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Measuring monetary policy deviations from the Taylor rule

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Abstract

We estimate deviations of the federal funds rate from the Taylor rule by taking into account the endogeneity of output and inflation to changes in interest rates. We do this by simulating the paths of these variables through a DSGE model using the estimated time series for the exogenous processes except for monetary shocks. We then show that taking the endogeneity of output and inflation into account can make a significant quantitative difference (which can exceed 40 basis points) when calculating the appropriate value of interest rates according to the Taylor rule.

JEL Classification: E32, E37, E50

Keywords: interest rates, New Keynesian models, sticky prices, DSGE, business cycles, Bayesian estimation.

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1 Introduction

In this paper we estimate a medium-scale dynamic stochastic general equilibrium (DSGE) model in which monetary shocks are measured as deviations from the interest rate rule proposed in Taylor (1993). We then use the DSGE model's parameter estimates and the estimated time series for the exogenous processes except for the monetary shock (the deviations in policy from the Taylor rule) to simulate the path that interest rates, inflation and output would have taken in the absence of deviations from the Taylor rule. That is, our calculation of the federal funds rate according to the Taylor rule takes into account that had interest rates been different, then the paths of inflation and output would not have been equal to those which were observed. This is the case because, according to New Keynesian theory, monetary policy shocks have both nominal and real effects (see for example Galí, 2008).

Our results show that the Federal Reserve deviated significantly from what the Taylor rule would have prescribed during the 70s, early 80s and in the early 21st century. We additionally calculated the federal funds rate implied by the Taylor rule assuming that inflation and output would not have been affected had interest rates taken a different value (as is conventionally done). A comparison with the federal funds rate predicted by our model in the absence of monetary shocks suggests that it can make a difference (which can be quantitatively significant and exceed 40 basis points) whether one takes or not into account the endogeneity of inflation and output. We also show that when the endogeneity of output and inflation is taken into account, the values of the Taylor rule become substantially more correlated with the historical (i.e. the observed) values for the federal funds rate.

Our findings are robust to using different modelling assumptions and different sub-sample periods in the estimation.

2 The Linearized DSGE Model

The main focus of our paper is to measure how much the Fed has deviated from the Taylor rule. So we start by describing the central bank's interest rate rule. We consider a general version of the Taylor rule which allows for interest rate smoothing (Clarida et al., 2000). Therefore, in our model, we assume that the central bank sets policy by responding to the interest rate (r_t) in the previous time period, the current inflation rate (π_t) and output (y_t):

$$r_t = \rho r_{t-1} + (1-\rho)[r_\pi \pi_t + r_y y_t] + \varepsilon_t^r, \tag{1}$$

where $\varepsilon_t^r = \eta_t^r$ is an exogenous monetary policy shock (assumed to be IID-Normal), which measures policy deviations from the Taylor rule. All variables are log-linearized around their steady state balanced growth path.

The remaining equations of the DSGE model are identical to Smets and Wouters (2007) and to conserve space we do not include them here (in the online appendix we provide a complete description of the model). Our motivation to use the Smets and Wouters (2007) model is based on its good fit to the main aggregate US time series. As Cúrdia and Reis (2010) point out "central banks around the world have adopted variants of this model" and this too informed our choice to use it as a main reference.

3 Estimation Methodology

The model presented in section 2 is estimated with Bayesian methods (which is currently the preferred approach in DSGE model estimation by macroeconomists, with several advantages over other methodologies, see Fernández-Villaverde, 2009). We start by maximizing the log posterior function, which combines the prior information on the parameters with the likelihood of the data. We then used the Metropolis-Hastings algorithm to get a complete picture of the posterior distribution.[1]

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[1] A 250,000 draw sample was created. The value adopted for the scale of the jumping distribution in the Metropolis-Hastings algorithm was chosen in order to have approximately an acceptance rate of 23% (the

The interest rate rule parameters were kept fixed in the estimation procedure. The inflation and output weights were fixed at 1.5 and $0.125 = 0.5/4$ respectively, following Taylor (1993). The value for the coefficient on the lagged interest rate was set at 0.75 which is consistent with the estimates of Clarida et al. (2000). These were also the mean values of the prior distributions chosen by Smets and Wouters (2007). We also fixed the steady state inflation level at a value of 0.5 (consistent with the Federal Open Market Committee aim for 2 percent annual inflation). We maintained the same priors for the remaining parameters as in Smets and Wouters (2007).

We estimated the model using the following 7 seasonally adjusted quarterly US aggregate time series: 100 times the first difference of the natural log of the GDP deflator, real consumption, real investment, real wages, real government expenses and real GDP; 100 times the natural log of average hours worked; and the federal funds rate. These are the same time series as in Smets and Wouters (2007) but we updated the dataset to include observations for more recent years. We will therefore estimate the model for the period 1966Q1 to 2013Q4 (whereas Smets and Wouters, 2007, estimated their model with data from 1966Q1 to 2004Q4).

4 Results

The estimates for most parameters are in line with those obtained by Smets and Wouters (2007). To conserve space parameter estimates are relegated to the online appendix. The steady-state annual real interest rate implied by the parameter estimates is about 2.3% which is not very different from the 2% value used by Taylor (1993).

In Figure 1 we show the historical federal funds rate (FF) and the federal funds rate time series which would have been set according to two different methods to calculate the Taylor rule (FF' and FF''). In the method used to calculate FF' we have taken into account that inflation and output would have taken different values from their actual historical paths

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optimal rate indicated in Gelman et al., 1996).

had there not been any deviations from the Taylor rule.[2] This was done by simulating the model in section 2 using the mean parameter estimates and the time series for the exogenous processes except for the monetary shock (the deviations in policy from the Taylor rule). The variable FF'' shows the value the federal funds rate would have taken using the historical values of inflation and output.

For both methods Figure 1 shows large deviations in the federal funds rate from the values implied by the Taylor rule during the late 60s and most of the 70s, the first half of the 80s and between the 2001 recession and the Great Recession. In the 90s the Taylor rule gave a very good fit of Federal Reserve policy. Our findings suggest that central bank policy should have set higher interest rates than it did during a large part of the 70s and in the years prior to the financial crisis of 2007/2008. On the other hand, during the Volcker years in the 80s the Fed deviated from the Taylor rule by setting interest rates too high.

While deviations from the Taylor rule are qualitatively similar according to both methods, Figure 1 also shows that taking into account the endogeneity of inflation and output can at times be quantitatively important. Differences between the methods can exceed 30 basis points (as is the case between 2004Q3 and 2005Q4) and even more than 40 basis points (as is the case between 1984Q3 and 1985Q2). The correlation of the historical federal funds rate for the period 1966Q1 to 2013Q4 with FF' is 0.79 but only 0.64 with FF''. Therefore, not taking into account the endogeneity of output and inflation to interest rate changes exaggerates how much monetary policy has deviated from the Taylor rule. These findings illustrate well the issue raised by Bernanke (2010) that assessing the extent of interest rate deviations from the Taylor rule is not an easy task and requires taking into account the response of inflation and output to monetary policy.

Estimates for interest rates according to the Taylor rule would be different had we used a different model (e.g. a model including a financial sector) or a different time period in the estimation (e.g. estimating the model only for the period of the "Great Moderation", a period of low inflation and economic volatility, in order to avoid issues concerning potential structural breaks). We therefore in the online appendix have the following robustness exercises: 1) a model with an autoregressive process to measure policy deviations from the Taylor rule ($\varepsilon_t^r = \rho_r \varepsilon_{t-1}^r + \eta_t^r$) rather than an IID-Normal shock; 2) a model with financial frictions; 3) considering only the period from 1966Q1 to 2007Q4 (so as to exclude the zero lower bound period, due to concerns that non-linearities could distort parameter estimates); and 4) considering only the period from 1984Q1 to 2004Q4 (which corresponds to the "Great Moderation"). We find that our results are quite robust. Taking into account the endogeneity of inflation and output always results in differences that can be quantitatively large (in all the robustness cases there are periods where differences exceed 40 basis points). It is also always the case that the Taylor rule which takes into account endogeneity of inflation and output is closer to the historical federal funds rate.

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[2] According to our estimates, had the Taylor rule been followed, inflation would have been quite similar to its historical path (the correlation between the two series is 0.9997). However, the same does not happen with output (the correlation between the two series is 0.9332).

5 Conclusion

We obtained federal funds rate deviations from the policy prescribed by the Taylor rule by estimating a structural business cycle model. This allowed us to incorporate the endogeneity of economic variables to interest rate changes when calculating the recommended value for the interest rate by the Taylor rule. We found that the differences in the prescribed interest rate values from taking endogeneity into account can be quantitatively large. Moreover, not taking into account the endogeneity of inflation and output overstates the extent to which monetary policy has deviated from the Taylor rule.

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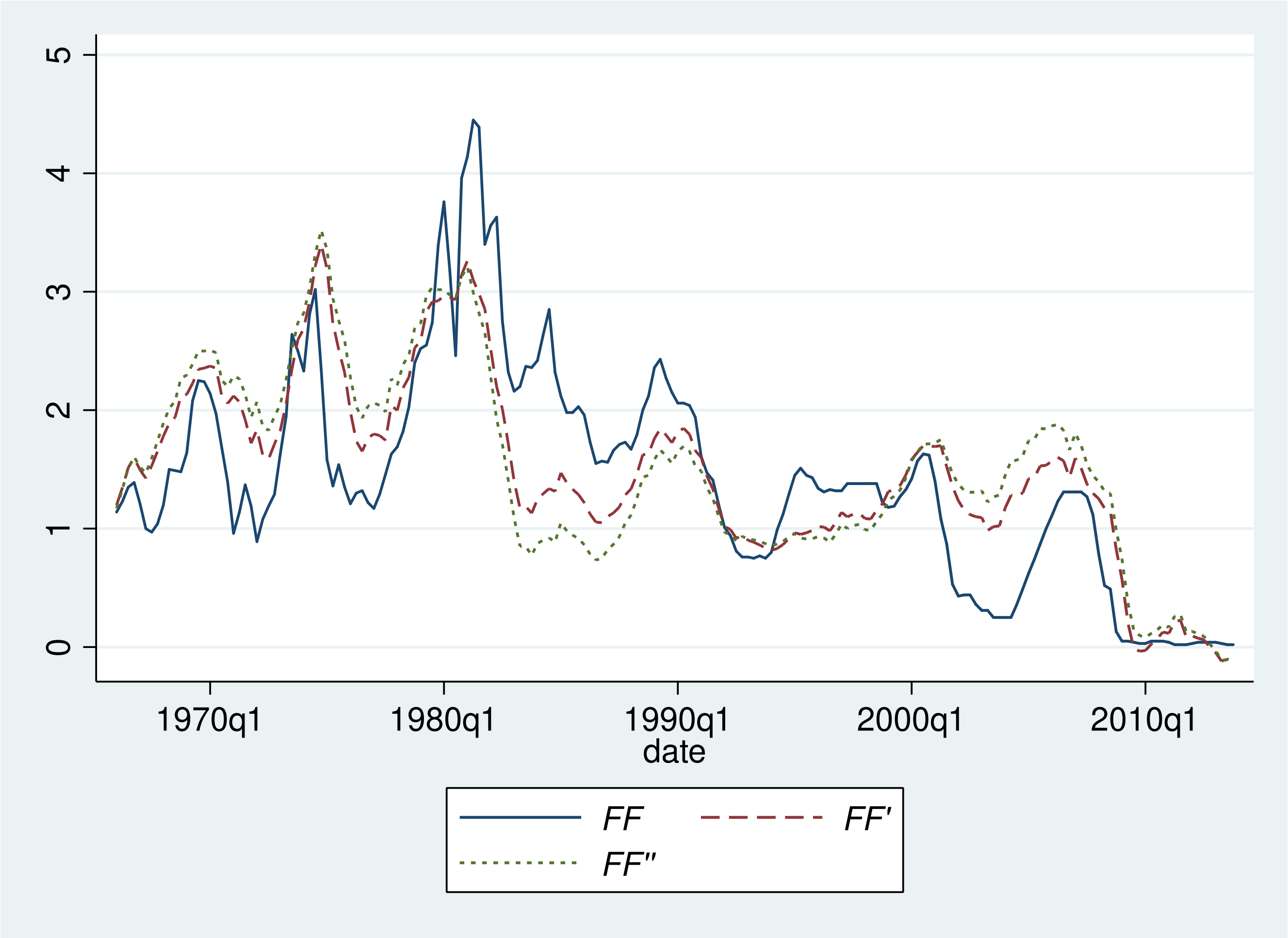
6 Figures

Figure 1 - Federal funds rate (%): historical value (FF), Taylor rule counterfactual taking into account endogeneity (FF') and without taking into account endogeneity (FF'') of inflation and output