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Identification-robust analysis of DSGE and structural macroeconomic models

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ABSTRACT

Full- and limited-information identification-robust methods are proposed for structural systems, notably DSGE models, which are valid whether identification is weak or strong, theory-intrinsic or data-specific. The proposed methods are applied to a standard New Keynesian system for the U.S. Single- and multi-equation estimation and fit are also compared. When a unique rational-expectation stable equilibrium is imposed, the model is rejected. In contrast, limited-information inference produces informative results regarding forward-looking behavior in the NKPC and precise conclusions on feedback coefficients in the reaction function, which cannot be reached via single-equation methods.

1. Introduction

Optimization-based macroeconomic models, in particular structures derived from dynamic stochastic general equilibrium (DSGE) assumptions, are routinely used for analyzing macroeconomic issues. In this respect, the solutions of log-linearized versions of these models are frequently taken to the data in order to obtain realistic quantitative answers to the questions studied. Classical and Bayesian estimations have both been used for this purpose, including methods that consider jointly all model restrictions (full-information [**FI**] approaches), and methods that focus on matching only some aspects of the data (limited-information [**LI**] approaches). However, finding reliable estimates for the parameters of such models is a challenging problem, regardless of the estimation strategy. In a recent survey, Schorfheide (2010) discusses, among others, two important (and related) reasons for this: weak identification and assumptions which are auxiliary to the theory yet necessary to complete a model, such as restrictions on disturbance distributions and information sets. This paper studies both problems, proposes econometric tools designed to overcome their consequences, and applies these tools to the New Keynesian model.

A number of studies have documented identification problems in well-known estimated models such as the New Keynesian Phillips Curve (NKPC) (see, for example, Dufour et al., 2006, 2010; Ma, 2002; Mavroeidis, 2004, 2005; Nason and Smith, 2008; Kleibergen and Mavroeidis, 2009); Taylor-type monetary policy rules (Mavroeidis, 2010; Inoue and Rossi, 2011);

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and the Euler equation for output (Fuhrer and Rudebusch, 2004; Magnusson and Mavroeidis, 2010). For multi-equation models, several studies have explored identification difficulties, the proper recovery of macroeconomic dynamics from structural VARs, and the role of added measurement errors; see Kim (2003), Beyer and Farmer (2007), Fernandez-Villaverde et al. (2007), Ruge-Murcia (2007), Canova and Sala (2009), Chari et al. (2009), Consolo et al. (2009), Chevillon et al. (2010), Iskrev (2010), Magnusson and Mavroeidis (2010), Moon and Shorfheide (2010), Cochrane (2011), Komunjer and Ng (2011), Andrews and Mikusheva (2011), and Granziera et al. (2011).

Macroeconomists are rarely dogmatic in favor of a fully specified model as an end in itself. Rather, models are viewed mainly as quantitative benchmarks for the evaluation of substantive economic issues. While there is a consensus that certain models are useful for this purpose, there is less agreement on how such models should be parameterized when taken to the data. Ideally, one would like to focus on implications of interest conforming with micro-founded structures while allowing the data to *speak freely* on the dimensions along which these may lack fit. In particular, the following features can affect identification and inference validity. First, an important challenge consists in minimizing the effects of auxiliary assumptions. For instance, innovations arising from measurement errors are usually non-fundamental. Alternatively, the existence of a unique rational expectation solution may challenge theory (see Cochrane, 2011). Second, DSGE–VAR methods broadly assess the structural form against an unrestricted VAR where the included variables are determined by the DSGE. The literature is witnessing a growing awareness on the possibility of misspecifying the benchmark and its consequences. Variable omission is a third recognized difficulty, since by construction and because of their specificity, DSGE models may exclude empirically relevant data. For all these reasons, the consequences of spuriously completing models should be taken into account.

This paper proposes *identification-robust* inference methods, *i.e.* methods which are valid whether identification is weak or strong, for DSGE setups. For definitions and surveys of the relevant econometric literature, see, for example, Stock et al. (2002), Dufour (2003), and Kleibergen and Mavroeidis (2009). Despite the considerable associated econometric literature, identification-robust methods for multi-equation systems are still scarce (see Moon and Shorfheide, 2010; Granziera et al., 2011; Guerron-Quintana et al., 2009; Magnusson and Mavroeidis, 2010; Andrews and Mikusheva, 2011). We introduce two system-based identification-robust methods which can address either all of the restrictions implied by the model ("full-information" inference), or only some of those restrictions ("limited-information" inference). So the latter approach (implicitly) considers a more general setup, though it retains basic features of the original model. We argue these approaches should be viewed as complementary, rather than mutually exclusive. Comparing LI with FI inference provides a useful specification check, and our incomplete-model alternative allows the researcher to draw inferences which are more robust to auxiliary model assumptions (such as the information used by economic agents to form their expectations). Both methods rely on estimation and test procedures whose statistical validity is not affected by identification issues and questionable auxiliary assumptions.

We apply these tools to an illustrative three-equation New Keynesian model, estimated from U.S. data. This fundamental structure has been extensively studied and forms the building block of many other more complex models; see Clarida et al. (1999), Woodford (2003), Christiano et al. (2005), Linde (2005), Benati (2008), Del Negro et al. (2007), to mention a few. Three features of the New Keynesian model are addressed. First, inflation persistence is studied within the NKPC, given the on-going debate in this regard (see the survey by Schorfheide, 2008). Second, the output gap coefficient in the NKPC and the real interest rate parameter in the output equation are analyzed, as currently available results lead to conflicting conclusions on the impact of these variables (see Schorfheide, 2010). For clarity, these are called the *forcing variables* of the corresponding equations. Third, the implications of imposing a unique rational expectation solution on the feedback coefficients in the Taylor rule are revisited, in light of serious issues arising from determinacy underscored, for example, by Mavroeidis (2010) and Cochrane (2011). Comparisons between our FI and LI assessments of these questions are discussed.

Our findings can be summarized as follows. When a stable and unique equilibrium is imposed to complete the model, it is rejected by the data. This is an important sense in which our analysis can be seen as an exploration of the pervasiveness of auxiliary FI assumptions. In contrast, although insignificant forcing variables in the NKPC and the output curves cannot be ruled out, our LI multi-equation results provide realistic conclusions on the nature of the NKPC, and yield precise estimates of feedback coefficients which appear consistent with the Taylor principle. It is shown that such conclusions cannot be reached via single-equation methods. These results indicate that a multi-equation estimation of the considered model can still utilize the information in the contemporaneous relationship between output, inflation, and interest rates, which positively affects identification and inference.

In Section 2, our framework and empirical model are described. Section 3 presents the methodology. Empirical results are provided in Section 4. Section 5 offers some conclusions.

2. Framework

Consider the general structural form

$$\Gamma_0 X_t = \Gamma_1 X_{t-1} + C + \omega v_t + \psi \eta_t, \tag{1}$$

where X_t is vector of m^* variables, C is a vector of constants, v_t is an exogenous shock, and η_t is a vector of expectation errors such that $E_t(\eta_{t+1}) = 0$. Collect all the parameters of (1) in the vector ϑ. Typically, only a vector (denoted Y_t) of n^*