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How much nominal rigidity is there in the US economy? Testing a new Keynesian DSGE model using indirect inference ☆

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ABSTRACT

We evaluate the Smets–Wouters New Keynesian model of the US postwar period, using indirect inference, the bootstrap and a VAR representation of the data. We find that the model is strongly rejected. While an alternative (New Classical) version of the model fares no better, adding limited nominal rigidity to it produces a 'weighted' model version closest to the data. But on data from 1984 onwards – the 'great moderation' – the best model version is one with a high degree of nominal rigidity, close to New Keynesian. Our results are robust to a variety of methodological and numerical issues.

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1. Introduction

In this paper we propose a new way to test dynamic stochastic general equilibrium (DSGE) models that is based on indirect inference and apply this to one of the leading DSGE models of the US economy, the model of Smets and Wouters (2007, SW). A key feature of this model is that it has sticky prices and wages, i.e. it is a New Keynesian (NK) model. The extent of nominal rigidity is a major area of disagreement between economists. We therefore compare the SW model with a New Classical (NC) version of their model which has flexible prices and wages but lagged information in the form of a one-quarter delay for households in receiving macro information. We also consider the possibility that the economy consists of a mixture of the two in which some parts of the economy display nominal rigidities and other parts do not.

We find that for post-war data a hybrid model, in which most of the economy enjoys price and wage flexibility, but a non-negligible part of the economy is subject to nominal contracts, comes closest to matching the data, whereas the NK

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and NC models are seriously at odds with the data. If, however, we use only data for the last part of the sample, from the mid-1980s to the mid-2000s, then a model with a high degree of nominal rigidity is able to match key aspects of the data. Our results suggest that the state-dependency of pricing could dominate its time-dependency for the bulk of the post-war period but during the later period of the 'great moderation', when the economy was more stable, time-dependency could have dominated. Though we do not consider evidence from micro data here, we note that both time dependence (Bils and Klenow, 2004) and state dependence (Gertler and Leahy, 2008) have been found in such data.

How to test a calibrated, or even a partially Bayesian estimated DSGE model, such as the SW model, is a long-standing problem. Early work compared particular features of data simulated from the calibrated or estimated model with the actual data. Our method, based on indirect inference, formalises this approach. It exploits the fact that the solution to a log-linearised DSGE model can be represented as a restricted vector autoregressive-moving-average (VARMA) model either in levels or in first differences (if there are permanent shocks), and this can be closely represented by a VAR. When identified, the *a priori* structural restrictions of the DSGE model impose restrictions on the VAR. The DSGE model can be tested by comparing unrestricted VAR estimates (or some function of these estimates such as the value of the log-likelihood function or the impulse response functions) derived using data simulated from the DSGE model with unrestricted VAR estimates obtained from actual data. In practice, we use a Wald test based on the VAR estimates. If the DSGE model is correct then the simulated data, and the VAR estimates based on these data, will be close to the actual data.

One advantage of this procedure over a classical likelihood ratio test is that we do not have to specify a different DSGE model as the alternative hypothesis. An unrestricted VAR model based on the actual data automatically generates an alternative hypothesis suitable for testing the specification of the model. The procedure requires that the DSGE model generates an identified VAR. We argue that the SW model does this.

A further issue is the probability distribution of the test statistic—in our case a Wald statistic. Instead of using the asymptotic distribution of the Wald statistic, we use an empirical estimate of its small sample distribution obtained by bootstrap methods.

This paper joins a large and rapidly expanding literature on the evaluation of DSGE models—see Minford et al. (2009) and Theodoridis (2006) for recent accounts. Two related issues stand out in this literature. First, how to measure the closeness of DSGE models to the data—see, for example, Watson (1993), Canova (1994, 1995, 2005), Del Negro and Schorfheide (2004, 2006), Corradi and Swanson (2007) and Del Negro et al. (2007a). Second, how well simulations of the model compare with various descriptions of the data such as moments, cross-moments and impulse response coefficients. Elsewhere (Le et al., 2010) we have referred to this as the 'puzzles methodology', as a poor match is often treated as a puzzle to be resolved by further model development; a recent example for a two-country world macro-model is Chari et al. (2002).

This paper contributes to this literature in two main ways. With respect to the puzzles methodology, it provides a formal statistical basis for comparing simulations of a calibrated or previously estimated DSGE model with key features of actual data. It also provides more detailed information on which features of the data the model is able and unable to capture, thereby supplementing available closeness measures.

The paper is organised as follows. In Section 2 we review the key features of the SW model of concern to us. We explain our test procedure in detail in Section 3. In Section 4 we report our test findings and compare the performance of alternative flexible price versions of the SW model, including a hybrid model that combines flexible and sticky price versions of the model. In Section 5 we examine whether changes in monetary regimes are a possible source of mis-specification. In Section 6 we consider the robustness of our test and various other related issues. We summarise our conclusions in Section 7.

2. The Smets–Wouters model of the US economy

One of the main issues that emerged from the first type of calibrated DSGE model, the real business cycle (RBC) model, was its failure to capture the stylised features of the labour market observed in actual data. Employment was found to be not nearly volatile enough in the RBC model compared with observed data, and the correlation between real wages and output was found to be much too high (see, for example, King et al., 1988). The clear implication is that in the RBC model real wages are too flexible. The Smets–Wouters model (2007; a development from Christiano et al., 2005) marks a major development in macroeconometric modelling based on DSGE models. Its main aim is to construct and estimate a DSGE model for the United States in which prices and wages, and hence real wages, are sticky due to nominal and real frictions arising from Calvo pricing in both the goods and labour markets, and to examine the consequent effects of monetary policy which is set through a Taylor rule. It may be said, therefore, to be a New Keynesian model. They combine both calibration and Bayesian estimation methods and use data for the period 1966Q1–2004Q4.

Unusually, the SW model contains a full range of structural shocks. In the EU version – Smets and Wouters (2003) – on which the US version is based, there are 10 structural shocks. These are reduced to seven in the US version: for total factor productivity, the risk premium, investment-specific technology, the wage mark-up, the price mark-up, exogenous spending and monetary policy. These shocks are generally assumed to have an autoregressive structure. The model finds that aggregate demand has hump-shaped responses to nominal and real shocks. A second difference from the EU version is that in the US version the Dixit–Stiglitz aggregator in the goods and labour markets is replaced by the aggregator developed by Kimball (1995) where the demand elasticity of differentiated goods and labour depends on their relative

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