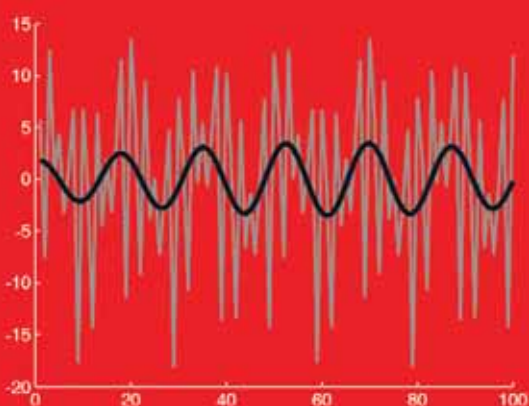
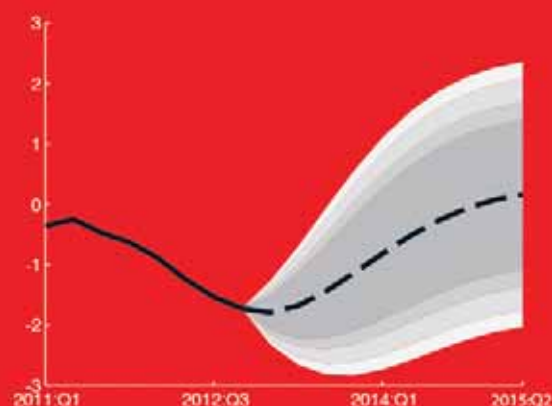
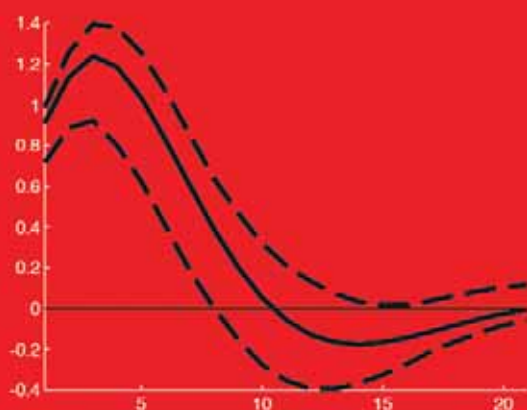


APPLIED TIME SERIES FOR MACROECONOMICS



Applied time series for macroeconomics

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To Christiane, Edvard and Trond

Aina and Lars

Preface and acknowledgements

Macroeconomics is about answering questions like:

- What will the inflation rate be the coming quarters?
- What explains economic cycles where booms are followed by busts?
- Do output and consumer prices fall if the interest rate is increased?
- Have all recessions been preceded by an increase in the price of crude oil?

The goal of this book is to give an intuitive yet formal understanding of the basic techniques used in applied econometrics to answer questions like these. The focus is on time series econometrics with applications in macroeconomics and international finance. Throughout the book we will cover univariate and multivariate models of stationary and nonstationary time series, including structural vector autoregression (SVAR) models and instrumental variable (IV) methods. Much focus is also devoted to the topic of macroeconomic forecasting, using both univariate and multivariate models.

Most of the econometric models covered in this book can be estimated using ordinary least squares. However, with varying depth, we also cover the Maximum likelihood estimator and different instrumental variable estimators like Two-stage least squared and Generalized Method of Moments.

The book is designed primarily for use in time series courses given to master students in economics and business. However, the first parts of the book emphasising univariate methods can be used in courses given to final year under-graduates, while the parts covering forecasting and multivariate models can be used as a supplement to a reference book used in courses given to first year PhD students. We do not intend this book to be a complete reference. For more rigorous treatment of many of the topics discussed we refer the reader to Hamilton (1994) and Lütkepohl (2005).

One of the guiding principles of this book is operationality, and we have emphasized ready access to the computer programs used in its preparation. The MATLAB codes, data files and descriptions are available from the website developed for this book: <http://www.timeseries.no>. If the link does not work, please contact one of the authors.

The framework of the book grew out of lecture notes developed by Hilde C. Bjørnland for master and PhD courses in applied time series econometrics at the University of Oslo and BI Norwegian Business School. We thank in particular Ida Wolden Bache for contributing actively to the development of these courses at an early stage.

Our work has benefited from comments by many friends and colleagues. Our grateful thanks go to Knut Are Aastveit, Drago Bergholt, Eleonora Granziera, Steffen Grønneberg, Anne Sofie Jore and Bjørn Naug for having commented constructively on our work. We would also like to thank Q. Farooq Akram for sharing his data.

We owe much to the present and past nowcasting teams of Norges Bank.¹ Special thanks to Francesco Ravazzolo, Christie Smith and Shaun Vahey for influencing and shaping our perception of how forecasting should be done.

We have also benefited from comments by many students, especially those attending the Master programme at the BI Norwegian Business School. Special thanks to Stefanie Fernandez for comments on an earlier draft and to Stein-Erik Hjørring for invaluable editorial help in the final stage.

Plan of the book

Throughout the course of this book we will present the necessary tools to study economic time series, with ample applications to macroeconomics and finance. The book is organized as follows. In Chapter 1 we start by reviewing some of the basic concepts and definitions used in statistical analysis. That is, we review the concept of random numbers, differences between a population and a sample, and finally the ordinary least squares estimator (OLS).

Chapters 2–5 deal with univariate time series and models. In particular, Chapters 2–3 provide us with the necessary tools to describe and forecast stationary time series. Most data in macroeconomics and finance can be described as time series: a set of repeated observations over time of the same variable, such as consumer prices, gross domestic product (GDP), stock prices, exchange rates, etc. Accordingly, to be able to understand macroeconomic fluctuations and financial markets we need to learn about the basic definitions and tools used for univariate time series analysis. An important area of application for time series data and models is forecasting. To be able to predict or forecast the future with a reasonable degree of accuracy is fundamental, as most decisions taken today are based on what we think will happen in the future. We therefore devote much emphasis on macroeconomic forecasting.

Following the analysis of stationarity, Chapters 4 and 5 introduce nonstationary time series so that we can analyse the trend in the data and the fluctuations around the trend (i.e., the business cycles). We will present and compare several detrending methods used to extract the business cycle, including the popular Hodrick-Prescott and the band-pass

¹ The views expressed are those of the authors and do not necessarily reflect those of Norges Bank.

filter. The latter filter operates on what is known as the frequency band of a time series. Hence, this chapter also defines some of the basics linking the time domain to the frequency domain.

Chapters 6–9 deal with multivariate methods to study co-movement among variables. Many of the concepts discussed there will be multivariate extensions of the tools and concepts introduced in Chapter 2. However, some are new and relate only to multivariate models, like the discussion of simultaneity and the identification of structural shocks. We start by introducing the concept of simultaneity in Chapter 6 and illustrate the usefulness of instrumental variable (IV) regression for dealing with this problem. The IV and Two-stage least squares estimators are described, and we also give a brief introduction to the Generalized Method of Moments (GMM) estimator. The GMM method has proven to be a very efficient way to estimate the parameters of the rational expectation models that are widely used in macroeconomics.

In Chapter 7 we introduce vector autoregressive (VAR) models, which is used throughout the next three chapters. We first discuss stability properties and show how one can derive the moving average representation of the VAR. Then we discuss issues related to specification, estimation and forecasting of the VAR, and finally we introduce an important concept called Granger causality. Chapter 8 is the main chapter on vector autoregression techniques where we deal with the simultaneity problem first introduced in Chapter 6. We show how various methods can be used to identify the structural vector autoregressive (SVAR) model, and discuss how one can construct and interpret structural shocks, such as monetary policy, aggregate demand and supply shocks. Key is the study of impulse responses and variance decompositions.

In Chapter 9 we explain the conditions and methods that permit us to work with nonstationary data in a multivariate setting directly. Such conditions are commonly referred to as cointegration. We show how one can use cointegration as a common tool for the analysis of long-run relationships between macroeconomic time series. As an example of a potential cointegration relationship derived from economic theory, we discuss the theory of purchasing power parity.

The final chapter of the book, Chapter 10, introduces and explains the so-called state-space representation, the Kalman Filter, and how to estimate state-space models using Maximum likelihood techniques. Together the state-space representation and the Kalman Filter tools are used in a wide variety of settings in time series analysis. They can for example be used to estimate unobserved economic variables, like the trend and the cycle, to estimate the parameters of time series models, infer missing values, and for conditional forecasting. As such, the filter applies to stationary, nonstationary, uni- and multivariate models alike.

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