PhD Course

Signal Extraction and Filtering in Economics (SiEFiE)

Dates: First semester A.Y. 2024-2025

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Course description

Measurement of latent processes and constructs like the business cycle, core inflation, potential output and the associated output gap, volatility, etc. is very relevant to economic discussion and modelling.

The course deals with methods and models for signal extraction and filtering in economics. It sets off with an introduction to time series analysis in the frequency domain.

Frequency domain methods focus on the spectral density function of stationary stochastic process. Inferences are based on the periodogram, which is a transformation of the series, based on the discrete Fourier transform, with interesting properties that bring out features of the series and facilitate inference for classes of time series models. The asymptotic properties of the periodogram will be considered and used for estimating the spectrum of a random process.

For a given time series model, parametric inferences can be based on a large sample approximation to the true likelihood known as the Whittle likelihood. Our illustrations deal with estimation of ARMA, unobserved component models for trend-cycle analysis, parametric and semiparametric long memory models for stochastic volatility, and high-dimensional factor models.

High-dimensional factor models is an approach to high-dimensional time series that plays a pivotal role for signal extraction and forecasting. They are based on a solid representation theory and provide the way of distilling the co-movements in a large set of macroeconomic time series, without incurring in the curse of dimensionality.

We conclude with an introduction to the class of locally stationary processes.

Programme

1. Stationary random processes and their second order properties:
- The autocovariance generating function
- The spectral density
- Linear filters. Band-pass filtering.
2. The periodogram
- Definition and properties
- Asymptotic properties
- Nonparametric spectral estimation
3. Maximum likelihood estimation in the frequency domain
- Derivation of the Whittle likelihood
- Applications: ARMA models, unobserved components models, long memory models.
4. Signal extraction in economics: the Hodrick and Prescott filter, the Wiener-Kolmogorov filter, the Hamilton filter. Estimating the output gap and potential output.
5. Multivariate spectral density. Coherence and phase. High dimensional factor models
6. Introduction to locally stationary processes

References

- The main reference for topics 1 and 2 is Brockwell, P.J. and Davis, R.A. (1991), Time Series: Theory and Methods, Springer-Verlag, New York, Chapters 4 and 10. For the band pass filter,
    1. Baxter, M., and King, R.G. (1999). Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series. The Review of Economics and Statistics, 81, 575-593.
    2. Christiano, L. J., and Fitzgerald, T. J. (2003). The band pass filter. International Economic Review, 44(2), 435–465.

- The main reference for topic 3 is Dzhaparidze, K., (1986), Parameter Estimation and Hypothesis Testing in Spectral Analysis of Stationary Time Series.

- For long memory models,
    1. Hassler, U. (2019), Time Series Analysis, with Long Memory in View, Wiley.
    2. Palma, W. (2007). Long-memory time series: theory and methods (Vol. 662). John Wiley & Sons.
    3. Giraitis, L., Koul, H. L., and Surgailis, D. (2012). Large sample inference for long memory processes. World Scientific Publishing Company.

- Part 4:
    1. Hodrick R.J., and Prescott, E.C. (1997). Postwar U.S. Business Cycles: an Empirical Investigation. Journal of Money, Credit and Banking, 29, 1-16.
    2. Proietti, T. (2009) Structural Time Series Models for Business Cycle Analysis, in Handbook of Econometrics: Vol. 2, Applied Econometrics, Part 3.4., ed. T. Mills and K. Patterson, Palgrave, London

3. Hamilton, J. D. (2018). Why you should never use the Hodrick-Prescott filter. Review of Economics and Statistics, 100(5), 831–843.

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- For high-dimensional factor models:
  1. Forni, M., Hallin, M., Lippi, M., and Reichlin, L. (2000). The Generalized Dynamic Factor Model: Identification and Estimation. The Review of Economics and Statistics, 82(4):540-554.
  2. 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, 100:830-840.
  3. Altissimo, F., Cristadoro, R., Forni, M., Lippi, M., and Veronese, G. (2010). New Eurocoin: Tracking Economic Growth in Real Time. The Review of Economics and Statistics, 92(4):1024-1034.
  4. Lippi, M., Deistler, M., and Anderson, B. (2023). High-dimensional dynamic factor models: A selective survey and lines of future research. Econometrics and Statistics, 26, 3–16.
  5. Giovannelli A., Lippi M. and Proietti T. (2023) Band-Pass Filtering with High-Dimensional Time Series. Arxiv.

- For locally stationary processes, see
  Proietti, T., Luati L. D'Innocenzo E. (2023). Generalized Linear Spectral Models for Locally Stationary Processes. In Liu Y., Hirukawa J. and Kakizawa Y. (Eds.) Research Papers in Statistical Inference for Time Series and Related Models: Essays in Honor of Masanobu Taniguchi. Singapore: Springer, 343-368.

Other important references are

- Fuller W. (1996). Introduction to statistical time series. Wiley. Chapters 3, 4, 7.
- Bloomfield, P. (2000). Fourier analysis of time series. An Introduction. Wiley.
- Percival, D. B., and Walden, A. T. (2020). Spectral Analysis for Univariate Time Series. Cambridge University Press.
- Brillinger R.D. (1981) Time series: data analysis and theory. SIAM
- Priestley, M. B. (1981). Spectral Analysis and Time Series. Academic Press.

Additional readings will be provided during the course.