



## 2. Teaching guide

### Introduction

This course examines the models and econometric techniques used to study time series data with a special emphasis to applications in macroeconomics.

The course has three specific objectives. The first is to equip students who anticipate using time series data in their Ph.D. research with the tools they need for state-of-the-art empirical research. The second objective is to lay out the econometric theory of time series analysis, with an emphasis on recent developments. The third objective is to analyze selected recent works in theoretical macroeconomic modeling with an emphasis on their empirical implications and analysis. The course is built so that for each topic the econometric tool is presented first, followed by the relevant empirical applications.

**Pre-requisites: The course builds and extends “Advanced Econometric Methods I, II and III”, which are therefore pre-requisites. Alternatively, students should obtain the Professor’s special permission to take the course.**

The course meets regularly on **Mondays and Tuesdays, 8:30-10:30 am, in room TBA**. Attendance to class is mandatory. A few classes may need to be re-scheduled, the changes will be announced in class. When needed, some lectures will be rescheduled **on a day/time TBA**.

My email is: [barbara.rossi@upf.edu](mailto:barbara.rossi@upf.edu) and my office is Jaume I (building 20), n. 207. My office hours will be on Monday morning, from **10:30 to 11:30**. The TA for the class is TBA and the TA’s email is: TBA. **TA sessions are scheduled on TBA in room TBA.**

The course grade is based 40% on midterm, 50% on final and 10% on problem sets and presentations.

General references:

Hamilton, J., 1994. Time series econometrics. Princeton: Princeton University Press.

Kilian and Lutkepohl, 2018. Structural VAR Analysis, Cambridge

Hayashi, F., 2000. Econometrics. Princeton: Princeton University Press.

Canova, F., 2007. Methods for applied macroeconomic research. Princeton: Princeton University Press.

White, H., 2000. Asymptotic theory for econometricians. Revised ed. Orlando: Academic Press.

Important: this syllabus is preliminary and the contents of the course may change during the semester; in particular, some of the discussion papers might be updated later on –please come to classes to keep up with the contents! Also, it is very comprehensive, not all papers/topics may be discussed in class.

**Also important: the department offers an Econometrics Seminar as well as the Barcelona GSE Time Series Summer Forum, both of which are open to students, and complement the course with frontier research on the topics. Attendance is strongly recommended.** These activities are really part of the course and will help you integrate with the research done in the time-series / applied macro literature! And they will be fun!

Link to previous years' BGSE Summer Forum:  
<http://barbararossi.eu/Conferences>

### Short presentations by students:

One of the objectives of the class is to teach students to critically read and understand papers, both theoretical and applied. We will devote some time each week to your reading and presentation of papers related to the course. On Tuesdays, all students should come with 5 slides prepared on a paper I will select, and be prepared to discuss the following 5 points (one per slide):

1. Background: what did the previous related literature do?
2. What is the main contribution of this paper and why does it advance the literature in 1?
- 3-4. Main results, findings (both theoretical and empirical) – include intuition
5. Your thoughts: criticisms, improvements, open questions, etc.

One student will be randomly picked for presentation. Be prepared to answer questions.

## 🔗 Contents

### LIST OF TOPICS

#### 1. Filters and business cycle estimation

##### a. Application: Description of time series data

- Census X-11 Seasonal adjustment.
- Stock, J. and Watson, M. Business cycle fluctuations in US macroeconomic time series. In: J. Taylor and M. Woodford, eds. 1999. *Handbook of Macroeconomics, Volume 1, Part A*. Amsterdam: Elsevier-North Holland. Ch. 1.  
Available at: <<http://www.nber.org/papers/w6528>>
- Stock, J. and Watson, M., 2010. Indicators for dating business cycles: cross-history selection and comparisons. *American Economic Review*, 100(2), pp. 16-19.
- Stock, J. and Watson, M., 2012. Disentangling the channels of the 2007-2009 recession. *Brookings Papers on Economic Activity*, Spring Issue, pp. 81-156.

##### b. Econometric theory

- Hayashi. Ch. 6.
- Baxter, M. and King, R., 1999. Measuring the business cycles: approximate band-pass filters for economic time series. *Review of Economics and Statistics*, 81(4), pp. 575-93.
- Canova, F., 2007. *Methods for applied macroeconomic research*. Princeton: Princeton University Press.

##### c. Discussion papers:

- Stock and Watson (2017), Twenty Years of Time Series Econometrics in Ten Pictures, *Journal of Economic Perspectives*.
- Ng, S. and Wright, J., 2014. Facts and challenges from the Great Recession for forecasting and macroeconomic modeling. *Journal of Economic Literature*, 51(4), pp. 1120-54.

#### 2. Heteroskedasticity and autocorrelation consistent (HAC) variance estimation

##### a. Theory

- Andrews, D., 1991. Heteroskedasticity and autocorrelation consistent covariance matrix estimation. *Econometrica*, 59(3), pp. 817-58.
- Andrews, D. and Monahan, C., 1992. An improved heteroskedasticity and autocorrelation consistent covariance matrix estimator. *Econometrica*, 60(4), pp. 953-66.

- Den Haan, W. and Levin, A. A practitioner's guide to robust covariance matrix estimation. In: G.S. Maddala and C.R. Rao, eds. 1997. *Handbook of Statistics, Volume 15: robust inference*. Amsterdam: Elsevier-North Holland. Ch. 12.
- Den Haan, W. and Levin, A., 2000. Robust covariance matrix estimation with data-dependent prewhitening order. Available at: <<http://www.nber.org/papers/T255>> .
- Kiefer, N., Vogelsang, T. and Bunzel, B., 2000. Simple robust testing of regression hypotheses. *Econometrica*, 69(3), pp. 695-714.
- Kiefer, N. and Vogelsang, T., 2002. Heteroskedasticity-autocorrelation robust standard errors using the Bartlett Kernel without truncation. *Econometrica*, 70(5), pp. 2093-95.
- Newey, W. and West, K., 1987. A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. *Econometrica*, 55(3), pp. 703-8.

**b. Discussion paper:**

- E. Lazarus, D. Lewis, J. Stock and M. Watson, 2018. HAR Inference: Recommendations for Practice, *Mimeo*. Available at: <https://papers.nber.org/sched/SI18EFFE>

**3. Models with Stochastic Time Variation: Structural Breaks and Instabilities**

**a. Motivation and Empirical Examples**

- Inoue, A. and Rossi, B., 2011. Identifying the sources of instabilities in macroeconomic fluctuations. *Review of Economics and Statistics*, 93(4), pp. 1186-1204.
- Rossi, B., 2006. Are exchange rates really random walks? Some evidence robust to parameter instability. *Macroeconomic Dynamics*, 10(1), pp. 20-38.
- Stock, J. and Watson, M., 1996. Evidence on structural instability in macroeconomic time series relations. *Journal of Business and Economic Statistics*, 14(1), pp. 11-30.

**b. Asymptotics: Beveridge-Nelson decomposition, shortcuts to time series asymptotics and convergence to stochastic integrals**

- Beveridge, S. and Nelson, C., 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(2), pp. 151-74.
- Hall and Heyde. Chs. 3, 4, and 5 and the Appendix.
- Hamilton. Ch. 17.
- Stock, J. Unit roots, structural breaks and trends. In: R.F. Engle and D.L. McFadden, eds. 1994. *Handbook of Econometrics, Volume 4*. Amsterdam: Elsevier-North Holland. Ch. 46. [see sections 1-4]

**c. Testing and Estimation**

- Andrews, D. and Ploberger, W., 1994. Optimal tests when a nuisance parameter is present only under the alternative. *Econometrica*, 62(6), pp. 1383-1414.
- Bai, J., 1997. Estimation of a change point in multiple regression models. *Review of Economics and Statistics*, 79(4), pp. 551-63.
- Elliott, G. and Müller, U., 2006. Efficient tests for general persistent time variation in regression coefficients. *Review of Economic Studies*, 73(1), pp. 907-40.
- Engle, R. Wald, likelihood ratio, and Lagrange multiplier tests in econometrics. In: Z. Griliches and M.D. Intriligator, eds. *Handbook of Econometrics, Volume 2*. Amsterdam: Elsevier-North Holland. Ch. 13.
- Nyblom, J., 1989. Testing for the constancy of parameters over time. *Journal of the American Statistical Association*, 84(405), pp. 223-30.
- Rossi, B., 2005. Optimal tests for nested model selection with underlying parameter instability. *Econometric Theory*, 21(5), pp. 962-90.
- Stock, J. Unit roots, structural breaks and trends. In: R.F. Engle and D.L. McFadden, eds. 1994. *Handbook of Econometrics, Volume 4*. Amsterdam: Elsevier-North Holland. Ch. 46. [see section 2]

**d. Discussion papers:**

- Rossi, B. 2013. Exchange Rate Predictability. *Journal of Economic Literature*.

**4. The Kalman filter, Nonlinear Filters, Threshold Models, STAR, Markov Switching and**

**applications****a. Motivation and Applications**

- Kilian, L. and Vigfusson, R., 2011. Are the responses of the U.S. economy asymmetric in energy price increases and decreases? *Quantitative Economics*, 2(3), pp. 419-53.
- Kilian, L. and Vigfusson, R., 2011. Nonlinearities in the oil price-output relationship. *Macroeconomic Dynamics*, 15(S3), pp. 337-63.

**b. Theory**

- Brockwell, P. and Davis, R., 2009. *Time series: theory and methods*. 2nd ed. New York: Springer. [see chapter 12]
- Cogley, T. and Sargent, T., 2005. Drifts and volatilities: monetary policies and outcomes in the post WWII US. *Review of Economic Dynamics*, 8(2), pp. 262-302.
- Hamilton. Ch. 22.
- Harvey, A., 1991. *Forecasting, structural time series models and the Kalman filter*. 2nd ed. Cambridge: Cambridge University Press.
- Müller, U. and Petalas, P., 2010. Efficient estimation of the parameter path in unstable time series models. *Review of Economic Studies*, 77(1), pp. 1508-39.
- Primiceri, G., 2005. Time varying structural vector autoregressions and monetary policy. *Review of Economic Studies*, 72(3), pp. 821-52.
- Stock, J. and Watson, M., 2007. Why has U.S. inflation become harder to forecast? *Journal of Money, Banking and Credit*, 39(S1), pp. 3-33.

**c. Discussion paper:**

- TBA

**5. GMM and Weak Instruments/Weak Identification, Many Instruments****a. Motivation**

- Stock, J., Wright, J. and Yogo, M., 2002. A survey of weak instruments and weak identification in generalized method of moments. *Journal of Business and Economic Statistics*, 20(4), pp. 518-29.
- Hansen, P., Heaton, J. and Yaron, A., 1996. Finite-sample properties of some alternative GMM estimators. *Journal of Business and Economic Statistics*, 14(3), pp. 262-80.
- Hansen, P. and Singleton, K., 1982. Generalized instrumental variables estimation of nonlinear rational expectation models. *Econometrica*, 50(5), pp. 1269-86; Hansen, P. and Singleton, K., 1984. Errata. *Econometrica*, 52(1), pp. 267-68.

**b. Methods**

- Andrews, D., Moreira, M. and Stock, J., 2006. Optimal two-sided invariant similar tests for instrumental variables regression. *Econometrica*, 74(3), pp. 715-52.
- Hall, A.R. Chs. 4 and 5.
- Hamilton. Ch. 14.
- Hayashi. Chs. 3 and 4.
- Inoue, A. and Rossi, B., 2011. Testing for weak identification in possibly nonlinear models. *Journal of Econometrics*, 161(2), pp. 246-61.
- Newey, W. and McFadden, D. Large sample estimation and hypothesis testing. In: R.F. Engle and D.L. McFadden, eds. 1994. *Handbook of Econometrics, Volume 4*. Amsterdam: Elsevier-North Holland. Ch. 36.
- Staiger, D. and Stock, J., 1997. Instrumental variables regression with weak instruments. *Econometrica*, 65(3), pp. 557-86.
- Stock, J. and Wright, J., 2000. GMM with weak identification. *Econometrica*, 68(5), pp. 1055-96.

**c. Discussion paper:**

- Mavroeidis, S., Plagborg-Møller, M. and Stock, J., 2014. Empirical evidence on inflation expectations in the new Keynesian Phillips Curve. *Journal of Economic Literature*, 52(1), pp. 124-88.

**6. Vector Autoregression and SVARs**

General reference: Kilian and Lutkepohl (2017), *Structural Vector Autoregressive Analysis*, Cambridge University Press.

#### **a. Motivation and Empirical applications**

- Ramey, V., 2011. Identifying government spending shocks: it's all in the timing. *Quarterly Journal of Economics*, 126(1), pp. 1-50.
- Rossi, B. and Zubairy, S., 2011. What is the importance of monetary and fiscal shocks in explaining U.S. macroeconomic fluctuations? *Journal of Money, Credit and Banking*, 43(6), pp. 1247-70.
- Ramey, V., 2011. Can government purchases stimulate the economy? *Journal of Economic Literature*, 49(3), pp. 673-85.

#### **b. Impulse response functions, variance decompositions, inference**

- Lütkepohl, H., 2005. *New introduction to multiple time series analysis*. New York: Springer. Ch. 3.7.
- Sims, C., 1980. Macroeconomics and reality. *Econometrica*, 48(1), pp. 1-48.
- Stock, J. and Watson, M., 2001. Vector autoregressions. *Journal of Economic Perspectives*, 15(4), pp. 101-15.
- Watson, M. Vector autoregressions and cointegration. In: R.F. Engle and D.L. McFadden, eds. 1994. *Handbook of Econometrics, Volume 4*. Amsterdam: Elsevier-North Holland. Ch. 47. [see section 3 only]

#### **c. Structural VARs: identification schemes**

- Bernanke, B., Gertler, M. and Watson, M., 1997. Systematic monetary policy and the effects of oil price shocks. *Brookings Papers on Economic Activity*, 1, pp. 91-157 (with discussion).
- Blanchard, O. and Watson, M. Are business cycles all alike? In: R. Gordon, ed. 1990. *NBER Book Series Studies in Business Cycles: The American business cycle. Continuity and change*. 2nd ed. Chicago: University of Chicago Press. Pp 123-180.
- Cochrane, J., and Piazzesi, M., 2002. The Fed and interest rates: a high-frequency identification. *American Economic Review*, 92(2), pp. 90-5.
- Faust, J., Rogers, J., Swanson, E. and Wright, J., 2003. Identifying the effects of monetary policy shocks on exchange rates using high frequency data. *Journal of the European Economic Association*, 1(5), pp. 1031-57.
- Faust, J., Swanson, E. and Wright, J., 2004. Identifying VARs based on high-frequency futures data. *Journal of Monetary Economics*, 51(6), pp. 1107-31.
- Magnusson, L. and Mavroeidis, S., 2014. Identification using stability restrictions. *Econometrica*, 82(5), pp. 1799-1851.
- Rigobon, R., 2003. Identification through heteroskedasticity. *Review of Economics and Statistics*, 85(4), pp. 777-92.
- Rudebusch, G., 1998. Do measures of monetary policy in a VAR make sense? *International Economic Review*, 39(4), pp. 907-31.
- Uhlig, H., 2005. What are the effects of monetary policy on output? Results from an agnostic identification procedure. *Journal of Monetary Economics*, 52(2), pp. 381-419.

#### **d. Long-run restrictions**

- Blanchard, O., and Quah, D., 1989. The dynamic effects of aggregate demand and supply disturbances. *American Economic Review*, 79(4), pp. 655-73.
- Chari, V., Kehoe, P. and McGrattan, E., 2008. Are structural VARs with long-run restrictions useful in developing business cycle theory? *Journal of Monetary Economics*, 55(8), pp. 1337-52.
- Galí, J., 1999. Technology, employment, and the business cycle: do technology shocks explain aggregate fluctuations? *American Economic Review*, 89(1), pp. 249-71.
- Gospodinov, N., 2010. Inference in nearly nonstationary SVAR models with long-run identifying restrictions. *Journal of Business and Economic Statistics*, 28(1), pp. 1-12.
- King, R., Plosser, C., Stock, J. and Watson, M., 1991. Stochastic trends and economic fluctuations. *American Economic Review*, 81(4), pp. 819-40.
- Pesavento, E. and Rossi, B., 2005. Do technology shocks drive hours up or down? *Macroeconomic Dynamics*, 9(4), pp. 478-88.
- Watson, M. Comment on Christiano, Eichenbaum, and Vigfusson's 'Assessing Structural VARs'. In: D. Acemoglu, K. Rogoff and M. Woodford, eds. 2007. *NBER Macroeconomics*

*Annual 2006, Volume 21.* Cambridge, MA: MIT Press. Pp. 97-102.

#### **e. Other identification procedures**

- Montiel-Olea, Stock and Watson (2018), Inference in Structural VARs with External Instruments, *mimeo*
- Wright, J. (2012), What does Monetary Policy do to Long-Term Interest Rates at the Zero Lower Bound?, *Economic Journal*
- Rigobon (2003), Identification through Heteroskedasticity, *The Review of Economics and Statistics* 85- 4, 777-792

#### **f. Inference for impulse responses**

- Kilian, L., 1999. Finite-sample properties of percentile and percentile-t bootstrap confidence intervals for impulse responses. *The Review of Economics and Statistics*, 81(4), pp. 652-60.
- Kilian, L., 2001. Impulse response analysis in vector autoregressions with unknown lag order. *Journal of Forecasting*, 20(1), pp. 161-79.
- Pesavento, E. and Rossi, B., 2006. Small sample confidence bands for multivariate impulse response functions. *Journal of Applied Econometrics*, 21(8), pp. 1135-55.
- Pesavento, E. and Rossi, R., 2007. Impulse response confidence intervals for persistent data: what have we learned? *Journal of Economic Dynamics and Control*, 31(1), pp. 2398-2412.
- Sims, C. and Zha, T., 1999. Error bands for impulse responses. *Econometrica*, 67(5), pp. 1113-55.
- Wright, J., 2000. Confidence intervals for univariate impulse responses with a near unit root. *Journal of Business and Economic Statistics*, 18(3), pp. 368-73.

#### **g. Bayesian VARs**

- De Mol, C., Giannone, D. and Reichlin, L., 2008. Forecasting using a large number of predictors: is Bayesian shrinkage a valid alternative to principal components? *Journal of Econometrics*, 146(2), pp. 318-28.
- Stock J. and Watson M., 2012. Generalized shrinkage methods for forecasting using many predictors. *Journal of Business and Economic Statistics*, 30(4), pp. 481-93.

#### **g. Discussion papers:**

- Stock, J. And M. Watson, Identification and Estimation of Dynamic Causal Effects in Macroeconomics, *Economic Journal*, Vol. 28, Issue 610, May 2018, pp. 917-948.
- Rossi, B. (2019), Identifying and Estimating the Effects of Unconventional Monetary Policy in the Data: How to Do It And What Have We Learned?, *mimeo*

### **7. Modeling of and inference for persistent time series**

#### **a. Univariate unit roots: estimation, testing, and local to unity theory**

- Dickey, D. and Fuller, W., 1979. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74(366), pp. 427-31.
- Elliott, G., Rothenberg, T. and Stock, J., 1996. Efficient tests for an autoregressive unit root. *Econometrica*, 64(4), pp. 813-36.
- Nelson, C. and Plosser, C., 1982. Trends and random walks in macroeconomic time series. *Journal of Monetary Economics*, 10(2), pp. 139-62.
- Ng, S. and Perron, P., 2001. Lag length selection and the construction of unit root tests with good size and power. *Econometrica*, 69(6), pp. 1519-54.
- Phillips, P., 1987. Time series regression with unit roots. *Econometrica*, 55(2), pp. 277-301.
- Rossi, B., 2005. Confidence intervals for half-life deviations from purchasing power parity. *Journal of Business and Economic Statistics*, 23(4), pp. 432-42.
- Stock, J., 1991. Confidence intervals for the largest autoregressive root in U.S. economic time series. *Journal of Monetary Economics*, 28(3), pp. 435-60.
- Stock, J. Unit roots, structural breaks and trends. In: R.F. Engle and D.L. McFadden, eds. 1994. *Handbook of Econometrics, Volume 4.* Amsterdam: Elsevier-North Holland. Ch.46. [see sections 1-4]

#### **b. Multivariate unit roots and cointegration**

- Chan, N.H., and Wei, C.Z., 1988. Limiting distributions of least squares estimates of unstable

- autoregressive processes. *Annals of Statistics*, 16(1), pp. 367-401.
- Elliott, G., 1998. The robustness of cointegration methods when regressors almost have unit roots. *Econometrica*, 66(1), pp. 149-58.
  - Engle, R. and Granger, C., 1987. Co-integration and error correction: representation, estimation, and testing. *Econometrica*, 55(2), pp. 251-76.
  - Johansen, S., 1988. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12(2-3), pp. 231-54.
  - Phillips, P. and Ouliaris, S., 1990. Asymptotic properties of residual based tests for cointegration. *Econometrica*, 58(1), pp. 165-93.
  - Sims, C., Stock, J. and Watson, M., 1990. Inference in linear time series models with some unit roots. *Econometrica*, 58(1), pp. 113-44.
  - Stock, J., 1987. Asymptotic properties of least squares estimators of cointegrating vectors. *Econometrica*, 55(5), pp. 1035-56.
  - Watson, M. Vector autoregressions and cointegration. In: R.F. Engle and D.L. McFadden, eds. 1994. *Handbook of Econometrics, Volume 4*. Amsterdam: Elsevier-North Holland. Ch.47. [see sections 1 and 2]
  - Stock, J. and Watson, M., 1993. A simple estimator of cointegrating vectors in higher-order integrated systems. *Econometrica*, 61(4), pp. 783-820.
  - Watson, M. Cointegration. In: S. Durlauf and L. Blume, eds. 2008. *The New Palgrave Dictionary of Economics*. 2nd ed. London: Palgrave Macmillan.

### c. Predictive regression with persistent regressors

- Cavanagh, C., Elliott, G. and Stock, J., 1995. Inference in models with nearly integrated regressors. *Econometric Theory*, 11(5), pp. 1131-47.
- Jansson, M. and Moreira, M., 2006. Optimal inference in regression models with nearly integrated regressors. *Econometrica*, 74(3), pp. 681-714.
- Rossi, B., 2007. Expectations hypotheses tests at long horizons. *Econometrics Journal*, 10(3), pp. 554-79.

### d. Long memory and fractional integration

- Baillie, R., 1996. Long memory processes and fractional integration in econometrics. *Journal of Econometrics*, 73(1), pp. 5-59.
- Diebold, F. and Inoue, A., 2001. Long memory and regime switching. *Journal of Econometrics*, 105(1), pp. 131-59.
- Robinson, P., 2003. *Time series with long memory*. Oxford: Oxford University Press.

### e. Discussion paper:

- Rossi, B., 2005. Confidence intervals for half-life deviations from purchasing power parity. *Journal of Business and Economic Statistics*, 23(4), pp. 432-42.

## 8. Big data: Dynamic Factor Models, FAVAR, Combinations, Bayesian Model Averaging, BVARs

### a. Motivation and Applications

- Aruoba, S., Diebold, F. and Scotti, C., 2009. Real-time measurement of business conditions. *Journal of Business and Economic Statistics*, 27(4), pp. 417-27.
- Faust, J. and Wright, J., 2009. Comparing Greenbook and reduced form forecasts using a large realtime dataset. *Journal of Business and Economic Statistics*, 27(4), pp. 468-79.
- Reis, R. and Watson, M., 2010. Relative goods' prices, pure inflation, and the Phillips correlation. *American Economic Journal: Macroeconomics*, 2(3), pp. 128-57.
- Stock, J. and Watson, M., 2004. Combination forecasts of output growth in a seven-country data set. *Journal of Forecasting*, 23(6), pp. 405-30.
- Timmermann, A., 2005. Forecast combinations. In G. Elliott, C.W.J. Granger and A. Timmerman, eds. 2006. *Handbook of Economic Forecasting, Volume 1*. Amsterdam: Elsevier-North Holland. Ch.4.

### b. Econometric Methods

- Amengual, D. and Watson, M., 2007. Consistent estimation of the number of dynamic factors in a large N and T panel. *Journal of Business and Economic Statistics*, 25(1), pp. 91-6.
- Bai, J., and Ng, S., 2002. Determining the number of factors in approximate factor models.

- Econometrica*, 70(1), pp. 191-221.
- Bernanke, B., Boivin, J. and Eliasziw, P., 2005. Measuring the effects of monetary policy: a factor-augmented vector autoregressive (FAVAR) approach. *Quarterly Journal of Economics*, 120(1), pp. 387-422.
  - Boivin, J. and Giannoni, M., 2006. "DSGE models in a data-rich environment. [research paper]. Available at: <<http://www.nber.org/papers/w12772.pdf>> [Accessed 2 March 2015].
  - Foerster, A., Sarte, P. and Watson, M., 2011. Sectoral vs. aggregate shocks: a structural factor analysis of industrial production. *Journal of Political Economy*, 119(1), pp. 1-38.
  - Forni, M., Hallin, M., Lippi, M. and Reichlin, L., 2005. The generalized dynamic factor model: one-sided estimation and forecasting. *Journal of the American Statistical Association*, 100(471), pp. 830-40.
  - Forni, M., and Reichlin, L., 1998. Let's get real: a factor analytical approach to disaggregated business cycle dynamics. *Review of Economic Studies*, 65(1), pp. 453-73.
  - Onatski, A., 2009. Testing hypotheses about the number of factors in large factor models. *Econometrica*, 77(5), pp. 1447-79.
  - Sargent, T. and Sims, C. Business cycle modeling without pretending to have too much a-priori economic theory. In: C. Sims, ed. 1977. *New methods in business cycle research: proceedings from a conference*. Minneapolis: Federal Reserve Bank of Minneapolis.
  - Stock, J. and Watson, M., 2002. Forecasting using principal components from a large number of predictors. *Journal of the American Statistical Association*, 97(460), pp. 1167-79.
  - Stock, J. and Watson, M. Dynamic factor models. In: M. Clements and D. Hendry, eds. 2011. *The Oxford Handbook of Economic Forecasting*. New York: Oxford University Press. Ch. 2.
  - Stock, J. and Watson, M. Forecasting with many predictors. In G. Elliott, C. Granger and A. Timmermann, eds. 2006. *Handbook of Economic Forecasting, Volume 1*. Amsterdam: Elsevier-North Holland. Ch. 10.
  - Stock, J. and Watson, M., 2014. Estimating turning points using large data sets. *Journal of Econometrics*, 178(1), pp. 368-81.
  - Wright, J., 2008. Bayesian model averaging and exchange rate forecasts. *Journal of Econometrics*, 146(2), pp. 329-41.

### c. Discussion paper:

- Bates B., Plagborg-Møller M., Stock J., and Watson M., 2013. Consistent factor estimation in dynamic factor models with structural instability. *Journal of Econometrics*, 177(2), pp. 289-304.
- Inoue, A. and X. Han, 2015, Tests for parameter instability in dynamic factor models, *Econometric Theory*, Pages 1117-1152
- James H. Stock, Mark W. Watson (2002), Has the Business Cycle Changed and Why?, NBER Macroannual.

## 9. Model Evaluation and Forecast Comparison

### a. Motivation and Empirical Applications

- Alquist, R., Kilian, L. and Vigfusson, R. Forecasting the price of oil. In G. Elliott and A. Timmermann, eds. 2013. *Handbook of Economic Forecasting, Volume 2, Part A*. Amsterdam: Elsevier-North Holland. Ch. 8.
- Chen, Y., Rogoff, K. and Rossi, B., 2010. Can exchange rates forecast commodity prices? *Quarterly Journal of Economics*, 125(3), 1145-94.
- Edge, R. and Gürkaynak, R., 2010. How useful are estimated DSGE model forecasts for central bankers? *Brookings Papers on Economic Activity*, Fall Issue, pp. 209-59.
- Estrella, A. and Hardouvelis, G., 1991. The term structure as a predictor of real economic activity. *Journal of Finance*, 46(2), pp. 555-76.
- Giacomini R. and Rossi, B., 2006. How stable is the forecasting performance of the yield curve for output growth? *Oxford Bulletin of Economics and Statistics*, 68(s1), pp. 783-95.
- Gürkaynak, R., Kısacıkoglu, B. and Rossi, B. Do DSGE models forecast more accurately out-of-sample than reduced-form models? In: T. Fomby, L. Kilian and A. Murphy, eds. 2013. *Advances in Econometrics, Volume 32: VAR Models in Macroeconomics – New Developments and Applications: Essays in Honor of Christopher A. Sims*. Bingley: Emerald-Insight. Pp. 27-80.
- Romer, C. and Romer, D., 2000. Federal Reserve information and the behavior of interest rates. *American Economic Review*, 90(3), pp. 429-57.
- Rossi, B., 2013. Exchange rate predictability. *Journal of Economic Literature*, 51(4), pp. 1063-

1119.

- Rossi, B. and Sekhposyan, T., 2010. Have models' forecasting performance changed over time, and when? *International Journal of Forecasting*, 26(4), pp. 808-35.
- Stock, J. and Watson, M., 1996. Evidence on structural instability in macroeconomic time series relations. *Journal of Business and Economic Statistics*, 14(1), pp. 11-30.

#### **b. Tests of Forecast Comparison**

- Diebold, F. and Mariano, R., 2002. Comparing predictive accuracy. *Journal of Business and Economic Statistics*, 20(1), pp. 134-44.
- McCracken, M., 2000. Robust out-of-sample inference. *Journal of Econometrics*, 99(2), pp. 195-223.
- West, K., 1996. Asymptotic inference about predictive ability. *Econometrica*, 64(5), pp. 1067-84.
- West, K. Forecast evaluation. In: G. Elliott, C. Granger and A. Timmermann, eds. 2006. *Handbook of Economic Forecasting, Volume 1*. Amsterdam: Elsevier-North Holland. Ch. 3.

#### **c. Special Issues: Nested Models, Null Hypotheses, Instabilities...**

- Andrews, D., 1993. Tests for parameter instability and structural change with unknown change point. *Econometrica*, 61(4), pp. 821-56.
- Clark, T. and McCracken, M., 2001. Tests of equal forecast accuracy and encompassing for nested models. *Journal of Econometrics*, 105(1), pp. 85-110.
- Clark, T. and McCracken, M., 2005. The power of tests of predictive ability in the presence of structural breaks. *Journal of Econometrics*, 124(1), pp. 1-31.
- Clark, T. and McCracken, M. Advances in forecast evaluation. In: G. Elliott and A. Timmermann, eds. 2013. *Handbook of Economic Forecasting, Volume 2, Part B*. Amsterdam: Elsevier-North Holland. Ch. 20.
- Clark, T. and McCracken, M., (forthcoming). Nested forecast model comparisons: a new approach to testing equal accuracy. *Journal of Econometrics*.
- Clark, T. and West, K., 2006. Using out-of-sample mean squared prediction errors to test the martingale difference hypothesis. *Journal of Econometrics*, 135(1-2), pp. 155-86.
- Diebold, F. and López, J. Forecast evaluation and combination. In: G.S. Maddala and C.R. Rao, eds. 1996. *Handbook of Statistics, Volume 14: statistical methods in finance*. Amsterdam: Elsevier-North Holland. Ch. 8.
- Giacomini, R. and Rossi, B., 2009. Detecting and predicting forecast breakdowns. *Review of Economic Studies*, 76(2), pp. 669-705.
- Giacomini, R. and Rossi, B., 2010. Forecast comparisons in unstable environments. *Journal of Applied Econometrics*, 25(4), pp. 595-620.
- Giacomini, R. and White, H., 2006. Tests of conditional predictive ability. *Econometrica*, 74(6), pp. 1545-78.
- Inoue, A. and Rossi, B., 2012. Out-of-sample forecast tests robust to the choice of window size. *Journal of Business and Economic Statistics*, 30(3), pp. 432-53.
- Rossi, B. Advances in forecasting under instability. In: G. Elliott and A. Timmermann, eds. 2013. *Handbook of Economic Forecasting, Volume 2, Part B*. Amsterdam: Elsevier-North Holland. Ch. 21.
- Timmermann, A. 2005. Forecast combinations. In: G. Elliott, C.W.J. Granger and A. Timmermann, eds. 2006. *Handbook of Economic Forecasting, Volume 1*. Amsterdam: Elsevier-North Holland. Ch. 4.

#### **d. Tests of Absolute Forecasting Performance (or Forecast Optimality Tests)**

- Mincer, J. and Zarnowitz, V. The evaluation of economic forecasts. In: J. Mincer, ed. 1969. *NBER Book Series Studies in Business Cycles: Economic forecasts and expectations: analysis of forecasting behavior and performance*. New York: National Bureau of Economic Research. Pp. 1-46.
- Rossi, B. and Sekhposyan, T., (2016). Forecast optimality tests in the presence of instabilities with applications to Federal Reserve and survey forecasts. *Journal of Applied Econometrics*.
- West, K. and McCracken, M., 1998. Regression-based tests of predictive ability. *International Economic Review*, 39(4), pp. 817-40.

#### **e. Predictive Densities**

- Amisano, G. and Giacomini, R., 2007. Comparing density forecasts via weighted likelihood ratio tests. *Journal of Business and Economic Statistics*, 25(2), pp. 177-90.
- Clark, T., 2011. Real-time density forecasts from Bayesian vector autoregressions with stochastic volatility. *Journal of Business and Economic Statistics*, 29(3), pp. 327-41.
- Clements, M. and Smith, J., 2000. Evaluating the forecast densities of linear and non-linear models: applications to output growth and unemployment. *Journal of Forecasting*, 19(4), pp. 255-76.
- Corradi, V. and Swanson, N., 2001. Predictive density evaluation. In: G. Elliott, C.W.J. Granger and A. Timmermann, eds. 2006. *Handbook of Economic Forecasting, Volume 1*. Amsterdam:Elsevier-North Holland. Ch. 5.
- Diebold, F., Gunther, T. and Tay, A., 1998. Evaluating density forecasts with applications to financial risk. *International Economic Review*, 39(4), pp. 863-83.
- Diebold, F., Tay, A. and Wallis, K. Evaluating density forecasts: the survey of professional forecasters. In: R. Engle and H. White, eds. 1999. *Cointegration, causality, and forecasting: a festschrift in honour of Clive W.J. Granger*. Oxford: Oxford University Press. Ch. 3.
- Jore, A., Mitchell, J. and Vahey, S., 2010. Combining forecast densities from VARs with uncertain instabilities. *Journal of Applied Econometrics*, 25(4), pp. 621-34.
- Rossi, B. and Sekhposyan, T., 2018. Alternative tests for correct specification of conditional forecast densities. *Journal of Econometrics*.
- Rossi, B. and Sekhposyan, T., 2014. Evaluating predictive densities of US output growth and inflation in a large macroeconomic data set. *International Journal of Forecasting*, 30(3), pp. 662-82.

**f. Discussion paper:**

- Rossi, B., 2020. Forecasting in the Presence of Instabilities: How Do We Know Whether Models Predict Well and How to Improve Them, *Journal of Economic Literature*, forthcoming. [The most recent version of the paper will be provided when requested].
- Giacomini, R. and Rossi, B., 2010. Forecast comparisons in unstable environments. *Journal of Applied Econometrics*, 25(4), pp. 595-620.

**10. Estimation and Inference of Linearized DSGEs (if time permits)**

- Canova, F. and Sala, L., 2009. Back to square one: identification issues in DSGE models. *Journal of Applied Econometrics*, 56(4), pp. 431-49.
- DeJong and Dave. Chs. 2-4.
- Guerron-Quintana, P., Inoue, A. and Kilian, L., 2013. Frequentist inference in weakly identified DSGE models. *Quantitative Economics*, 4(2), pp. 197-229.
- Hall, A., Inoue, A., Nason, J. and Rossi, B., 2012. Information criteria for impulse response function matching estimation of DSGE models. *Journal of Econometrics*, 170(2), pp. 499-518.
- Iskrev, N., 2010. Local identification of DSGE models? *Journal of Monetary Economics*, 57(2), pp. 189-202.
- Smets, F. and Wouters, R., 2003. An estimated dynamic stochastic general equilibrium model of the Euro Area. *Journal of the European Economic Association*, 1(5), pp. 1123-75.

**Discussion paper:**

- Inoue, Kuo and Rossi (2016), Identifying the Sources of Model Misspecification, *Journal of Monetary Economics*, forthcoming.
- Primiceri (2005), Time Varying Structural Vector Autoregressions and Monetary Policy, *Review of Economic Studies* 72 (3): 821-852.

**🔗 Assessment and Grading System**

There will be two exams: a midterm exam and a final exam. The exams will be in class. The midterm exam will be on TBA at the regular class time. The final exam is on the last day of class (TBA) in class.

There should be various problem sets during the course and short presentations of discussion papers by students.

**Please note: I reserve the right to change the information in this syllabus at any time.**