Fiscal Stimulus and the Systematic Response of Monetary Policy

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The response of monetary policy is one of the key determinants of the aggregate effects of fiscal stimulus. While an aggressive monetary reaction may largely moderate the expansionary effects of fiscal purchases, monetary accommodation—for example because nominal interest rates are already constrained by an effective lower bound—could lead to strong amplification (Farhi and Werning, 2016). Empirical evidence on the transmission of fiscal policy implicitly provides treatment effects that average across in-sample monetary policy reactions to the identified fiscal experiments. What should researchers do if they are interested in a different monetary policy reaction than the one that happened to be observed in their sample?

In this short note I leverage the results of McKay and Wolf (2022) to propose a simple empirical strategy that allows researchers to predict the effects of fiscal stimulus under arbitrary monetary policy reaction, in a way that is robust to the Lucas critique.

I. Identification result

I begin with the theory underlying the proposed empirical strategy. While the discussion builds very closely on McKay and Wolf (2022), I have adapted both the general model description as well as the numerical illustration to the task at hand—fiscal policy shock counterfactuals for different monetary policy reaction functions.

A. Environment

I begin by sketching a general family of structural models. For any data-generating process in this family, the empirical method used in the remainder of the paper will correctly recover the desired policy counterfactual. For expositional ease the model will be presented in perfect-foresight sequence-space notation; I emphasize that, due to certainty equivalence, all results stated below will apply without change to models with aggregate risk solved using first-order perturbation techniques.

The first "block" of the model is the private sector:

$$\mathcal{H}_x \boldsymbol{x} + \mathcal{H}_g \boldsymbol{g} + \mathcal{H}_m \boldsymbol{m} = \boldsymbol{0} \tag{1}$$

where: boldface denotes time paths, e.g. $\boldsymbol{x} = (x_0, x_1, \dots)'$; x collects endogenous (private-sector) variables; g and m are vectors of fiscal and monetary policy instruments, respectively; and the conformable linear maps $\mathcal{H}_\bullet$ contain the private-sector behavioral relationships. In Appendix A I show how to write the private-sector relations of a simple textbook New Keynesian model in the general form (1).

The second block are the policy rules—rules that specify how the policy instruments g and m are set as a function of endogenous macroeconomic outcomes x as well as the exogenous policy shocks ν_g and ν_m, respectively. The fiscal rule is

$$\mathcal{A}_x \boldsymbol{x} + \mathcal{A}_g \boldsymbol{g} + \mathcal{A}_m \boldsymbol{m} + \boldsymbol{\nu}_g = \boldsymbol{0} \tag{2a}$$

while the monetary rule is

$$\mathcal{B}_x \boldsymbol{x} + \mathcal{B}_g \boldsymbol{g} + \mathcal{B}_m \boldsymbol{m} + \boldsymbol{\nu}_m = \boldsymbol{0} \tag{2b}$$

I emphasize that entries of the two policy shock vectors $\boldsymbol{\nu}_g$ and $\boldsymbol{\nu}_m$ for $t > 0$ should be interpreted as news shocks—i.e., deviations from the policy rule announced at date 0 but implemented at $t > 0$.

Given bounded sequences of shocks $(\boldsymbol{\nu}_g, \boldsymbol{\nu}_m)$, an equilibrium is a set of bounded sequences $(\boldsymbol{x}, \boldsymbol{g}, \boldsymbol{m})$ that solves (1) - (2b). I assume that such an equilibrium exists

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and is unique, and I write the solution as $(\boldsymbol{x}(\boldsymbol{\nu}_g, \boldsymbol{\nu}_m), \boldsymbol{g}(\boldsymbol{\nu}_g, \boldsymbol{\nu}_m), \boldsymbol{m}(\boldsymbol{\nu}_g, \boldsymbol{\nu}_m))$.

I am interested in the propagation of a given fiscal policy shock $\boldsymbol{\nu}_g$ under alternative monetary policy rules. In a slight abuse of notation, I write the impulse responses to the shock $\boldsymbol{\nu}_g$ (which assume that the monetary rule is followed perfectly, i.e. $\boldsymbol{\nu}_m = \mathbf{0}$) as $(\boldsymbol{x}(\boldsymbol{\nu}_g), \boldsymbol{g}(\boldsymbol{\nu}_g), \boldsymbol{m}(\boldsymbol{\nu}_g))$. My object of interest are the analogous impulse responses if the monetary rule (2b) was replaced by the counterfactual rule

$$\tilde{\mathcal{B}}_x \boldsymbol{x} + \tilde{\mathcal{B}}_g \boldsymbol{g} + \tilde{\mathcal{B}}_m \boldsymbol{m} = \mathbf{0} \tag{2b'}$$

I write them as $(\tilde{\boldsymbol{x}}(\boldsymbol{\nu}_g), \tilde{\boldsymbol{g}}(\boldsymbol{\nu}_g), \tilde{\boldsymbol{m}}(\boldsymbol{\nu}_g))$.

The general model environment (1) - (2b) has two important properties. First, it is linear. Second, the policy rules (2a) and (2b) are allowed to shape private-sector behavior (1) *only* through current and (expected) future realizations of the policy instruments g and m. These properties, while restrictive, are consistent with the vast majority of structural macroeconomic models used for counterfactual policy analysis, including for example the classical RBC model, quantitative New Keynesian DSGE environments, or even models with rich microeconomic heterogeneity (like HANK). Such models are routinely linearized, and they all share the feature that policy affects private-sector behavior only through the policy instrument itself.

B. *From policy shocks to rule counterfactuals*

I now develop the identification result at the heart of the proposed empirical method. The key takeaway will be that the causal effects of monetary policy *shocks* $\boldsymbol{\nu}_m$ actually suffice to predict the counterfactual propagation of the fiscal experiment $\boldsymbol{\nu}_g$ under arbitrary alternative monetary *rules.*

The solution of the model (1) - (2b) gives a mapping from the shocks $(\boldsymbol{\nu}_g, \boldsymbol{\nu}_m)$ into $(\boldsymbol{x}, \boldsymbol{g}, \boldsymbol{m})$. I write this mapping as

$$\begin{pmatrix} \boldsymbol{x} \\ \boldsymbol{g} \\ \boldsymbol{m} \end{pmatrix} = \begin{pmatrix} \Theta_{x,g} & \Theta_{x,m} \\ \Theta_{g,g} & \Theta_{g,m} \\ \Theta_{m,g} & \Theta_{m,m} \end{pmatrix} \times \begin{pmatrix} \boldsymbol{\nu}_g \\ \boldsymbol{\nu}_m \end{pmatrix} \tag{2}$$

The matrices $\Theta_{\bullet}$ collect impulse responses to the two vectors of policy shocks. Note that the first column of each such matrix gives responses to contemporaneous shocks, while higher-order columns collect the impulse responses to news shocks.

Result 1—which follows directly from McKay and Wolf (2022)—shows how an econometrician living in the economy described by (1) - (2b) could predict the counterfactual shock impulse responses $(\tilde{\boldsymbol{x}}(\boldsymbol{\nu}_g), \tilde{\boldsymbol{g}}(\boldsymbol{\nu}_g), \tilde{\boldsymbol{m}}(\boldsymbol{\nu}_g))$. The key takeaway is that she does not need to know all the structural equations of the model; rather, impulse responses to monetary policy shocks $\boldsymbol{\nu}_m$ suffice to map the baseline fiscal shock impulse responses $(\boldsymbol{x}(\boldsymbol{\nu}_g), \boldsymbol{g}(\boldsymbol{\nu}_g), \boldsymbol{m}(\boldsymbol{\nu}_g))$ into the desired counterfactual of interest.

RESULT 1: *The counterfactual responses $(\tilde{\boldsymbol{x}}(\boldsymbol{\nu}_g), \tilde{\boldsymbol{g}}(\boldsymbol{\nu}_g), \tilde{\boldsymbol{m}}(\boldsymbol{\nu}_g))$ under the alternative monetary policy rule (2b') are equal to $(\boldsymbol{x}(\boldsymbol{\nu}_g, \tilde{\boldsymbol{\nu}}_m), \boldsymbol{g}(\boldsymbol{\nu}_g, \tilde{\boldsymbol{\nu}}_m), \boldsymbol{m}(\boldsymbol{\nu}_g, \tilde{\boldsymbol{\nu}}_m))$, where the auxiliary monetary policy shock sequence $\tilde{\boldsymbol{\nu}}_m$ is the unique solution of the system*

$$\tilde{\mathcal{B}}_x \left[\boldsymbol{x}(\boldsymbol{\nu}_g) + \Theta_{x,m} \times \tilde{\boldsymbol{\nu}}_m\right] + \tilde{\mathcal{B}}_g \left[\boldsymbol{g}(\boldsymbol{\nu}_g) + \Theta_{g,m} \times \tilde{\boldsymbol{\nu}}_m\right] + \tilde{\mathcal{B}}_m \left[\boldsymbol{m}(\boldsymbol{\nu}_g) + \Theta_{m,m} \times \tilde{\boldsymbol{\nu}}_m\right] = \mathbf{0}$$

The basic idea underlying Result 1 is straightforward. The fiscal shock impulse responses $(\boldsymbol{x}(\boldsymbol{\nu}_g), \boldsymbol{g}(\boldsymbol{\nu}_g), \boldsymbol{m}(\boldsymbol{\nu}_g))$ implicitly embed the baseline monetary policy rule (2b). If the econometrician knows the monetary policy shock causal effect matrices $\Theta_{\bullet,m}$, then she can construct an artificial sequence of monetary shocks $\tilde{\boldsymbol{\nu}}_m$ such that, in response to both $\boldsymbol{\nu}_g$ *and* $\tilde{\boldsymbol{\nu}}_m$, the desired counterfactual rule (2b') holds instead, both at date-0 and (in expectation) for all future dates. But then, since only the value of the policy instrument matters for private-sector behavior (by (1)), it follows that all equilibrium outcomes are exactly as if the model had been closed with the counterfactual rule (2b') in the first place.

C. *Illustration*

To further illustrate the logic of Result 1 I in this section briefly consider a particular numerical example. I also use the example to connect the above identification result

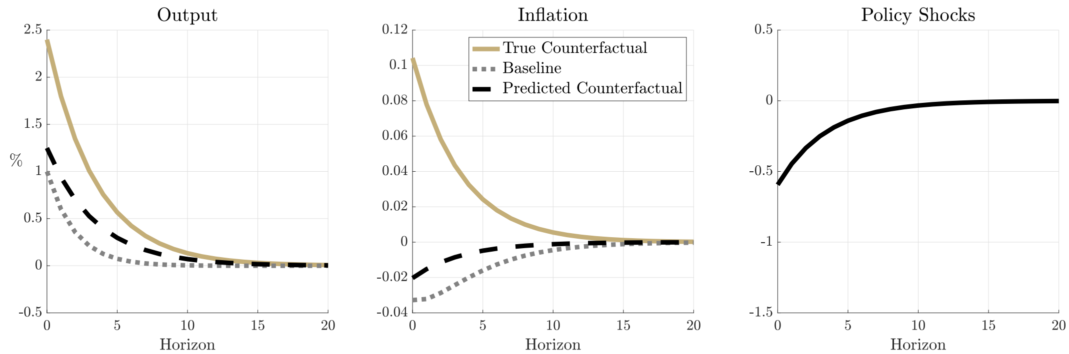

Figure 1. : Enforcing the counterfactual with one policy shock

Note: Fiscal policy shocks under the baseline monetary rule (dotted) and monetary accommodation (solid) in a standard New Keynesian model. The dashed lines show the counterfactual if the new rule is enforced with a sequence of realizations of a single policy shock, following Sims and Zha (1995). Implementation details for that method as well as further information on model and parameterization are presented in Appendix A.

with the well-known econometric strategy of Sims and Zha (1995). I provide further details on the underlying model and its parameterization in Appendix A.

The left and middle panels of Figure 1 show output and inflation impulse responses to an expansionary government spending shock in a textbook New Keyenesian model. The dotted lines correspond to impulse responses under the "baseline" monetary policy rule (a standard Taylor-type rule), while the solid lines give impulse responses under a counterfactual alternative: monetary accommodation, with the nominal rate not responding at all. As is well-known, the absence of a monetary reaction further amplifies fiscal stimulus—inflation increases, thus lowering real rates and further increasing consumer spending. In the right panel, I consider an econometrician who knows the causal effects of a one-off monetary policy shock, and uses a sequence of such shocks—displayed as the solid line on the right—to ensure that nominal interest rates do not move, consistent with the contemplated monetary policy counterfactual. This is the empirical strategy originally proposed by Sims and Zha (1995). The dashed lines give the impulse responses of output and inflation to the original fiscal policy shock *plus* this sequence of artificial monetary shocks. Importantly, we see that those dashed lines are *not* equal to the solid lines. The reason is simple: in the true counterfactual, the private sector *knows* at date $t = 0$ that nominal rates will remain constant forever; in the dashed approximation, on the other hand, the fact that rates do not move is a surprise, requiring a new surprise monetary policy shock at $t = 1, 2, \ldots$.

In Figure 2 I go one step further and illustrate the logic of Result 1. Specifically, I consider an econometrician that knows the causal effects of the first $n = 8$ monetary policy shocks—that is, the first eight entries of $\boldsymbol{\nu}_m$. Unlike the first experiment, she can use these shocks to enforce the desired counterfactual monetary policy not just ex post, but also *in expectation* for the next $n - 1 = 7$ periods. Two changes emerge. First, the counterfactual is now largely enforced using date-0 shocks, with almost no further ex post surprises at dates $t = 1, 2, \ldots$ (right panel). Second, the constructed counterfactuals (dashed) are closer to the truth (left and middle panels). Result 1 is simply the limit of this: when the counterfactual monetary rule is enforced using *only* date-0 shocks (without any ex post surprises, which is what $\tilde{\boldsymbol{\nu}}_m$ in Result 1 achieves), then the constructed counterfactual will equal the truth.

II. Empirical method & application

I now leverage the theoretical identification result in Result 1 to propose an empirical strategy for predicting the effects of fis-

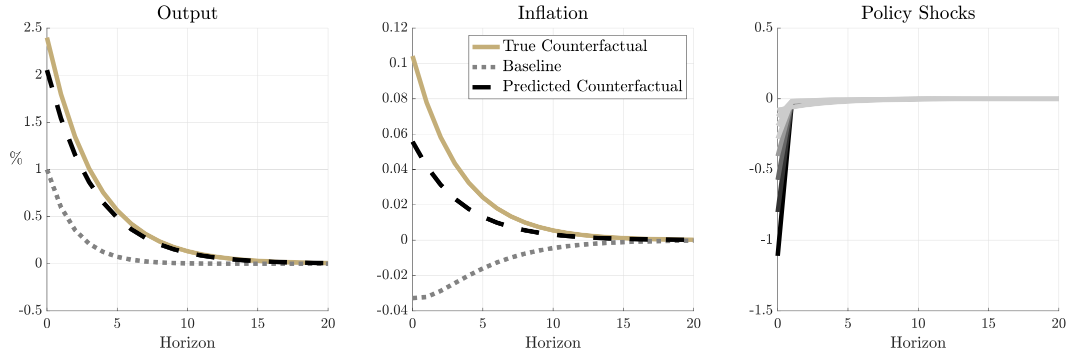

Figure 2. : Multiple Shocks: Match $n-1$-Period-Ahead Expectations

Note: See Figure 1. The counterfactual is now constructed using a generalization of the method of Sims and Zha that uses the first eight monetary policy shocks. Implementation details again in Appendix A.

cal stimulus under arbitrary monetary policy reaction. I first discuss the proposed method in the abstract, and then apply it to the well-known fiscal policy shock of Caldara and Kamps (2017). Supplementary details are provided in Appendix B.

A. *Using the identification result in practice*

Consider a researcher that wishes to predict the propagation of a fiscal policy shock under some hypothetical monetary policy reaction function—e.g., monetary accommodation, inflation targeting, or nominal GDP targeting. In light of the theoretical identification result in Result 1 she could proceed as follows.

1) Estimate the propagation of a fiscal policy shock using the standard macroeconometric toolkit. The estimated impulse responses will implicitly embed some averaged in-sample systematic monetary policy reaction. In keeping with the analysis in Section I I will denote these fiscal policy impulse responses by $(\boldsymbol{x}(\boldsymbol{\nu}_g), \boldsymbol{g}(\boldsymbol{\nu}_g), \boldsymbol{m}(\boldsymbol{\nu}_g))$.
2) Estimate the propagation of *multiple distinct* (say k) monetary policy shocks—e.g., transitory as well as more persistent changes in nominal rates. This can again be done using the conventional macroeconometric toolkit. Collect those impulse responses as the k columns of the causal effect matrices $(\Omega_{x,m}, \Omega_{g,m}, \Omega_{m,m})$. Then find the linear combination of k *date*-0 monetary policy shocks $\boldsymbol{v}_m$ that enforces the desired counterfactual monetary policy rule *as well as possible* in a standard least-squares sense; that is, solve

$$\min_{\boldsymbol{v}_m} ||\tilde{\mathcal{B}}_x \left[\boldsymbol{x}(\boldsymbol{\nu}_g) + \Omega_{x,m} \times \boldsymbol{v}_m\right] + \tilde{\mathcal{B}}_g \left[\boldsymbol{g}(\boldsymbol{\nu}_g) + \Omega_{g,m} \times \boldsymbol{v}_m\right] + \tilde{\mathcal{B}}_m \left[\boldsymbol{m}(\boldsymbol{\nu}_g) + \Omega_{m,m} \times \boldsymbol{v}_m\right] ||$$

Denote the solution by $\tilde{\boldsymbol{v}}_m$.
3) Compute the impulse responses to the combination of shocks $(\boldsymbol{\nu}_g, \tilde{\boldsymbol{v}}_m)$.

Relative to Result 1, the proposed empirical methodology involves an approximation. The informativeness of its output is thus inherently application-dependent: sometimes the desired counterfactual can be implemented with a high degree of accuracy given available evidence on monetary policy shocks, and sometimes not. If the approximation accuracy is good, however, then the proposed method is very powerful: it will provide counterfactuals that are robust to the Lucas critique for *any* structural model that could be written in the general form (1) - (2b).

B. *Application to U.S. fiscal policy shocks*

For my application I consider the fiscal policy shock identified by Caldara and Kamps (2017). The shock leads to meaningful real stimulus (see the dashed lines in the left and middle panels of Figure 3) and

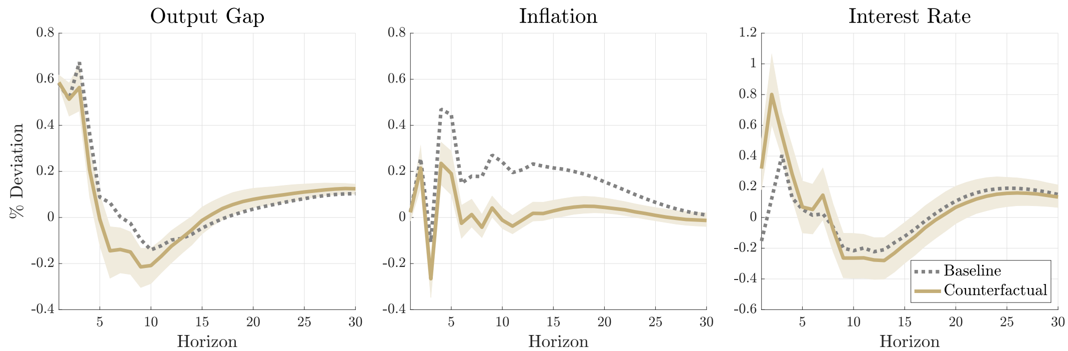

Figure 3. : Fiscal expansion under strict inflation targeting

Note: Impulse responses to the identified fiscal policy shock of Caldara and Kamps (2017) under (i) the actual monetary policy reaction (dotted) and (ii) a best Lucas critique-robust approximation to strict inflation targeting (solid). The shaded areas correspond to 16th and 84th percentile confidence bands. Implementation details are presented in Appendix B.

is largely accommodated by the monetary authority (right panel).

My object of interest is instead the counterfactual propagation of this fiscal shock under the reaction of a strict inflation targeting central bank—that is, a central bank that tries to keep inflation as close to target as possible. I construct this counterfactual through evidence on two identified monetary policy shocks: the transitory shock of Romer and Romer (2004) and the more persistent one of Gertler and Karadi (2015). The counterfactual results are displayed as the solid lines in Figure 3. Under strict inflation targeting, the central bank would have leaned much more against the fiscally induced expansion in demand, hiking rates aggressively and thus moderating inflation at the cost of somewhat lower output.

III. Concluding thoughts

In this short note I have argued that one of the more important limitations of empirical evidence on fiscal policy shocks—its dependence on whatever the in-sample monetary policy reaction happened to be—can in principle be sidestepped through empirical measurement. The more evidence on the propagation of monetary shocks is available, the larger the space of policy counterfactuals that can be constructed in this way, bringing us closer to the ideal of Result 1. It would thus be useful if future applied work tried to explicitly identify monetary policy innovations at different points on the yield curve (corresponding to different $\boldsymbol{\nu}_m$'s).

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