



Computational tools in econometric modeling for macroeconomics and finance

Gilles Dufrénot^a, Fredj Jawadi^{b,*}

^a Aix Marseille Université (Aix-Marseille School of Economics & CNRS & EHESS), France

^b Université of Evry & FBS, Campus Amiens, France

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ABSTRACT

This paper presents the evolution of structural and non-structural macroeconomic models and discusses the progress of quantitative macroeconomics. We also present and discuss several empirical studies that model the statistical properties of the macroeconomic and financial series under consideration in different ways, using diverse econometric and computational tools. We examine the challenges of quantitative macroeconomics. These elements are illustrated by the different contributions of this special issue.

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1. Introduction

“*Macroeconomics and Reality*” is the title of a paper by Christopher Sims published in *Econometrica* in 1980, in which the author discusses the relationship between macroeconomics and econometric analysis as well as the consequences of statistical theory on macroeconomics models. The author points to the complexity of macroeconomic and financial series dynamics and suggests the importance of econometric specifications and identification for macroeconomics models to enable them reflecting reality appropriately. Furthermore, the fact that large macroeconomic models are rather dynamic makes their checking through econometric models more complex than even required. Accordingly, Sims started a challenging research program on multivariate vector regressions and time series models that have the advantage of focusing on multiple equation systems. Such framework has the advantage of not having too much a priori Economic Theory (Sargent and Sims, 1977), which also enables macroeconomists and policymakers to lead to a good time path for economy and to develop macro-models of much use in policy projection.

The understanding of the interplay between measurement and theory is also the focus of a paper by Diebold (1998), who investigates the issue of macroeconomic forecasting over time. The author suggests that macroeconomic forecasting has been improved thanks to the development of powerful identification and estimation theory, computation and simulation techniques, etc. But as economic systems and rules considerably vary over times and the theories of the 20s and 30s are less available after the 70s and 80s, obviously the computational framework also evolves, which helps to resolve some macroeconomic problems and to develop new modern and advanced economic systems and principles. That is, the marriage of statistics and economic theory enabled

thus to emerge econometrics via the Econometric Society and its Journal “*Econometrica*”. The econometrics focuses on the identification, estimation and validation of econometric models implying interesting tools to check economic and financial theories.

As for macroeconomic theories, while Keynesian theories dominated until the 50s, economists suggested its insufficiency/limitation with the lack of foundations for the disequilibrium nature of markets, implying several interesting extensions. First, an interesting new research program on micro-foundations for Keynesian macroeconomic theory has been developed by Phelps et al. (1970) and Mankiw and Romer (1991). Second, macroeconomics knew a “rational expectation revolution” after Muth (1960) and Sargent and Wallace (1975)’s papers. Accordingly, assumptions associated with the Keynesian macro-econometric program and the “system-of-equations” approach did evolve significantly implying different extensions for the overall modeling approach (consumption function, investment function, price dynamics, etc.). Thus, new emerging works increased notably after the Lucas’ (1976) formal critical of the system of equation approach, which addresses limitations for providing conditional forecasting based on decision rules, as the latter may change when policies change. Also, it is important to recall economic systems across several questions after the 1970s due to simultaneous high inflation and unemployment, suggesting further and required consideration of Keynesian macroeconomics. Hereafter, a wide empirical research has been developed to test and compare macroeconomic theories. These on-going research programs have benefit from the development of computational tools, econometrics and database.

This introduction aims to briefly explain the interaction between macroeconomics and methodology. It also presents an overview on the evolution of structural and non-structural macroeconomic models and discusses the progress of quantitative macroeconomics. We also present and discuss several empirical studies that model the statistical properties of the macroeconomic and financial series under consideration in different ways, using diverse econometric and computational tools. The analysis of their findings indicates interesting results and significant contributions to the literature.

* Corresponding author.

E-mail addresses: Lopaduf@aol.com (G. Dufrénot), fredj.jawadi@univ-evry.fr (F. Jawadi).

The introduction is organized as follows. Section 2 briefly discusses the main aspects of nonstructural macroeconometrics evolution and briefly examines the progress of quantitative macroeconomics. Finally, we present the different contributions of this special issue in the last section.

2. Nonstructural macroeconometrics evolution

After 1970, the development of alternative macroeconomic models different from the Keynesian model was required implying the development of nonstructural methods. The latter benefited from Sargent and Sims (1977)' paper titled: "Business Cycle Modeling Without Pretending to Have too Much a Priori Theory". The interest also in nonstructural econometrics was helpful even though the later predated the Keynesian episode. Indeed, the emergence of nonstructural econometrics started with the introduction of linear difference equations by Slutsky (1937) and Yule (1921, 1926), which provide appropriate framework to model and forecast macroeconomic and financial series. These stochastic difference equations enabled to define autoregressive and moving processes. Later, Frisch (1933) made use of them to develop the idea of "impulse" and "propagation" issue and thanks to Wold investigation Slutsky–Yule models became powerful to describe time series. The publication of Box and Jenkins' book in 1970 stimulated the start of this literature with the development of ARMA models.

Several extensions have been developed hereafter. One of them involves vector autoregressive models to reproduce multivariate relationships in macroeconomics thanks to Sims (1980a, 1980b)'s paper that had the advantage of developing a system for which all the variables were endogenous and thus captured cross-variable linkages and lead-lag effects. In such a context, an important contribution was by Granger (1969) and Sims (1972) through the development of causality tests to explore causal patterns in multivariate systems.

Also, another major multivariate contribution was introduced by Sargent and Sims (1977) and Geweke (1977) through the dynamic factor models and the presence of economic shocks that are common across sectors. The use of such models and the presence of common factors imply significant comovements and enable the emergence of macroeconomic panel datasets and cross-country analyses.

As for the study of long-run relationships between macroeconomic and financial time-series, Granger (1981) and Engle and Granger (1987) developed the cointegration theory and the error-correction model. The extension of this framework to a multivariate case was developed by Johansen (1988). The idea of cointegration theory constitutes the essence of the Stock and Watson (1988) "common trends" representation and is also related to the principle of dynamic factor model as comovements and the activation of cointegration relationship is due to dependence on common factors.

However, all these models are based on a linear framework. The related first interest on nonlinear relationships has been introduced within financial data through the development of volatility dynamic models (Bollerslev et al., 1992; Bollerslev et al., 1994; Engle, 1982). Such nonlinearity is showed in several successful applications in finance rather in macroeconomics, as nonlinear models require large high-quality data. Macroeconomic data are naturally often aggregated implying less probability of ARCH effect and also available in short samples. However, an increasing and an ongoing nonlinear literature – that focuses on nonlinearity in the first moment or mean of a process – seems to be potentially relevant for macroeconomic data. Indeed, it is obvious that business cycle phases (expansion and contraction) might be viewed differently through different regimes. Accordingly, regime-switching models, including threshold models of Tong (1983) and Granger and Teräsvirta (1993) and Markov switching models of Hamilton (1989), have been used in several applied econometric papers to model nonlinearity for macroeconomic and financial data. The combination of nonlinearity and nonstationarity provides interesting econometric framework related to threshold cointegration (Balke and Fomby,

1997) and multivariate nonlinear cointegration models (Hansen and Seo, 2002). These nonlinear multivariate cointegration frameworks are relevant tools used to model financial and macroeconomic data for developed and emerging countries.

Overall, the development of such econometric tools and computational techniques provides excellent pieces of research and enables to modernize economic modeling. Furthermore, the development of important recent databases and the introduction of sophisticated computer techniques enable cheap and fast calculus to model and forecast macroeconomic relationships. Thus, the development of sophisticated numerical and simulation tools is actually more obvious than some decades ago, making the estimation of complicated models rather more relaxed and the test and checking of financial and economic theories more simple and less time-consuming. This provides new and numerous research programs investigating several empirical questions and addressing different practical challenges regarding financial markets, investors and risk premium, economic policies, inflation and central banks, government and public debts, business cycle and shocks, fiscal and monetary rules, decision rules for consumption and investment behavior, and unemployment. Indeed, recent studies not only help to develop interesting challenges but also point to different ways macroeconomic and financial issues might be advanced. Interestingly, the combination of modern macroeconomic theory (e.g. DSGE model) and nonstructural time-series econometrics provides interesting way for a new structural econometric framework.

The current issue of *Economic Modelling* publishes a selection of papers associated with the second International Symposium on Computational Economics and Finance (ISCEF) that has been organized in Tunis on February 25–27, 2012 (www.iscef.com). It includes seventeen papers which focus on different questions in macroeconomics and finance and dealing with a rich class of econometrics and computation tools. The next section contains a concise presentation of these contributions.

3. Presentation of the contributions

The first paper titled: "Hopf Bifurcation in the Clarida, Gali and Gertler Model", is by William Barnett (University of Kansas and Center for Financial Stability) and Unal Eryilmaz (OECD). The authors focus on bifurcation phenomena in the open-economy New Keynesian CCG Model based on Clarida, Gali and Gertler's approach. The authors point to complex dynamics that seem to be associated with the open economy framework. Accordingly, the authors suggest more attention and consideration from policymakers on any change in monetary policy as the later can produce significant unexpected bifurcation. The values of bifurcation parameters can however be affected within an adequate econometric specification.

"Real Business Cycles in Emerging Economies: Turkish Case" is the title of the second paper by Hüseyin Tastan (Yildiz Technical University). This study also deals with open economy but for an emerging country: Turkey. The author checks whether a real business cycle (RBC) model driven by nonstationary productivity shocks can explain business cycles in Turkey. Accordingly, the author estimates a DSGE model using Bayesian methods and he suggests the failure of RBC model to replicate some of the key features of Turkish economic fluctuations. Interestingly, an alternative stochastic dynamic general equilibrium model with financial frictions seems to supplant the RBC model in providing a more realistic picture of business cycles for the Turkish economy. The author associates this finding to the fact that the stylized facts of business cycles in emerging markets are quite different from those of developed markets (e.g. consumption volatility excess in relation to output, volatility excess for exports, etc.).

The third and fourth papers deal with questions about monetary issues. Indeed, the third paper titled: "Inflation Targeting in a Learning Economy: an ABM Perspective" by Isabelle Salle, Murat Yildizoglu and Marc-Alexandre Sénégal (University of Bordeaux) investigates the

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