The Econometrics of Temporal Aggregation: 1956 - 2014

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## **Selected Bibliography**

Aït-Sahalia, 2007. Estimating continuous-time models using discretely sampled data. In R. Blundell, T. Perrson, and W. K. Newey (eds.), *Advances in Economics and Econometrics, Theory and Applications, Ninth World Congress.* Econometric Society Monographs, Cambridge University Press, Cambridge.

Abraham, B., 1982. Temporal aggregation and time series. International Statistical Review, 50, 285-291.

Alper, C. E., S. Fendoglu, and B. Saltoglu, 2008. Forecasting stock market volatilities using MIDAS regressions: An application to the emerging markets. MPRA Paper No. 7460.

Anathanosopoulos, G., R. J. Hyndman, H. Song, and D. C. Wu, 2011. The tourism forecasting competition. *International Journal of Forecasting*, 27, 822-844.

Andreou, E., E. Ghysels, and A. Kourtellos, 2013. Should economic forecasters use daily financial data and how? *Journal of Business and Economic Statistics*, 31, 240-251.

Armesto, M. T., K. M. Engemann, and M. T. Owyang, 2010. Forecasting with mixed frequencies. *Federal Reserve Bank of St. Louis Review*, 92, 521-536.

Bachelier, L., 1900. Théorie de la spéculation. Ph.D. thesis, Sorbonne, France.

Bai, J. and S. Ng, 2005. Tests for skewness, kurtosis and normality for time series data. *Journal of Business and Economic Statistics*, 23, 49-60.

Barsoum, F. and S. Stankiewicz, 2013. Forecasting GDP growth using mixed-frequency models with switching regimes. Working Paper Series 2013-10, Department of Economics, University of Konstanz.

Bartlett, M. S., 1946. On the theoretical specification and sampling properties of autocorrelated timeseries. *Journal of the Royal Statistical Society*, *B*, 8, 27-41.

Baumeister, C., P. Guérin, and L. Killian, 2013. Do high-frequency financial data help forecast oil prices? The MIDAS touch at work. CFS Working Paper No. 2013/22, Center for Financial Studies.

Belderassi, B. and G. B. Tranquilli, 1987. Dependence structures of normal observations and distributions of one-way ANOVA statistics. *Statistica*, 47, 589-606.

Bergstrom, A. R. (ed.), 1976. *Statistical Inference in Continuous Time Models*. North-Holland, Amsterdam.

Bergstrom, A. R., 1983. Gaussian estimation of structural parameters in higher order continuous time dynamic models. *Econometrica*, 51, 117-152.

Bergstrom, A. R., 1984. Continuous time stochastic models and issues of aggregation over time. In Z. Griliches and M. D. Intriligator (eds.), *Handbook of Econometrics*, Vol. 2. North-Holland, Amsterdam Chapter 20.

Bergstrom, A. R., 1985. The estimation of parameters in non-stationary higher-order continuous time dynamic models. *Econometric Theory*, 1, 369-385.

Bergstrom, A. R., 1986. The estimation of open higher-order continuous time dynamic models with mixed stock and flow data. *Econometric Theory*, 2, 350-373.

Bergstrom, A. R., 1988. The history of continuous time econometric models. *Econometric Theory*, 4, 365-383.

Bergstrom, A. R., 1990. Continuous Time Econometric Modelling. Oxford University Press, Oxford.

Bergstrom, A. R., 1996. A survey of continuous time econometrics. In W. A. Barnett, G. Gandalfo, and C. Hillinger (eds.), *Dynamic Disequilibrium Modelling*. Cambridge University Press, Cambridge, 3-26.

Bergstrom, A. R. and K. B. Nowman, 2007. A Continuous Time Econometric Model of the United Kingdom with Stochastic Trends. Cambridge University Press, Cambridge.

Bergstrom, A. R., K. B. Nowman, and C. R. Wymer, 1992. Gaussian estimation of a second order continuous time macroeconometric model of the United Kingdom. *Economic Modelling*, 9, 313-352.

Bergstrom, A.R., and C.R. Wymer, 1976. A model of disequilibrium neoclassical growth and its application to the United Kingdom. In A.R. Bergstrom (ed.), *Statistical Inference in Continuous Time Economic Models*. North-Holland, Amsterdam, 267-327.

Boswijk, H. P. and F. Klaasen, 2003. Why frequency matters for unit root testing. Discussion Paper 2003/12, Department of Quantitative Economics, University of Amsterdam.

Bowman, K. O. and L. R. Shenton, 1975. Omnibus test contours for departures from normality based on  $\sqrt{b_1}$  and  $b_2$ . *Biometrika*, 62, 243–250.

Brännäs, K., and J. G. De Gooijer, 1994. Autoregressive-asymmetric moving average model for business cycle data. *Journal of Forecasting*, 13, 529–544.

Brännäs, K. and H. Ohlsson, 1999. Asymmetric time series and temporal aggregation. *Review of Economics and Statistics*, 81, 341-344.

Breitung, J. and N. R. Swanson, 2002. Temporal aggregation and spurious instantaneous causality in multiple time series models. *Journal of Time Series Analysis*, 23, 651-665.

Brewer, K. R. W., 1973. Some consequences of temporal aggregation and systematic sampling for ARMA and ARMAX models. *Journal of Econometrics*, 1, 133-154.

Campos, J., N. R. Ericsson, and D. F. Hendry, D. F., 1990. An analogue model of phase averaging procedures. *Journal of Econometrics*, 43, 275-292.

Christriano, L. J. and M. Eichenbaum, 1987. Temporal aggregation and structural inference in macroeconomics. *Carnegie-Rochester Conference Series on Public Policy*, 26, 63-130.

Clements, M. P., and A. B. Galvao, 2006. Macroeconomic forecasting with mixed frequency data: Forecasting US output growth and inflation. Warwick Economic Research Paper No. 773, University of Warwick.

Drost. F. C. and T. E. Nijman, 1993. Temporal aggregation of GARCH processes. *Econometrica*, 61, 909-927.

Durbin, J., 1959. Efficient estimation of parameters in moving average models. *Biometrika*, 46, 306-316.

Engle, R. F., 1969. Biases From Time Aggregation of Distributed Lag Models. Ph.D. Dissertation, Department of Economics, Cornell University.

Engle, R. F., 1970. The inconsistency of distributed lag estimators due to misspecification by time aggregation. Working Paper No. 63, Department of Economics, Massachusetts Institute of Technology.

Foroni, C., M. Marcellino, and C. Schumacher, 2011. U-MIDAS: MIDAS regressions with unrestricted lag polynomials. Discussion Paper Series 1: Economic Studies No. 35/2011, Deutsche Bundesbank.

Gasser, T., 1975. Goodness-of-fit tests for correlated data. *Biometrika*, 62, 563–570.

Georgoutsus, D. A., G. P. Kouretas, and D. E. Tserkesos, 1998. Temporal aggregation in structural VAR models. *Applied Stochastic Models and Data Analysis*, 14, 19-34.

Geweke, J., 1978. Temporal aggregation in the multiple regression model. *Econometrica*, 46, 643-661.

Ghysels, E., 2014. Cambridge-INET Masterclass: The econometric analysis of mixed frequency data. http://www.inet.econ.cam.ac.uk/files/EricGhyselsMasterclassesSlidesCambridgeApril2014.pdf

Ghysels, E., J. B. Hill and K. Motegi, 2013. Testing for Granger causality with mixed frequency data. DP9655, Centre for Economic Policy Research.

Ghysels, E. and J. I. Miller, 2013. Testing for cointegration with temporally aggregated and mixed-frequency time series. Mimeo., Department of Economics, University of North Carolina, Chapel Hill.

Ghysels, E. and J. I Miller, 2014. On the size distortion from linearly interpolating low-frequency series for cointegration tests. Mimeo., Department of Economics, University of North Carolina, Chapel Hill.

Ghysels, E., P. Santa-Clara, and R. Valkanov, 2004. The MIDAS touch: Mixed data sampling regression models. Working Paper 2004s-20, CIRANO.

Ghysels, E., P. Santa-Clara, and R. Valkanov, 2006. Predicting volatility: Getting the most out of return data sampled at different frequencies. *Journal of Econometrics*, 131, 59-95.

Ghysels, E., A. Sinko, and R. Valkanov, 2007. MIDAS regressions: Further results and new directions. *Econometric Reviews*, 26, 53-90.

Giles, D. E., 2014. Modelling asymmetries in the market for gasoline in western Canadian cities. Paper to be presented at the 2014 Joint Statistical Meetings, Boston, MA, August.

Giles, D. E. and R. T. Godwin, 2014a. The effects of temporal aggregation on tests for normality in time series and regression models. Working Paper, in progress, Department of Economics, University of Victoria.

Giles, D. E. and R. T. Godwin, 2014b. On the robustness of tests of linear restrictions to MA processes in regression errors. Working Paper, in progress, Department of Economics, University of Victoria.

Giles, D.E.A. and O. Lieberman, 1993. Bounds on the effect of heteroscedasticity on the Chow test for structural change. *Communications in Statistics: Theory and Methods*, 22, 687-703.

Granger, C. W. J., 1966. The typical spectral shape of an economic variable. *Econometrica*, 34, 150-161.

Granger, C. W. J., 1980. Long memory relationships and the aggregation of dynamic models. *Journal of Econometrics*, 14, 227-238.

Granger, C. W. J., 1987. Implications of aggregation with common factors. *Econometric Theory*, 3, 208-222.

Granger, C. W. J., 1990. Aggregation of time-series variables: A survey. In T. Barker and M. H. Pesaran (eds.), *Disaggregation in Econometric Modelling*. Routledge, London.

Granger, C. W. J. and T. H. Lee, 1999. The effect of aggregation on nonlinearity. *Econometric Reviews*, 18, 259-269.

Granger, C. W. J. and Morgenstern, O. ,1963. Spectral analysis of New York stock market prices. *Kyklos*, 16, 1–27.

Granger, C. W. J. and P. L. Siklos, 1995. Systematic sampling, temporal aggregation, seasonal adjustment, and cointegration: Theory and evidence. *Journal of Econometrics*, 66, 357-369.

Grenander, U., 1950. Stochastic processes and statistical inference. Arkiv För Matematik, 1, 195-275.

Gulasekaran, R. and T. Abeysinghe, 2002. The distortionary effects of temporal aggregation on Granger causality. Working Paper No. 0204, Department of Economics, National University of Singapore.

Hakkio, G. S. and M. Rush, 1991. Cointegration: How short is the long run?. *Journal of International Money & Finance*, 10, 57-581.

Hansen, L. P. and T. J. Sargent, 1991. Two difficulties in interpreting vector autoregressions. In L.P. Hansen and T. J. Sargent, eds., *Rational Expectations Econometrics*. Westview Press, Boulder, 77–119.

Harvey, A. C. and J. H. Stock, 1989. Estimating integrated higher-order continuous time autoregressions with an application to money-income causality. *Journal of Econometrics*, 42, 319–336.

Hatanaka, M., 1963. A spectral analysis of business cycle indicators: Lead-lag in terms of all time points. Research Memorandum No. 53, Econometric Research Program, Princeton University.

Ironmonger, D. S., 1959. A note on the estimation of long run elasticities. *Journal of Farm Economics*, XLI, 626-632.

Jarque, C. M. and A. K. Bera, 1987. A test for normality of observations and regression residuals. *International Statistical Review*, 55, 163–172.

Kasparis, I. and P. C. B. Phillips, 2012. Dynamic misspecification in nonparametric cointegrating regression. *Journal of Econometrics*, 168, 270-284.

Kiviet, J. F., 1989. Tighter bounds for the effects of ARMA disturbances on tests for regression coefficients. In J. Gruber (ed.), *Econometric Decision Models: New Methods of Modeling and Applications*. Springer-Verlag, Berlin, 404-418.

Kiviet, J. F., 1980. Effects of ARMA errors on tests for regression coefficients: Comments on Vinod's articles; improved and additional results. *Journal of the American Statistical Association*, 75, 353-358.

Koopmans, T. C., 1950. Models involving a continuous time variable. In T. C. Koopmas (ed.), *Statistical Inference in Dynamic Economic Models*. Cowles Commission Monograoh No. 17. Wiley, New York.

Krämer, W., 1989. On the robustness of the F-test to autocorrelation among disturbances. *Economics Letters*, 30, 37-40.

Larsson, R., 2014. A likelihood ratio type test for invertibility in moving average processes. *Computational Statistics and Data Analysis*, 76, 489-501.

Leipus, A., A. Philippe, D. Puplinskaite, and D. Surgailis, 2014. Aggregation and long memory: Recent developments. *Journal of the Indian Statistical Association*, 52, 82-112.

Lippi, M. and L. Reichlin, 1991.Trend-cycle decomposition and measures of persistence: Does time aggregation matter?. *Economic Journal*, 101, 314-323.

Lobato, I. and C. Velasco, 2004. A simple test of normality for time series. *Econometric Theory*, 20, 671–689.

Lomnicki, Z. A., 1961. Tests for departure from normality in the case of linear stochastic processes. *Metrika*, 4, 37–62.

Lütkepohl, H., 1987. Forecasting Aggregated Vector ARMA Processes. Springer-Verlag, New York.

Mamingi, N., 1996. Aggregation over time, error correction models and Granger causality: A Monte Carlo investigation. *Economics Letters*, 52, 7-14.

Marcet, A., 1991. Temporal aggregation of economic time series. In L. P. Hansen and T. J. Sargent, *Rational Expectations Econometrics*. Westview Press, Boulder, CO.

Marcellino, M., 1996. Aggregation of an I(2) process (in Italian with an English summary). *Proceedings* of the XXXVIII Meeting of the Italian Statistical Society, 2, 549-556

Marcellino, M., 1999. Some consequences of temporal aggregation in empirical analysis. *Journal of Business and Economic Statistics*, 17, 129-136.

McCrorie, J. R. and M. J. Chambers, 2004. Granger causality and the sampling of economic processes. Discussion Paper N0. 2004-39, CentER, Tilburg University.

Medel, C. A., 2014. The typical spectral shape of an economic variable: A visual guide. *Applied Economics Letters*, 21, 1017-1024.

Miller, J. I., 2014. Mixed-frequency cointegrating regressions with parsimonious distributed lag structures. *Journal of Financial Econometrics*, 12, 584-614.

Moran, P. A. P., 1971. Maximum-likelihood estimation in non-standard conditions. Proceedings of the Cambridge Philosophical Society, 70, 441-450.

Moriguchi, C., 1970. Aggregation over time in macroeconomic relations. *International Economic Review*, 11, 427-440

Mundlak, Y., 1961. Aggregation over time in distributed lag models. *International Economic Review*, 2, 154-163.

Nerlove, M., 1959. On the estimation of long run elasticities: A reply. *Journal of Farm Economics*, XLI, 632-640.

Oguchi, N. and T. Furuchi, 1990. On temporal aggregation of linear dynamic models. *International Economic Review* 31, 187-193.

Phillips, A. W. H., 1956. Some notes on the estimation of time-forms of reactions in interdependent dynamic systems. *Economica*, 90, 99-113.

Phillips, A. W. H., 1959. The estimation of parameters in systems of stochastic differential equations. *Biometrika*, 46, 67-76.

Phillips, A. W. H., 1962. Estimation in continuous time series models with auto-correlated distrurbances. Presentation notes for a meeting at Nuffield College, Oxford. Reprinted in R. Leeson (ed.), 2000, A. W. H. *Phillips: Collected Works in Contemporary Perspective*. Cambridge University Press, Cambridge, 449-450.

Phillips, A. W. H., 1962. Efficient fitting of rational spectral density functions and transfer functions. Incomplete paper. Reprinted in R. Leeson (ed.), 2000, A. W. H. Phillips: Collected Works in Contemporary Perspective. Cambridge University Press, Cambridge, 451-457.

Phillips, A. W. H., 1966. Estimation of systems of difference equations with moving average disturbances. Walras-Bowley Lecture, North American Meeting of the Econometric Society, San Francisco, CA. Reprinted in R. Leeson (ed.), 2000, A. W. H. Phillips: Collected Works in Contemporary Perspective. Cambridge University Press, Cambridge, 423-444.

Phillips, P. C. B., 1972. The structural estimation of a stochastic differential equation system. *Econometrica*, 40, 1021-1041.

Phillips, P. C. B., 1973. The problem of identification in finite parameter continuous time models. *Journal of Econometrics*, 1, 351-362.

Phillips, P. C. B., 1988. An interview with Professor A. R. Bergstrom. Econometric Theory, 4, 301-328.

Phillips, P. C. B., 1991. Error correction and long-run equilibrium in continuous time. *Econometrica*, 59, 967-980.

Phillips, P. C. B., 2000. The Bill Phillips legacy of continuous time modelling and econometric model design. In R. Leeson (ed.), 2000, *A. W. H. Phillips: Collected Works in Contemporary Perspective*. Cambridge University Press, Cambridge, 342-347.

Phillips, P. C. B. and J. Yu , 2009. Maximum likelihood and Gaussian estimation of continuous time models in finance. In T. G. Andersen, R. A. Davis, J-P. Kreiß, and Th. V. Mikosch (eds.), *Handbook of Financial Time Series*, Springer, Berlin, 497–530.

Pierse, R. G. and J. Snell, 1995. Temporal aggregation and the power of tests for a unit root. *Journal of Econometrics*, 65, 333-345.

Plosser, C. I. and G. W. Schwert, 1977. Estimation of a non-invertible moving average process: The case of overdifferencing. *Journal of Econometrics*, 6, 199-224.

Quenouille, M. H., 1957. The Analysis of Multiple Time Series. Griffin, London.

Ryan, K. F. and D. E. A. Giles, 1998. Testing for unit roots in economic time-series with missing observations. In T. B. Fomby and R. C. Hill (eds.), *Advances in Econometrics*. JAI Press, Greenwich, CT, 203-242.

Sala, L., 2014. DSGE models in the frequency domain. Journal of Applied Econometrics, in press.

Sargan, J. D. and A. Bhargava. 1983. Maximum likelihood estimation of regression models with first order moving average errors when the root lies on the unit circle. *Econometrica*, 51, 799-820.

Sims, C. A., 1971. Discrete approximations to continuous time distributed lags in econometrics. *Econometrica*, 39, 545-563.

Sorensen, H., 2004. Parametric inference for diffusion processes observed at discrete points in time: A survey. *International Statistical Review*, 72, 337–354.

Stock, J. H., 1987. Temporal aggregation and structural inference in macroeconomics: A comment. *Carnegie-Rochester Conference Series on Public Policy*, 26, 131-140.

Rossana, R. J. and J. J. Seater, 1995. Temporal aggregation and economic time series. *Journal of Business and Economic Statistics*, 13, 441-451.

Rothenberg, T. J., 1984. Hypothesis testing in linear models when the error covariance matrix is nonscalar. *Econometrica*, 52, 827-842.

Silvestrini, A. and D. Veredas, 2008. Temporal aggregation of univariate and multivariate time series models: A survey. Working Paper No. 685, Bank of Italy.

Strotz, R. H., 1960. Interdependence as a specification error. *Econometrica*, 28, 428-42.

Tanaka, K., 1990. Testing for a moving average unit root. *Econometric Theory*, 6, 433-444.

Tanaka, K. and S. E. Satchell, 1989. Asymptotic properties of the maximum likelihood and nonlinear least squares estimators for noninvertible moving average models. *Econometric Theory*, 5, 333-353.

Teles, P. and W. W. S. Wei, 2000. The effects of temporal aggregation on tests of linearity of a time series. *Computational Statistics and Data Analysis*, 34, 91-103.

Teles, P. and W. W. S. Wei, 2002. The use of aggregate time series in testing for Gaussianity. *Journal of Time Series Analysis*, 23, 95-116.

Telser, L. 1967. Discrete samples and moving sums in stationary stochastic processes. *Journal of the American Statistical Association*, 62, 484-499.

Theil, H., 1954. Linear Aggregation of Linear Economic Relations. North-Holland, Amsterdam.

Tiao, G. C., 1972. Asymptotic behaviour of temporal aggregates of time series. *Biometrika*, 59, 525-531.

Tiao, G. C., 1999. The ET interview: Professor George C. Tiao. Econometric Theory, 15, 389-324.

Tiao, G. C. and W. W. S. Wei, 1976. Effect of temporal aggregation on the dynamic relationship of two time series variables. *Biometrika*, 63, 513-523.

Vinod, H. D., 1976. Effect of ARMA errors on the significance tests of regression coefficients. *Journal of the American Statistical Association*, 71, 929-933.

Watson, G. S., 1955. Serial correlation in regression analysis I. Biometrika, 42, 327-341.

Watson, G. S. and E. J. Hannan, 1956. Serial correlation in regression analysis I. Biometrika, 43, 436-448.

Wei, W. W. S., 1978. The effect of temporal aggregation on parameter estimation in distributed lag models. *Journal of Econometrics*, 8, 237-246.

Wei, W. W. S., 1979. Some consequences of temporal aggregation in seasonal time series models. In A. Zellner (ed.), *Seasonal Analysis of Economic Time Series*, NBER, 433-448.

Wei, W.W.S., 1982. The effect of systematic sampling and temporal aggregation on causality – A cautionary note. *Journal of the American Statistical Association*, 77, 316-319.

Wei, W. W. S., 2006. *Time Series Analysis: Univariate and Multivariate Methods*, 2<sup>nd</sup>. ed. Pearson, Boston MA.

Wei, W. S. and D. O. Stram, 1990. Disaggregation of time series. *Journal of the Royal Statistical Society*, *B*, 52, 453-467.

Weiss, A., 1984. Systematic sampling and temporal aggregation in time series models. *Journal of Econometrics*, 26, 271-281.

Wiener, N., 1923, Differential space. Journal of Mathematical Physics, 2, 132-174.

Working, H., 1960. Note on the correlation of first differences of averages in a random chain. *Econometrica*, 29, 916-918.

Wymer, C. R., 1997. Structural non-linear continuous-time models in econometrics. *Macroeconomic Dynamics*, 1, 518-548.

Wymer, C. R., 2009. Estimation of continuous time models in economics: An overview. Working Paper No. 7, Department of Economics, University of Rome.

Yang, C. and R. Zhang, 2014. Does mixed-frequency investor sentiment impact stock returns? Based on the empirical study of MIDAS regression model. *Applied Economics*, in press.

Yu, J., 2014. Econometric analysis of continuous time models: A survey of Peter Phillips' work and some new results. *Econometric Theory*, in press.

Zellner, A. and C. Montmarquette, 1971. A study of some aspects of temporal aggregation problems in econometric analysis. *Review of Economics and Statistics*, 63, 335-342.