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Output, inflation, and interest rates in an estimated optimizing model of monetary policy ☆

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ABSTRACT

This paper examines the impact of sticky price and limited participation frictions, both separately and combined, in a dynamic stochastic general equilibrium model. Using U.S. data on output, inflation, interest rates, money growth, consumption, and investment, likelihood ratio tests and Bayesian pseudo-odds measures reveal that the data prefers a model with both structural features. Our results also show that the combined model mimics many important features of the business cycle. In particular, the model generates plausible impulse responses, and monetary policy shocks are responsible for only a modest amount of output, inflation, and nominal interest rate movements.

1. Introduction

In recent years, the development of a plausible structural model of the monetary transmission mechanism has been an important objective in monetary economics. Most macroeconomists believe that such a model should be able to generate, at a minimum, a fall in output, a persistent decline in inflation, and a rise in the nominal interest rate after a contractionary monetary policy shock. While models with numerous frictions often are evaluated on their ability to replicate those responses, formal statistical tests also are needed to determine whether including those frictions improves a model's fit with the data. To address that matter, this paper uses maximum likelihood to estimate our model's parameters and then employs likelihood ratio tests and a Bayesian-motivated, pseudo-odds measure to compare our model's fit with and without certain frictions.

Interest in modeling the effects of monetary policy has generated numerous competing dynamic stochastic general equilibrium (DSGE) models, each stressing different structural features. Two popular structural features used in monetary models

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are price stickiness and limited participation of the representative household in financial markets.[1] King and Watson (1996) document that sticky price models, such as King (1991) and Kimball (1995), are unable to generate the liquidity effect (i.e., the rise in the nominal interest rate after a contractionary monetary disturbance), while limited participation models, such as Christiano and Eichenbaum (1992, 1995), are unable to account for the output and inflation effects after a monetary policy shock. Keen (2004) builds on the research of King and Watson (1996) by specifying a DSGE model with both sticky prices and limited participation and finds that the model can generate plausible qualitative responses for output, inflation, and the nominal interest rate. Those results suggest that statistical tests are needed to compare the fit of a model with sticky price and limited participation frictions to a model without either friction.

This paper constructs and estimates the parameters by maximum likelihood of three DSGE models: a sticky price model, a limited participation model, and a sticky price and limited participation model. The parameters are estimated using quarterly U.S. data on output, inflation, money growth, nominal interest rate, consumption, and investment under the assumption that those data series provide the best information on the actual values for the degree of price stickiness, and the size of the time adjustment costs.[2] Analysis of our models using likelihood ratio tests and a Bayesian-motivated, pseudo-odds measure indicates that a sticky price and limited participation model fits the data better than either the sticky price model or the limited participation model. When evaluated at its estimated parameter values, our sticky price and limited participation model is able to produce simultaneously the output, inflation, and liquidity effects after a monetary disturbance. The estimated model also is able to generate other business cycle features observed in many empirical studies. For example, monetary policy shocks account for a modest portion of the variability in output, inflation, and the nominal interest rate. The ability of a sticky price and limited participation model to fit the data and replicate key features suggests, at the very least, that the model is a reasonable benchmark for the development of future monetary models.

This study compliments a growing literature that estimates DSGE models and compares their performance to behavior observed in the data. Christiano et al. (2005) develop a DSGE model with numerous nominal and real rigidities and then estimate its parameters by minimizing the distance between their DSGE model's and a vector-autoregression (VAR) model's impulse response functions. Furthermore, Christiano et al. (2005) show that their model can replicate many features observed in the data.[3] Using Bayesian methods, Smets and Wouters (2003) estimate a DSGE model similar to Christiano et al. (2005) with Euro data and find that their model fits the data better than a VAR model. Taking a more narrow approach, Ireland (2001) uses maximum likelihood to estimate a DSGE model, and then shows that the data supports stickiness in the price level but not in the inflation rate. Our paper is closer in methodology to Ireland (2001) than to Smets and Wouters (2003) and Christiano et al. (2005). That is, we explicitly test for both price stickiness and limited participation in a DSGE model and compare the resulting business cycle features with those observed in the data. Note that it is not the objective of this paper to build an extensive model of the economy that fits the data better than a VAR model.

The remainder of the paper is structured as follows. Section 2 discusses existing models of the business cycle. Section 3 outlines our model. Section 4 describes the model's solution and the estimation procedure. Section 5 presents the maximum likelihood estimates and assesses the qualitative and quantitative properties of the model. Section 6 serves as the conclusion.

2. Existing models of the business cycle

Many studies evaluate DSGE models by comparing their qualitative responses after a monetary policy shock to those obtained from the estimation of identified VAR models. Using Bayesian techniques, Schorfheide (2000), however, argues that approach is credible only if the VAR model obtains a higher posterior probability than the DSGE model. The result suggests that models should not be rejected solely on the basis of their ability to match certain behavior emanating from the VAR literature. It is still reasonable, however, to examine whether a DSGE model can replicate results emerging from a large subset of the VAR literature. For example, after analyzing the results from that literature, Christiano et al. (1999) conclude that a contractionary monetary policy shock causes a reduction in output, a persistent decline in inflation, and a rise in the nominal interest rate.[4] This section briefly describes the ability of sticky price models and limited participation models to produce those outcomes. We then summarize findings that suggest that a model with both sticky prices and limited participation can generate results consistent with some key qualitative effects of a monetary policy shock observed in many empirical studies.

Sticky price models, such as King and Wolman (1996) and Ireland (1997), introduce methods to enable prices to adjust gradually after a monetary policy shock. In those models, the price stickiness causes output to fall temporarily in response to a contractionary monetary disturbance. The temporary decline in output prompts the representative household to decrease its savings in order to smooth out its consumption. Furthermore, the lower output demand in subsequent periods decreases the demand for investment. The response of the real interest rate to the monetary policy shock depends on the relative

[1] Limited participation is one source of financial market frictions. Other well-known sources include Carlstrom and Fuerst's (1997) agency costs and Bernanke et al.'s (1999) financial accelerator.

[2] Time adjustment costs are a type of limited participation constraint.

[3] For example, Christiano et al. (2005) is able to generate a fall in output, a persistent decline in inflation, and a rise in the nominal interest rate after a contractionary monetary policy shock.

[4] Using a new agnostic method, Uhlig (2005) argues that a monetary policy shock has no significant effect on output even though the price level gradually changes.