this exam, writing a scientific overview of a modern research area in econometrics, or doing an applied econometrics paper on a topic of their choice. The empirical paper may be used for the applied econometrics paper requirement. Past take home exams over many years are all available on the web and some solution sets are available.

The following is a general outline of how we proceed through the course material. Some of the material may be taught in section based on earlier years' lectures to help us cover more material in the course. We adjust lecture content according to the rate of progress, importance of the material, and relevance to applied work. Some empirical applications will be discussed.

Week	Content
1 & 2	Ideas and approaches to time series. Primary concerns and methods of inference: Classical, Bayesian and prequential approaches. Role of unit roots and cointegration in econometric modeling. Brownian motion, the Karhunen-Loève representation, and some of its recent applications.
3 & 4	Heuristic ideas and implications for inference and modelling. Simple parametric models, including VARs, and Cointegrated systems. Optimal estimation and IV approaches. Some preliminary asymptotics. Information criteria and model selection asymptotics. Trend Elimination.
5 & 6	Ergodicity, the ergodic theorem, and notions of weak dependence. Conditional expectations and Hilbert projections. The Wold decomposition and forecasting. Grenander Rosenblatt theory.
7 & 8	The Phillips-Solo device & shortcuts to time series asymptotics. Strong laws and CLT's for time series. Unit root limit theory, asymptotic degeneracy, realized volatility, quadratic variation, and quarticity. Optimal estimation of cointegrated systems.
9 & 10	Martingales and time series applications of the martingale convergence theorem. Explosive and mildly explosive time series. Bubbles, crashes and applications in finance.
11	Nonlinear nonstationary models, spatial density, estimation of local time. Applications to market intervention.
12 & 13	Frequency domain approaches and spectral regression. Spectral density and long run variance estimation. Nonparametric regression. Long memory models and econometric methods. More on unit roots and cointegration.
December - January	<i>Take Home examination paper, overview paper, or applied econometrics paper</i>

Reading Guide

Time series is a vast subject. The following list covers only that part of the subject that relates most closely to econometric research. The list is subdivided into topics that are relevant to material we intend to discuss, if only briefly in some cases, during the course.

0. General References²

- Aoki, M. (1987) *State Space Modeling of Time Series*. New York: Springer.
- Anderson, T.W. (1971) *The Statistical Analysis of Time Series*. New York: Wiley.
- Banerjee, A., J. Dolado, J.W. Galbraith and D.F. Hendry (1993) *Cointegration, Error-Correction and the Econometric Analysis of Non-Stationary Data*. Oxford: Oxford University Press.
- Bierens, H. J. (1996) *Topics in Advanced Econometrics: Estimation, testing and specification of cross section time series models*. Cambridge University Press.
- * Billingsley, P. (1999) *Weak Convergence of Probability Measures*. Second Edition. New York: Wiley.
- Box, G.E.P. and G.M. Jenkins (1976) *Time Series Analysis: Forecasting and Control*, 2nd ed. San Francisco: Holden Day.
- * Brillinger, D.R. (1981) *Time Series: Data Analysis and Theory*, 2nd ed. San Francisco: Holden Day.
- * Brockwell, P.J. and R.A. Davis (1986) *Time Series: Theory and Methods*. New York: Springer (2nd ed., 1991).
- Clements M. P. and D. F. Hendry (1998) *Forecasting Economic Time Series*. Cambridge: Cambridge University Press.
- * Davidson, J. (1995) *Stochastic Limit Theory* Oxford: Oxford University Press.
- Dhrymes, P. (1989) *Topics in Advanced Econometrics*. New York: Springer Verlag.
- Fan, J. and Q. Yao (2003) *Nonlinear Time Series. Nonparametric and Parametric Methods*. New York: Springer.
- * Fuller, W.A. (1996) *Introduction to Statistical Time Series, 2nd Edition*. New York: Wiley.
- Fishman, G. (1969) *Spectral Methods in Econometrics*. Cambridge: Harvard University Press.
- Giraitis L., H. L. Koul, and D. Surgailis (2012). *Large Sample Inference for Long Memory Processes*. London: Imperial College Press.
- * Gouriéroux C. and A. Monfort (1997). “Time Series and Dynamic Models”. Cambridge: Cambridge University Press.

² Asterisked references are more important to the course.

- Granger, C.W.T. and P. Newbold (1987) *Forecasting Economic Time Series*, 2nd edition. New York: Academic Press.
- Grenander, U. and M. Rosenblatt (1957) *Statistical Analysis of Stationary Time Series*. New York: Wiley.
- * Hall, P. and C.C. Heyde (1980) *Martingale Limit Theory and its Applications*. New York: Academic Press.
- Hannan, E.J. (1970) *Multiple Time Series*. New York: Wiley.
- Hannan, E.J. and M. Deistler (1988) *Statistical Theory of Linear Systems*. New York: Wiley.
- * Hamilton, J.D. (1994) *Time Series Analysis*. Princeton: Princeton University Press.
- Harvey, A.C. (1993) *Time Series Models*. Hemel Hempstead: Harvester Wheatsheaf.
- Harvey, A.C. (1990) *Forecasting Structural Time Series Models and the Kalman Filter*. New York: Cambridge University Press.
- Hendry, D. F. (1995) *Dynamic Econometrics*. Oxford: Oxford University Press.
- Hsiao, C. (2003) *Analysis of Panel Data*. (2nd Ed.) Cambridge: Cambridge University Press.
- Hylleberg, S. (1992) *Modelling Seasonality*. Oxford: Oxford University Press.
- * Lutkepohl, H. (1993) *Introduction to Multiple Time Series Analysis*, 2nd ed. New York: Springer Verlag.
- * Lutkepohl, H. (2005) *A New Introduction to Multiple Time Series Analysis*, New York: Springer Verlag.
- * Lutkepohl, H. and M. Kratzig (2004) *Applied Time Series Econometrics*, Cambridge University Press.
- Maddala, G. S. and I-M. Kim (1998). *Unit Roots, Cointegration, and Structural Change*. Cambridge University Press.
- * Martin, V., S. Hurn and D. Harris (2012). *Econometric Modelling with Time Series: Specification, Estimation and Testing*. Cambridge University Press.
- Matyas, L. (1999). *Generalized Methods of Moments Estimation*., Cambridge: Cambridge University Press.
- Mills, T. C. (1990) *Time Series Techniques for Economists*. Cambridge: Cambridge University Press
- Potscher B. and I. Prucha, “Dynamic Nonlinear Econometric Models” New York: Springer.
- Priestley, M.B. (1981) *Spectral Analysis and Time Series*. Vol. 1, New York: Academic Press.

- Rao, B.B. (1994) *Cointegration for the Applied Economist*. St. Martin's Press.
- Reinsel, G. (1993) *Elements of Multivariate Time Series Analysis*. New York: Springer.
- Taniguchi, M. and Y. Kakizawa (2000). *Asymptotic Theory of Statistical Inference for Time Series*. New York: Springer Verlag.
- Tong, H. (1990) *Non-Linear Time Series: A Dynamical System Approach*. Oxford: Clarendon Press.
- Van de Vaart (1998). *Asymptotic Statistics*. Cambridge University Press.
- Watson, M. (1995) "Vector Autoregressions and Cointegration." In R.F. Engle and D. McFadden, eds., *Handbook of Econometrics*, Vol. 4. Amsterdam: North Holland.
- Wang, Q. (2015). *Limit Theorems for Nonlinear Cointegrating Regression*, Singapore: World Scientific.
- West, M. and P.J. Harrison (1989) *Bayesian Forecasting and Dynamic Models*. New York: Springer-Verlag.
- White, H. (1994) *Estimation, Inference and specification Analysis*. Cambridge: Cambridge University Press.
- White, H. (2002) *Asymptotic Theory for Econometricians*. (Revised Edition) San Diego: Academic Press.
- Whittle, P. (1984) *Prediction and Regulation*, 2nd ed. Oxford: Blackwell.
- Wooldridge, J. M. (1995) "Estimation and Inference for Dependent Processes" in R. F. Engle and D. L. McFadden *Handbook of Econometrics Vol IV*. Amsterdam: North Holland.
- Yaglom, A.M. (1962) *An Introduction to the Theory of Stationary Random Functions*. New York: Dover.

1. Ideas and Approaches

- * Phillips P. C. B. (1989 & 1995) Lecture notes

Phillips, P.C.B. (1992, 2008) "Unit Roots." In P. Newman, M. Milgate and J. Eatwell, eds., *The New Palgrave Dictionary of Money and Finance*, 726-730.

Phillips, P.C.B. (1995) "Unit Roots and Cointegration: Recent Books and Themes for the Future," *Journal of Applied Econometrics*

Phillips P. C. B. (1998) "Econometric Analysis of Nonstationary Data", IMF Lectures

Phillips, P. C. B. (1998). "New Tools for Understanding Spurious Regressions". *Econometrica*, 66, 1299-1326.

Phillips, P. C. B. (2001): "Descriptive Econometrics for Nonstationary Time Series with Empirical Illustrations," *Journal of Applied Econometrics*, 16, 389-413.

Phillips P. C. B. (2003) "Laws and Limits of Econometrics", *Economic Journal*, Vol. 113, No. 486, March, 2003, pp. C26-C52.

Phillips, P. C. B. (2005) "Challenges of Trending Time Series Econometrics" *Mathematics and Computers in Simulation*, 68, 401-416.

Phillips, P. C. B. (2005) "Automated Discovery in Econometrics" *Econometric Theory*, 21, 3-20.

Phillips, P. C. B. (2009) "Econometric Theory and Practice," *Econometric Theory*, 25, 583-586.

2. Karhunen Loève Representation, Unit Roots and Cointegration, Optimal Estimation of Cointegrated Systems, Nonlinear Cointegration

Johansen, S. (1995), Likelihood-based inference in cointegrated vector autoregressive models, Oxford: Oxford University Press.

Phillips, P. C. B. (1986). "Understanding spurious regressions in econometrics," *Journal of Econometrics* 33, 311--340.

Phillips, P. C. B. (1987). "Time Series Regression with a Unit Root," *Econometrica*, 55, 277--302.

Phillips, P. C. B. (1991b). "Optimal inference in cointegrated systems," *Econometrica* 59, 283--306.

Phillips, P. C. B. (1998). "New Tools for Understanding Spurious Regressions". *Econometrica*, 66, 1299-1326.

Phillips, P. C. B (2001). "New Unit Root Asymptotics in the Presence of Deterministic Trends". *Journal of Econometrics*, 11, 323-353.

Phillips, P. C. B. (2014). "Optimal Estimation of Cointegrated Systems with Irrelevant Instruments", *Journal of Econometrics*, 178, 210-224.

Phillips, P. C. B. and B. E. Hansen (1990). "Statistical inference in instrumental variables regression with I(1) processes," *Review of Economic Studies*, 57, 99--125.

Phillips, P. C. B. and M. Loretan (1991). "Estimating long-run economic equilibria," *Review of Economic Studies* 59, 407--436.

Saikkonen, P. (1991). "Asymptotically efficient estimation of cointegration regressions," *Econometric Theory* 7, 1--21.

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

Wang, Q. and P. C. B. Phillips (2009). "Asymptotic Theory for Local Time Density Estimation and Nonparametric Cointegrating Regression", *Econometric Theory*, 25, 710-738.

Wang, Q. and P. C. B. Phillips (2009). "Structural Nonparametric Cointegrating Regression", *Econometrica*, 77, 1901-1948.

Wang, Q. and P. C. B. Phillips (2012) "A Specification Test for Nonlinear Nonstationary Models", *Annals of Statistics*, 40, 727-758.

Wang Q. (2015) op. cit.

3. Classical and Bayesian Asymptotics for time series and Model Selection

Chen, C. F. (1985). "On asymptotic normality of limiting density functions with Bayesian implications," *Journal of the Royal Statistical Society, Series B*, 47, 540-546.

Hartigan, J. A. (1983). *Bayes Theory*. New York: Springer-Verlag.

Heyde, C. C. and I. M. Johnstone (1979). "On asymptotic posterior normality for stochastic processes," *Journal of the Royal Statistical Society*, 41, 184-189.

Kim, J. Y. (1994). "Bayesian asymptotic theory in a time series model with a possible nonstationary process," *Econometric Theory*, 10, 764-773.

Kim J. Y. (1998) "Large Sample Properties of Posterior Densities Bayesian Information Criterion and the Likelihood Principle in Nonstationary Time Series Models," *Econometrica*, 66, 359-380.

Le Cam, L. and G. L. Yang (1990). *Asymptotics in Statistics: Some Basic Concepts*. New York: Springer

* Phillips, P.C.B. (1996) "Econometric Model Determination " *Econometrica*, 64, 763-812.

* Phillips, P. C. B. and W. Ploberger (1996). "An asymptotic theory of Bayesian inference for time series," *Econometrica*, 64, 381-413.

Ploberger W. and P. C. B. Phillips (2003) "Empirical Limits for Time Series Econometric Models", *Econometrica*, Vol. 71, No. 2, pp. 627-673.

* Schwarz, G. (1978) "Estimating the dimension of a model," *Annals of Statistics*, 6:461-464.

Sweeting, T. J. and A. O. Adekola (1987). "Asymptotic posterior normality for stochastic processes revisited," *Journal of the Royal Statistical Society, Series B*, 49, 215-222.

4. Strict Stationarity and Ergodic Theory

Cramer, H. and M.R. Leadbetter (1967) *Stationary and Related Stochastic Processes*. New York: Wiley.

* Dhrymes (1989) op. cit.

Rozanov, Y.A. (1967) *Stationary Random Processes*. San Francisco: Holden Day.

* Stout, W.F. (1974) *Almost Sure Convergence*. New York: Academic Press.

Walters, P. (1982) *An Introduction to Ergodic Theory*. New York: Springer.

5. Projections and the Wold Decomposition

Anderson (1971) *op. cit.*

* Brockwell and Davis (1993) *op. cit.*

* Hannan (1970) *op. cit.*

Whittle (2002) *op. cit.*

6. Weak Dependence and Mixing Processes

* Davidson J. (1995) *op. cit.*

Gallant A. R. and H. White (1988) *A Unified Theory of Estimation and Inference for Nonlinear Dynamic Models*. New York: Basil Blackwell.

Ibragimov, I.A. and Y.V. Linnik (1971) *Independent and Stationary Sequences of Random Variables*. Groningen: Wolters-Noordhoff.

Potscher B. and I. Prucha (1997) *op. cit.*

* White, H. (2002) *op. cit.*

White, H. and I. Domowitz (1984) "Nonlinear Regression with Dependent Observations," *Econometrica*, 52:143-162.

7. BN Decomposition and Phillips-Solo Device

* Beveridge, S. and C. R. Nelson (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.

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

8. Martingales, Martingale Convergence Theory and Strong Laws for Dependent Sequences

Billingsley, P. (1979) *Probability and Measure*. New York: Wiley.

Doob, J.L. (1953) *Stochastic Processes*. New York: Wiley.

* Hall, P. and C.C. Heyde (1980) *Martingale Limit Theory and its Application*. New York: Academic Press.

McLeish, D.L. (1975) "A Maximal Inequality and Dependent Strong Laws," *Annals of Probability*, 3:829-839.

* Phillips, P.C.B. and V. Solo (1992) *op. cit.*

9. Central Limit Theory for Dependent Variables

Davidson J. (1995) *op. cit.*

* Hall and Heyde (1980) *op. cit.*

* Phillips and Solo (1992) *op. cit.*

White, H. (2002) *op. cit.*

10. Spectrum, HAC and Long Run Variance Matrix Estimation

* Andrews, D.W.K. (1991) "Heteroskedasticity and Autocorrelation Consistent Covariance Matrix Estimation," *Econometrica*, 817-858.

Andrews, D.W.K. and J.C. Monahan (1992) "An Improved Heteroskedasticity and autocorrelation Consistent Covariance Matrix Estimator," *Econometrica*, 60, 953-966.

Den Haan, W.J., and A. Levin, 1997, "A practitioner's guide to robust covariance matrix estimation," in *Handbook of Statistics 15*, G.S. Maddala and C.R. Rao, eds., Elsevier (Amsterdam), pp.299-342.

Den Haan, W.J., and A. Levin, 2000, "Robust covariance matrix estimation with data-dependent prewhitening order", Working Paper 2000-11, University of California, San Diego

* Hannan, E. J. (1970) *op. cit.*

Lee, C. C. and P. C. B. Phillips (1994) "An ARMA-prewhitened long run variance estimator", Yale University, mimeographed.

Newey, W.K. and K.D. West (1987) "A Simple Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica*, 55, 703-708.

Parzen, E. (1957) "On Consistent Estimates of the Spectrum of a Stationary Time Series," *Annals of Mathematical Statistics*, 28:329-348.

Phillips, P. C. B. (2004). "HAC Estimation by Automated Regression." *Econometric Theory*, 21, 116-142.

Phillips, P. C. B., Y. Sun and S. Jin (2006) "Spectral Density Estimation and Robust Hypothesis Testing using Steep Origin Kernels without Truncation", *International Economic Review*.

Phillips, P. C. B., Y. Sun and S. Jin (2006) "Long Run Variance Estimation and Robust Regression Testing using Sharp Origin Kernels with No Truncation" (with Yixiao Sun and Sainan Jin), *Journal of Statistical Planning and Inference*, 2006 (forthcoming)

* Priestley (1981) *op. cit.*

Robinson, P.M. (1998), "Inference-without-smoothing in the Presence of Nonparametric Autocorrelation," *Econometrica*, 66, 1163-1182.

Sul, D., C-Y Choi and P. C. B. Phillips (2005) "Prewhitening Bias in HAC Estimation", *Oxford Bulletin of Economics and Statistics*, 67, 517-546.

Sun, Y., P. C. B. Phillips, and S. Jin (2008) "Optimal Bandwidth Selection in Heteroskedasticity-Autocorrelation Robust Testing" *Econometrica*. 76, 175-194.

White, H. (1980) "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test of Heteroskedasticity," *Econometrica*, 48, 817-838.

White, H. (2002) *op. cit.*

11. Spectral Regression Theory

Corbae, D., S. Ouliaris and P. C. B. Phillips (2002) "Band Spectral Regression with Trending Data". *Econometrica*, 70, 1067-1110.

* Hannan, E. J. (1963) "Regression for Time Series" in M. Rosenblatt (Ed.) *Time Series Analysis*, New York: Wiley.

* Hannan (1970) *op. cit.*

Phillips, P. C. B. (1997) "New developments on Hannan Regression", Ted Hannan Lecture, Australasian meetings of Econometric Society, Melbourne.

Robinson, P.M. (1991) "Automatic frequency domain inference on semiparametric and nonparametric models," *Econometrica*, 59, 1329-1364.

Xiao, Z. and P. C. B. Phillips, (1998). "Higher Order Approximations for Frequency Domain Time Series Regression", *Journal of Econometrics*, Vol. 86, 1998, pp. 297-336

12. VAR'S, BVAR's, Impulse Response Analysis

Cooley, T.B. and S.F. LeRoy (1985) "Atheoretical Macroeconometrics: A Critique," *Journal of Monetary Economics*, 16:283-308.

* Hamilton (1994) Chs. 11, 12.

Litterman, R.B. (1986) "Forecasting with Bayesian Vector Autoregressions: Five Years of Experience," *Journal of Business and Economic Statistics*, 4:25-38.

- Litterman, R.B. and L. Weiss (1985) "Money, Real Interest Rates, and Output: A Reinterpretation of Postwar U.S. Data," *Econometrica*, 53:129-156.
- * Lutkepohl, H. (1990) "Asymptotic Distributions of Impulse Response Functions and Forecast Error Variance Decompositions of Vector Autoregressive Models," *Review of Economics and Statistics*, 72:116-125.
- * Lutkepohl, H. (1993) *op.cit.*, Ch. 5.
- Phillips, P.C.B. (1995a) "Bayesian Model Selection and Prediction with Empirical Applications," *Journal of Econometrics*, 69, 289-332
- Phillips, P.C.B. (1995b) "Bayesian Prediction: A Response," *Journal of Econometrics*, 69, 351-365.
- * Phillips, P.C.B. (1998) "Impulse response and forecast error asymptotics in nonstationary VAR's," *Journal of Econometrics*, 83, 21-56.
- Runkle, D. (1987) "Vector Autoregressions and Reality," *Journal of Business and Economic Statistics*, 5(4):437-432.
- * Sims, C.A. (1980) "Macroeconomics and Reality," *Econometrica*, 48:1-48.
- Todd, R.M. (1990) "Vector Autoregression Evidence on Monetarism: Another Look at the Robustness Debate," *Federal Reserve Bank of Minneapolis Quarterly Review*, 19-37.
- Todd, R.M. (1995) "Improving Economic Forecasting with Bayesian Vector Autoregression," *Federal Reserve Bank of Minneapolis Quarterly Review*, 4:18-29.
- Zellner, A. and C.K. Min (1992) "Bayesian Analysis, Model Selection and Prediction," University of Chicago, Mimeographed.

13. Long Memory Models and Econometric Methods

- * Baillie, R. T. (1996). "Long memory processes and fractional integration in econometrics". *Journal of Econometrics*, 73, 5-59.
- Baillie, R. T. and T. Bollerslev (1994). "Long memory in the forward premium". *Journal of International Money and Finance*, 13, 565-571.
- Geweke J. and S. Porter-Hudak (1983) "The estimation and application of long memory time series models". *Journal of Time Series Analysis*, 4, 221-237.
- Giraitis et al. (2012) *op. cit.*
- Granger, C. W. J. (1980). "Long memory relationships and the aggregation of dynamic models". *Journal of Econometrics*, 14, 227-238.
- * Granger, C. W. J. and R. Joyeux (1980). "An introduction to long memory time series models and fractional differencing". *Journal of Time Series Analysis*, 1, 15-39.
- * Hosking, J. R. M. (1981). "Fractional differencing". *Biometrika*, 68, 165-176.

- Kunsch, H. (1986). "Discrimination between monotonic trends and long-range dependence". *Journal of Applied Probability*, 23, 1025-1030.
- Mandelbrot, B. B. and J. W. Van Ness (1968). "Fractional Brownian motions, fractional Brownian noises and applications". *SIAM Review*, 10, 422-437.
- Mandelbrot, B. B. and J. Wallis (1968). "Noah, Joseph and operational hydrology". *Water Resources Research*, 4, 909-918.
- * Phillips, P. C. B. (1999) "Discrete Fourier Transforms of Fractional Processes". Cowles Foundation Discussion Paper #1243, Yale University.
- Phillips, P. C. B. & K. Shimotsu (2004) "Local Whittle Estimation in Nonstationary and Unit Root Cases," *Annals of Statistics*, 32, 656-692.
- Phillips, P. C. B. (2006) "Unit Root Log Periodogram Regression", *Journal of Econometrics*,
- * Robinson, P. M. (1995). "Log periodogram regression of time series with long range dependence". *Annals of Statistics*, 23, 1048-1072.
- Robinson, P. M. (1995). "Gaussian semiparametric estimation of time series with long range dependence". *Annals of Statistics*, 23, 1630-1661.
- Shimotsu, K. & Phillips, P. C. B (2005) "Exact Local Whittle Estimation of Fractional Integration" *Annals of Statistics*, 33, 1890-1933
- Shimotsu, K. & Phillips, P. C. B (2006). "Local Whittle Estimation of Fractional Integration and Some of its Variants", *Journal of Econometrics*, 130, 209-233.
- Sowell, F. B. (1986). "Fractionally integrated vector time series". Ph.D. dissertation (Duke University, Durham, NC).
- Sowell, F. B. (1992). "Maximum likelihood estimation of stationary univariate fractionally integrated time series models". *Journal of Econometrics*, 53, 165-188.
- Sun, Y. and P. C. B. Phillips (2003). "Nonlinear Log-Periodogram Regression for Perturbed Fractional Processes", *Journal of Econometrics*, Vol. 115, No. 2, pp. 355-389.
- Journal of Econometrics*, Vol. 73 (1996) [special issue].