**What Do Structural Models Tell Us About the Effects of Monetary Policy?\***

William B. English

Yale University

Robert Tetlow

Board of Governors of the Federal Reserve System

Connor Brennan

Board of Governors of the Federal Reserve System

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**Abstract**

The appropriate calibration of monetary policy requires an evaluation of the size and timing of the effects of policy changes on the economy. Despite many decades of research, significant uncertainty about those effects remain. We use a large collection of structural macroeconomic models and a range of different policy rules to simulate the effects of monetary policy shocks on output and inflation. The range of the resulting impulse-response functions is very wide, with some models showing very rapid and large effects, while others show much more gradual or modest effects. We then examine how the speed and size of the monetary policy effects relate to a range of model attributes. On the whole, the effects of policy are larger and more gradual to build in models that are estimated rather than calibrated. In addition, models with wage and price indexation generally show somewhat more persistent and larger economic effects. Models that were developed by economists on the staff of central banks show somewhat larger effects of monetary policy than models prepared by other economists. We conclude that economists are less in agreement than might have been expected about the effects of monetary policy, suggesting that policymakers need to be humble about their knowledge of the effects of changes in policy and approach monetary policy decisions with a risk management framework.

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1. **Introduction**

In order to decide on the appropriate stance of monetary policy in a given economic environment, policymakers would like to have a good understanding of the size and timing of the effects of monetary policy on output, employment, and inflation. For example, if monetary policy has large effects with short lags, then policymakers will want to make modest adjustments to the stance of policy in response to current economic developments. By contrast, if monetary policy has smaller effects that operate with a substantial lag, then policymakers will want to adjust policy more forcefully over time, but in response to changes in the economic outlook, rather than current conditions.

Unfortunately, and despite a great deal of work done by many economists over recent decades, there remains considerable uncertainty about the size and timing of the effects of monetary policy. The resulting uncertainty has real consequences for monetary policy decision making. As the Federal Reserve increased interest rates rapidly in response to high inflation in 2022 and 2023, policymakers emphasized that lags in the effects of policy meant that policy tightening would need to cease well before inflation returned to target in order to avoid overshooting and an undesirably large decline in output and employment (Powell, 2023). On the other hand, some policymakers argued that lags might be short, suggesting less need to be concerned about such outcomes (Waller, 2023).

In part uncertainty about the effects of monetary policy likely reflects differences in its effects across economies and across time. Differences in industrial mix, in financial structure, and in monetary policy communications can all affect the size and timing of policy effects (See, e.g., Carlino and DeFina (1998), Cecchetti (1999), Doh and Foerster (2022).

Despite these difficulties, policymakers must do the best they can to judge the likely effects of changes in monetary policy since, at least implicitly, the appropriate calibration of monetary policy depends on that judgement.[[1]](#footnote-1) To support policymakers in making such judgements, we evaluate the timing and size of the effects of changes in monetary policy on output and inflation in a wide range of macroeconomic models of the United States economy employed in papers published in economic journals over the past few decades.[[2]](#footnote-2) For each of the approximately 100 models we select, we calculate impulse response functions for a shock to monetary policy using one of three possible monetary policy rules: A traditional Taylor Rule, a Taylor Rule with added inertia, and a policy rule expressed in differences rather than levels.[[3]](#footnote-3)

Looking across the simulation results, the median effects on output and inflation are of reasonable size, with maximum effects on output of xxx percent and maximum effects on inflation of xxx percentage points; those maximum effects are typically reached after about xxx quarters in the case of output and xxx quarters in the case of inflation. These median results are broadly similar to those seen in well-known models, such as Semts and Wouters (2003), Christiano, Eichenbaum, and Evans (2005), and FRB/US (Lafort, 2018). That being said, the range of model results is striking, with maximum effects ranging from essentially no effect to an xxx percent effect on output and an xxx percent effect on inflation, while the peak effects a reached immediately in some cases, but only after more than xxx quarters in others.

We use these simulation results to examine what model attributes are associated with different estimated effects of policy. We find that lags on the effects of policy are shorter in models that are smaller and calibrated. The estimated effects of policy are larger and more gradual in models in which wages or prices are indexed. In addition, the effects on inflation are smaller for models that are estimated based on more recent data, when inflation expectations were well anchored, and so inflation remained near 2 percent.

The bottom line appears to be that economists appear less in agreement than one might have expected about the effects of monetary policy on the economy. Models developed by serious practitioners and intended for use in policy analysis differ widely in their assessments of the impact of changes in monetary policy. The implication for policymakers is that they should be humble about their understanding of the effects of policy and should undertake policy with a risk management approach, taking account of possible costs of outcomes in which monetary policy proves to work more or less rapidly than expected and has more or less power than anticipated.

The remainder of this paper is organized as follows: the next section provides a review of the literature on identifying the effects of monetary policy on the economy and comparing the effects of monetary policy across models, the third section describes in more detail the exercise we undertook and the models we used, the fourth section provides the results of the analysis, and the fifth section looks at the model attributes contributing to the differences in estimated policy effects across models. The final section offers some brief concluding remarks.

1. **Literature Review**

Starting point is Ramey (2016) and Taylor and Wieland (2012). (Different ways to estimate the effects of monetary policy, and comparisons of results across different models.) Other papers we wanted to cite are in the References.

1. **Empirical Approach**

In order to better understand how researchers have assessed the effects of monetary policy on the economy, we want to look at a broad range of structural macroeconomic models employed in the literature. However, doing so is difficult for a number of reasons. First, one would need to collect the models and ensure that they had consistent measures of output and inflation as well as the same policy rules. With a large set of such models, one could look at the effects of identical monetary policy shocks on interest rates, output gaps, and inflation across the models.

Happily, the Macroeconomic Model Data Base (MMB) has done much of this work.[[4]](#footnote-4) The database is an archive of models collected from papers published over the last 25 years or so. It contains the code for more than 150 structural macroeconomic models programmed in MatLab, and it provides a common front end that makes use of the models relatively easy. For example, the models employ the same variable names and the same timing conventions. As a consequence, it is relatively straightforward to run the same experiment on each of the models and collect the results. In our case, we provide one of a small set of monetary policy rules, and then look at the impulse-response functions from a 100 basis point shock to monetary policy.

One important issue is the selection of models to be used. Our aim is to select models that are intended to capture the dynamics of the US economy, and the MMB has a set 61 estimated models of the United States. (There are also estimated models of the Euro area economy, but we have left those aside.) The MMB also includes 43 “calibrated” models, which are presumably intended to capture the dynamics of large advanced economies. These are generally simpler models, closer in spirit to the New Keynesian benchmark, and so may not capture the dynamics of the US economy as well as the estimated models. Nonetheless, we included them in our model set, but will consider below whether they provide plausible results. The database also includes a small set of multi-country models that are a mix of calibrated and estimated. Eight of these are intended to capture open economy issues for the US economy. Finally, the MMB includes 11 calibrated or estimated models of the US economy with adaptive learning.

To conduct our analysis, we need to add to the models a monetary policy rule. To ensure that our results are not dependent on a specific rule, we used three different rules.[[5]](#footnote-5) First, the standard Taylor (1993) rule:[[6]](#footnote-6)

Where *i* is the nominal federal funds rate, is annual (four-quarter) inflation, and is the output gap.

Second, a version of the Taylor rule that allows for policy inertia:

And finally, a growth rule that is aimed at reducing dependence on real time estimates of the output gap:

We dropped some of the models from our analysis for a number of reasons. First, for some of the models there was more than one version included in the MMB. In some of those cases, we chose the version that seemed most likely to be useful for looking at monetary policy shocks. In other cases, the different version had very similar results, and so to avoid double counting, we chose one version to include. This was commonly the case, for example, with the models with adaptive learning, presumably because the type of learning in the model was not relevant to the experiment we were conducting. Finally, some of the model/rule pairs had no solution for the monetary policy simulation we were using, and so had to be dropped. In the end, we had 85 models in our dataset. In 83 cases, the models could be solved with all three policy rules, but in one case there were solutions for only two of the rules, and for one there was only one rule that resulted in a solution. See Appendix A for a list of the models and rules included in the analysis.

1. **Results**

The impulse-response functions for output, inflation, and the federal funds rate in response to a negative 100 bps shock to the federal funds rate are shown in Figures 1a-1c for the Taylor rule, the inertial Taylor rule, and the difference rule, respectively. It is immediately clear that there is a wide range of estimates. Looking across the rules, the Taylor (1993) rule has much the smallest effects, reflecting the very brief spike in the federal funds rate that results from the shock. The effects are generally larger for the inertial rule and the growth rule, consistent with the more long-lasting shocks to rates with those rules. Even for a given rule, there is a very wide range of effects of the same policy shock. Table 1 provides a set of descriptive statistics for the cumulative effects of the monetary policy shocks on output, inflation, and the real federal funds rate, summing over the 20 quarters after the policy shock.[[7]](#footnote-7) As expected from the figures, the mean and median effects differ widely across the three rules. In addition, for a given rule, the standard deviation of the cumulative effects is comparable in size to the mean effect, and the distribution is strongly skewed to the upside. The skewness is not that surprising, since almost all models get a positive sign of the effects on output and inflation, but in some cases, the effects are very large.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Table 1  **Descriptive statistics**  (selected variables) | | | | | |
| *variable* | *statistic* | Sample (policy rule) | | | |
| *All rules* | *Taylor* | *Inertial Taylor* | *Growth* |
| y\_cum20 | mean | 2.08 | 0.33 | 1.98 | 3.91 |
| pi\_cum20 | 0.87 | 0.09 | 0.76 | 1.75 |
| rrate\_cum20 | -1.59 | -0.74 | -2.32 | -1.70 |
| y\_cum20 | median | 1.25 | 0.19 | 1.65 | 2.54 |
| pi\_cum20 | 0.58 | 0.03 | 0.65 | 1.38 |
| rrate\_cum20 | -1.59 | -0.86 | -2.46 | -2.10 |
| y\_cum20 | standard deviation | 3.41 | 0.35 | 1.37 | 5.14 |
| pi\_cum20 | 1.28 | 0.32 | 0.90 | 1.61 |
| rrate\_sum20 | 1.33 | 0.57 | 0.73 | 1.78 |
| y\_cum20 | skewness | 7.07 | 1.22 | 1.23 | 5.11 |
| pi\_cum20 | 3.83 | 5.15 | 2.03 | 3.80 |
| rrate\_sum20 | 3.60 | 2.00 | 0.68 | 4.58 |
| Notes: only rrate\_cum20 under the ITR comes even close to passing the J-B test for normality, p=0.035. | | | | | |

Figures 2a and 2b and Table 2 show the results separated for the estimated and calibrated models. The smaller and simpler calibrated models show a much more rapid response, with the peak effect on output and inflation often coming in the quarter of the shock, even with the inertial and growth rules. By contrast, the peak effect in the estimated models generally comes only after a year or more. In addition, the cumulative size of the effects on output and inflation are much larger on average for the calibrated models, and the standard deviations are very wide. By contrast, the cumulative effects for the estimated models are smaller on average, and concentrated in a much narrower range

[How about tables showing the median, mean, sd, and skewness of y\_cum/r\_cum (slope of the IS curve), pi\_cum/y\_cum (sacrifice ratio), pi\_cum/r\_cum (effects of monetary policy on inflation), and timing of peak effect on y and pi (to get at lags); break those out by estimated/calibrated and within those two groups, by rule. That’s a bunch of big tables, but those all seem like interesting things to me. We could put highlights in the text and the rest in an appendix. Could also show histograms of the peak effect timing, which might be more informative.]

1. **Estimating the effects of model attributes**

Given the wide range of the size and timing of the effects of monetary policy across models that we find, it is natural to consider which model attributes contribute to the diverse results. To test for these contributions, we regress variables summarizing the effect of monetary policy on the economy (e.g., the ratio of the cumulative effect on output to the cumulative effect on the real interest rate, the timing of the peak effect on output, etc.) on each of set of model attributes. The model attributes we examined can be divided into three sets.[[8]](#footnote-8)

Attributes related to the monetary policy transmission mechanism:

* 1. Whether the model is open or closed economy
  2. Whether the model has net worth effects
  3. Whether the model has bank lending effects
  4. Whether the model has other transmission mechanisms of monetary policy

Attributes related to the handling of nominal stickiness:

1. Use of Calvo pricing
2. Use of Rotemberg pricing
3. Wage stickiness
4. Indexation

Attributes related to the design and estimation of the model:

1. Vintage of the model (as measured by the date of publication or the time period used in estimation)
2. The size of the model
3. The extent of fiscal block
4. The fraction of the authors affiliated with a central bank

Tables 3.1 to 3.3 show the results of regressing each of our summary variables (the ratios of the cumulative effect on output to the cumulative effect on the real interest rate, the cumulative effect on output to the cumulative effect on inflation, the cumulative effect on inflation to the cumulative effect on output, and the time period of the largest effects on output and inflation) on each of the model attributes, one at a time. In addition to the results for all model results, the table includes separate regressions for estimated and calibrated models, as well as separate regressions for each of the three policy rules.

[We may want to do regressions with more than one attribute variable at the same time, depending on how this looks.]

[And we may do better using Connor’s coefficient plots rather than showing the regressions. There will be a zillion regressions here, and we will want to present them in a way that is digestible.]

1. **Concluding remarks**
2. A surprising amount of uncertainty about the power of monetary policy
3. But for estimated models that have fairly detailed monetary policy transmission mechanisms, the results are broadly similar and suggest that…

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**Appendix A**

List of models used in this study

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| MMB name | Source | Used with which rules? | | | Comments |
|  |  | Taylor ‘93 | Inertial Taylor | Growth |  |
| NK\_AFL15 | Angeloni et al. (2015): Monetary policy and risk taking, *Journal of Economic Dynamics & Control* 52, pp. 285-307 | x | x | x |  |
| US\_CCF12 | Chen et al. (2012): The Macroeconomic Effects of Large-scale Asset Purchase Programmes, *The Economics Journal* 122(November), pp. F289-F315 |  | x | x |  |
| Etc. |  |  |  |  |  |

**Appendix B**

Descriptive statistics for the model attribute variables

**Appendix C**

Cloud graphs for the model rules.

1. Given the uncertainty surrounding assessments of the effects of policy, decisionmakers may want to aim for a “robust” monetary policy reaction function. That is, monetary policy that yields relatively good results for a range of estimates of the timing and size of the effects of monetary policy. See Taylor and Weiland, 2012 for a discussion. While that is a useful approach, better information on the effects of policy on the economy should still allow policymakers to do a better job of fostering their objectives. [↑](#footnote-ref-1)
2. We draw the model code from the Macroeconomic Model Data Base (MMB) curated by Volker Wieland and his colleagues at the Institute for Monetary and Financial Stability at Goethe University Frankfurt. Link: https://www.macromodelbase.com/ [↑](#footnote-ref-2)
3. Refer to Orphanides and Williams (2002) for a discussion of the possible benefits of a difference-style rule. [↑](#footnote-ref-3)
4. See Wieland et al (2012) and Wieland et al (2016) for more information. The MMB is available at <https://www.macromodelbase.com/>. [↑](#footnote-ref-4)
5. We also calculated impulse-response functions based on the rules included in the models for those models (about xxx percent) that included a rule. None of the qualitative results noted in this paper change significantly when the model-specific rules are used. However, since comparisons across models using different rules is potentially deceptive, we leave those results aside. See Appendix C for more information on these simulations [cloud chart for the “model” rules]. [↑](#footnote-ref-5)
6. The rules are written in terms of deviations from steady state values. [↑](#footnote-ref-6)
7. The results are not qualitatively different if you use 40 or 60 quarters. [↑](#footnote-ref-7)
8. Tables showing descriptive statistics for each of these attribute variables are included in Appendix B. [↑](#footnote-ref-8)