Cyclical Government Spending : Theory and Empirics

Jordan Roulleau-Pasdeloup
National University of Singapore

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Abstract

I provide a thorough analysis of the presence of a systematic response of government spending to the cycle in a simple New Keynesian model. I show that it has important implications for the transmission of various shocks. I then exploit the gap between OLS and 2SLS government spending multipliers that is typically reported in the literature on local multiplier effects to estimate how cyclical the systematic part of government spending is. I use a GMM method for estimation and show that it is quick, simple and fares better than usual alternatives. I estimate that when unemployment increases by 1%, the systematic component of government spending increases by 0.23%. Additional results suggests that government spending multipliers reported in the literature slightly overestimate the true impact multiplier and are larger than medium-run cumulative ones.

1 Introduction

One of the main lessons we can draw from the recent Great Recession is the following : stabilizing business cycle fluctuations cannot be left only to monetary policy. Instead, multiple calls have been made for using fiscal policy alongside monetary policy to achieve better outcomes. To be sure, fiscal policy in the form of variations in government spending has been used recently as monetary policy was impeded by the Zero Lower Bound, with varying degrees of effectiveness.[1]

In a recent contribution, Corsetti et al. (2017) argue that fiscal policy —government spending on goods and services in particular—should be more accommodative over the cycle and propose ways to implement this in the context of the Euro Area. This suggests that governments should follow some sort of feedback rule such that government spending becomes relatively loose in a recession. In other words, we can distinguish a discretionary component of government spending from its systematic one that varies over the cycle. Such a distinction is well understood in the case of monetary policy and usually takes the form of a Taylor rule. In its standard form (Taylor (1993)), the nominal interest rate systematically reacts to variations in inflation and GDP deviations from a relevant benchmark, but discretionary shocks can also generate movements in the nominal interest rate. In the case of government spending however, this distinction has been much less studied.

In this paper, I first conduct a thorough analysis of systematic government spending and its implications. Using a standard New Keynesian model augmented with a feedback rule for government spending, I provide analytical results regarding its implications for (i) the impact effects of discount factor, monetary and government spending shocks and (ii) the possibility of an economy to end up in a sunspot- or fundamental-driven liquidity trap. These results point towards systematic government spending as an important feature shaping macroeconomic dynamics.

With this in mind, the natural question that arises is : how do we measure the cyclicality of government spending in the data? Many attempts have been made at estimating a feedback parameter for fiscal policy[2] —not just govern-

[1] While there is a recent and developing literature (See McKay & Reis (2016) and the references therein) on taxes and transfers as automatic stabilizers, I will focus on government spending on goods and services in this paper. This is both because of the data that I am going to use and the fact that many of the academic/policy debates centered around this particular item of fiscal policy.

[2] Lane (2003) studies the cyclicality of government spending while Fatás & Mihov (2010)

ment spending. The main empirical challenge that arises is that virtually any measure of the cycle on which the fiscal policy variable will be regressed is endogenous and needs to be instrumented. Assuming that the simple New Keynesian model is the true Data Generating Process, I review these efforts and find that they most likely yield biased estimates of the *true* feedback parameter. One therefore needs a better method to estimate the cyclicality of government spending. Accordingly, in the second part of the paper, I develop a GMM estimation procedure to reliably estimate this kind of parameter.

The GMM procedure takes advantage of a recent and burgeoning empirical literature on the government spending multiplier.[3] Because they work with panel data, the papers in this literature are able to find good instruments for government spending at the State level and can exploit variation in the cross-section. A consistent finding in this literature is that 2SLS estimates of government spending multipliers are (i) significantly higher than 1 and (ii) much higher than OLS estimates. There are usually two main reasons for such a gap to arise: either government spending as a whole is mis-measured and the instrument corrects for that, or government spending is counter-cyclical. I extend the open economy New Keynesian DSGE model developed in Nakamura & Steinsson (2014) to allow for (potentially mis-measured) total government spending to include a systematic component that reacts to the cycle. I then estimate the feedback parameter and the standard deviation of the measurement error to match the moments used to construct OLS and 2SLS estimates.

Focusing on Military expenses, I find that government spending is estimated to be significantly *counter-cyclical*.[4] Using my baseline specification, if unemployment increases by 1%, systematic/endogenous government spending increases by 0.23%. I also find that the low estimated OLS multiplier in the data is mostly due to measurement error, which is known to bias OLS estimates downward. Since the model matches the moments of the data very well, I proceed under the assumption that it is a relevant Data Generating Process to run counterfactual scenarios. I then study whether the empirical specification laid out in Nakamura & Steinsson (2014) recovers the true multiplier effect. I find that it does a good job in recovering the impact multiplier effect, but that it overestimates the long-run cumulative effect.

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study the cyclically-adjusted balance as a percent of potential output.

[3] Cohen et al. (2011), Nakamura & Steinsson (2014), Acconcia et al. (2014), Shoag (2016) and Chodorow-Reich (2017).

[4] Even though it is financed at the Federal level, politicians at the State level have some influence regarding the allocation of military expenses across States. If a particular State has a relatively high unemployment rate, military spending can be used as a stimulus measure at the State level.

I study the robustness of the estimation method by assuming different measures of the cycle in the feedback equation. The main advantage of using the GMM procedure developed here is that it is very fast : a few seconds only. I also estimate the model using Bayesian techniques as in An & Schorfheide (2007) and get qualitatively similar results, but this estimation procedure takes several hours to run.

This paper is related to a growing literature using identified moments along with fully specified general equilibrium models to learn about macroeconomic dynamics (see Nakamura & Steinsson (2017)). Aside from the literature on local multiplier effects previously cited, this paper is also related to a large literature on monetary/fiscal policy interactions. Several papers in this literature have developed setups in which government spending features both systematic[5] and discretionary components. In these setups, government spending usually reacts to variations of the structural balance to stabilize public debt (Leeper et al. (2010b),Leeper et al. (2010a), Leeper et al. (2015)). The presence of public debt as a state variable however precludes an analytical solution to study the role of the systematic component of government spending. Some papers do model government spending as a feedback depending on business cycle conditions (Schmidt (2016)) but they do not offer a thorough study of systematic government spending's implications. Following Benhabib et al. (2002), Schmidt (2016) studies how a suitable feedback rule for government spending can protect the economy against expectations-driven liquidity traps as in Mertens & Ravn (2014), but does not provide closed form results as I do here.

The paper is structured as follows. In section 2 I develop the open economy DSGE model that I will use for estimation. In section 3, I use a simple version of the model and provide analytical results regarding the role of systematic government spending. I report the estimation results in section 4 and provide robustness and sensitivity tests in section 5.

[5]A large literature has also studied setups in which government spending is optimally chosen, possibly alongside monetary policy. Such setups can be found in Woodford (2011), Werning (2011), Mankiw & Weinzierl (2011), Schmidt (2013), Nakata (2013), Bilbiie et al. (2014), and Nakata (2015) in the context of a closed economy, and Bhattarai & Egorov (2016) in the context of a small open economy. Bouakez et al. (2017) study both optimal government consumption and government investment. Most of these studies focus on the Zero Lower Bound and do not yield themselves to the estimation procedure that I will develop in this paper.

2 The Model

The model that I am going to use is based on Nakamura & Steinsson (2014). This is an open-economy New Keynesian model, in which special attention is devoted to fiscal policy. The model is set up in discrete time, with t corresponding to one year. I will lay out the main features of the model and relegate the first order conditions of the model in the Appendix. Upper case letters denote variables in level while lowercase letters denote log-deviations from their steady state level. Upper case letters without time subscript denote the steady state level of the variable.

2.1 Households

The economy is populated by a representative infinitely lived household that maximizes its expected lifetime utility subject to a sequence of budget constraints and to a no-Ponzi-game condition. Utility depends on consumption, C_t; hours worked, L_t. Preferences are assumed to be represented by the following lifetime utility function

$$\mathcal{U}_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \exp(\epsilon_t^d) \left[\frac{(C_t - \chi L_t^{1+\nu^{-1}}/(1+\nu^{-1}))^{1-\sigma^{-1}}}{1-\sigma^{-1}} \right],$$

where β is the household's subjective discount factor and is subject to shocks through ϵ_t^d. I follow Nakamura & Steinsson (2014) and assume that households have Greenwood et al. (1988)-type preferences. Since the model is set up to reproduce an estimated output multiplier of 1.44, this is needed as separable preferences imply an output multiplier that is lower than unity[6]. The consumption basket C_t is defined as

$$C_t = \left[\psi_h^{\frac{1}{\lambda}} (\overline{C}_{H,t})^{\frac{\lambda-1}{\lambda}} + \psi_f^{\frac{1}{\lambda}} (\overline{C}_{F,t})^{\frac{\lambda-1}{\lambda}} \right],$$

where $\overline{C}_{H,t}$ and $\overline{C}_{F,t}$ denote the consumption of composites of home and foreign produced goods. The parameter λ governs the elasticity of substitution between home and foreign goods, while ψ_h and ψ_f govern the household's

[6]See Monacelli & Perotti (2008) and Bilbiie (2011).

relative preference for both goods. The composites are in turn defined as

$$\overline{C}_{H,t} = \left[\int_0^1 C_{H,t}(j)^{\frac{\theta-1}{\theta}} dj\right]^{\frac{\theta}{\theta-1}} \quad \text{and} \quad \overline{C}_{F,t} = \left[\int_0^1 C_{F,t}(j)^{\frac{\theta-1}{\theta}} dj\right]^{\frac{\theta}{\theta-1}}$$

Finally, the households face the following budget constraint:

$$P_t C_t + \mathbb{E}_t[M_{t,t+1} B_{t+1}] \leq B_t + W_t L_t + T_t,$$

where P_t is the aggregate price level, B_t is the payoff of bonds in terms of home currency and $M_{t,t+1}$ is the state-contingent price of this bond. Housholds get wage income W_t and T_t denotes dividend income from ownership of the firms net of lump-sum taxes.

2.2 Firms

In both the home and foreign economy, there is a continuum of firms indexed by i. Firm i in the home economy specializes in the production $Y_{H,t}(i)$ of a differentiated good i. The production function is

$$Y_{H,t}(i) = \exp(\epsilon_t^a) L_t(i)^a,$$

where ϵ_t^a is a technology shock and $L_t(i)$ is the amount of labor demanded by firm i. The parameter a governs the productions function's returns to scale. Firms can randomly change the price they charge with probability $1 - \alpha$ as in Calvo (1983). The optimal price set by home firm at period t solves

$$\max_{P_{H,t}^o} \mathbb{E}_t \sum_{s=t}^{\infty} \alpha^s M_{t,t+s} \left[P_{H,t}^o Y_{H,t+j} - W_{t+s} L_{t+s}(i) \right].$$

Foreign firms face the same type of environment.

2.3 Monetary and Fiscal Policy

The Federal government conducts a common monetary policy for both the home and foreign region. The nominal interest rate is set according to the following Taylor rule:

$$r_t = \rho_R r_{t-1} + (1 - \rho_R) \left(\Phi_\pi \pi_t^{agg} + \Phi_y y_t^{agg} \right) + \epsilon_t^m,$$

where $\pi_t^{agg} = n\pi_{H,t} + (1-n)\pi_{F,t}$ is aggregate inflation expressed as log-deviations from its steady state level and n is the relative size of the home region. The same applies for aggregate output and ϵ_t^m is a monetary policy shock.

The Federal government also conducts fiscal policy. Total government spending in the home region is given by

$$G_{H,t} = G_{H,t}^{ex} + G_{H,t}^{end} \tag{1}$$
$$= \exp(\epsilon_t^g) + \mathcal{F}(L_{H,t}) + \exp(u_t^{ME}), \tag{2}$$

where ϵ_t^g is exogenous government spending and u_t^{ME} is a measurement error term. Endogenous spending in year t is a generic function of employment in year t in the home region. The same applies for the foreign region.

3 Preliminary Results

3.1 Analytical Results using a Special Case of the Model

To convey the intuition for the main results of the paper, it will be useful to study the closed economy limit of the model presented in section 2. Just for this section, I also assume standard separable preferences[7] as this will allow for simpler expressions. I will consider the log linear approximation of this model around the non stochastic steady state. The resulting model is then just the familiar three equations New Keynesian model, with two additional equations that details (i) the feedback rule for endogenous government spending and (ii) the law of motion for exogenous spending:

$$c_t = \mathbb{E}_t c_{t+1} - \sigma(R_t - \mathbb{E}_t \pi_{t+1} + log(\beta) - \epsilon_t^d) \tag{3}$$
$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa\{\zeta_c c_t + \zeta_g g_t\} \tag{4}$$
$$R_t = -\log(\beta) + \Phi_\pi \pi_t + \epsilon_t^m \tag{5}$$
$$g_t = \epsilon_t^g - \eta\{\bar{c} \cdot c_t + g_t\} + u_t^{ME} \tag{6}$$

where $\eta = -\frac{L\mathcal{L}'(L)}{\mathcal{F}(L)}$ is the elasticity of the feedback function with respect to aggregate output, $\bar{c} = C/Y$ is the steady state ratio of private consumption to total output and the ϵ_t^D (resp. ϵ_t^M and ϵ_t^G) shocks are demand (resp. monetary

[7]The utility function is $\mathcal{U}(C_t, L_t) = \frac{C_t^{1-\sigma^{-1}}}{1-\sigma^{-1}} - \chi \frac{L_t^{1-\nu^{-1}}}{1-\nu^{-1}}$.

and government spending) shocks. The term in brackets in equation (4) is the real marginal cost of the representative firm, while the term in brackets in equation (6) is the definition of total output. The constant parameters are related to deep parameters as follows

$$\begin{aligned}
\zeta &= \frac{1}{1+\psi_\nu\theta} \\
\psi_\nu &= \frac{1+\nu^{-1}}{a} - 1 \\
\zeta_c &= \zeta\{\sigma^{-1} + \psi_\nu \bar{c}\} \\
\zeta_g &= \zeta\psi_\nu,
\end{aligned}$$

To obtain simple analytical results, I follow Eggertsson (2010) and assume that (i) both the monetary and fiscal policy shocks have a two state Markov structure with transition probability p, (ii) the the state in which they are zero is an absorbing state and (iii) the economy starts off with a given vector $[\epsilon^d \epsilon^m \epsilon^g]$. Consider a positive realization of ϵ^m : for reasons unrelated to the current state of the business cycle, the Central Bank decides to raise its nominal interest rate. In each subsequent period, the monetary policy shocks stays at this level with probability p and goes back to its steady state level of 0 with probability $1-p$. As the latter is an absorbing state, once the shock gets there it stays there indefinitely. Assuming away government spending shocks for the moment, I obtain

$$\frac{\partial y_t}{\partial \epsilon^m} = -\frac{\bar{c}\sigma(1-\beta p)}{\mathcal{D}(\Phi_\pi, \eta)} \tag{7}$$

where $\mathcal{D}$ is defined as:

$$\mathcal{D}(\Phi_\pi, \eta) = (1-p)(1-\beta p)(1+\eta) + \kappa\sigma(\Phi_\pi - p)\{\zeta_c(1+\eta) - \bar{c}\eta\zeta_g\}.$$

Several results emerge from equation (7). First, unless η is such that $\mathcal{D}(\Phi_\pi, \eta) < 0$, an increase in interest rates will depress private consumption and thus total output. Second, the magnitude/sign of this effect depends on the systematic component of monetary policy Φ_π through $\mathcal{D}$. Third, the magnitude/sign of the monetary policy shock will also be affected by the presence of a systematic feedback mechanism from output to government spending. In the standard New Keynesian model, the higher Φ_π, the lower the magnitude of the effect. In this setup, the effect of varying Φ_π will depend on the precise value of η.

In addition, the effect of varying η is ambiguous. In the special case with infinitely elastic labor supply and constant returns to scale[8], we can get clear

[8] Assuming $a = 1$ and $\nu \to \infty$, I get $\zeta_g = 0$.

cut answers. Under these assumptions, $\zeta_g = 0$ and increasing both Φ_π and η will decrease the impact effect of the monetary policy shock. A higher Φ_π means that the real interest rate will increase by more after a contractionary monetary policy shock, depressing private consumption. A higher η means that the decrease in private consumption will be somewhat compensated by an increase in government spending as fiscal policy becomes more counter-cyclical.

Finally, when there is a large negative realization of ϵ_t^D, the resulting drop in consumption and inflation can force the Central Bank to lower the nominal interest rate all the way down to zero. In this case, both the Euler equation and New Keynesian Phillips Curve are sloping upward. For there to be a minimum state variable solution without sunspot equilibria, the slope of the Euler equation (with π_t expressed as a function of c_t) has to be *higher* than the one for the New Keynesian Phillips Curve. A sufficient condition is then

$$\mathcal{D}(0, \eta) > 0.$$

This condition shows that the presence of sunspot equilibria at the ZLB after a large negative demand shock depends very much on how pro/counter cyclical fiscal policy is. I show in the Appendix that given a more counter-cyclical fiscal policy, the model requires a more negative demand shock to reach the ZLB as the former makes the New Keynesian Phillips Curve flatter. It can also be shown that a more counter-cyclical fiscal policy will reduce the likelihood of sunspot equilibria once at the ZLB. Furthermore, the slope of the Phillips Curve is non-linear in the degree of cyclicality. While more counter-cyclicality will not matter much quantitatively, a highly pro-cyclical stance will most likely open the door to sunspots equilibria.

I know move to describe the implications of cyclical fiscal policy for the government spending multiplier. To isolate the contribution of endogenous government spending, I assume again constant returns to scale and infintely elastic labor supply. Assuming away shocks other than government spending, it can be shown that

$$\frac{\partial y_t}{\partial \epsilon_t^G} = \frac{1}{1+\eta}. \tag{8}$$

This is a knife-edge result in the sense that $\zeta_g = 0$ implies that the reaction of monetary policy does not have any influence on the effects of an increase in government spending. In particular, whether or not the economy is at the ZLB will not change the stimulative properties of fiscal policy. Nonetheless, this illustrates that the degree of pro/counter-cyclicality can generate a wide range of multiplier effects. A strong counter-cyclical policy (meaning a high value for η) will generate smaller multipliers.

The intuition for this result is based on the definition of total government spending—equation (6). Assume that $\eta > 0$, so that fiscal policy is counter-cyclical. An exogenous increase in government spending will raise output today, but since fiscal policy is counter-cyclical, higher output means a lower level of *endogenous* spending. It follows that the percent increase in total spending is less than the percent increase in exogenous spending. Since what matters for total output is the increase in total spending, counter-cyclical fiscal policy acts to dampen the effects of a fiscal stimulus. If $\eta < 0$ and fiscal policy is pro-cyclical, these mechanisms play in reverse to give an output multiplier that is potentially higher than one —provided that $\eta > -1$, so that fiscal policy is not overly pro-cyclical, in which case there is a singularity and the output multiplier goes from infinite to negative as η crosses the -1 threshold.

For all these reasons, we would like to know more about the actual cyclical behavior of fiscal policy. In the next subsection, I outline a strategy for estimating the feedback parameter using selected moments.

3.2 Intuition for the Estimation Strategy

Assume that the model given by equations (3)-(6) is our Data Generating Process (DGP). Given suitable values for the parameters (regrouped in the vector Θ) of the model, one can compute the policy rules that relate all endogenous variables to the path of exogenous government spending. In particular, for output we can write[9]

$$y_t = \bar{c} \cdot c_t + g_t \equiv \mathcal{M}(\Theta) \cdot \epsilon_t^G.$$

Note that since $y_t = l_t$ in this simple model, output and employment multipliers are the same. Since exogenous variation of government spending ultimately only comes from ϵ_t^G, the latter will be the model-equivalent to the predicted first stage of government spending in a standard 2SLS regression. Given our DGP, the 2SLS estimator of the government spending multiplier

[9]This can be written because this simple model has no endogenous variable. In a model wit private capital, this expression would be replaced with an $AR(1)$ representation for y_t.

will simply be

$$
\begin{aligned}
\beta^{2SLS} &= \frac{Cov(y_t, \epsilon_t^G)}{\mathbb{V}(\epsilon_t^g)} \\
&= \frac{Cov(\mathcal{M}(\Theta) \cdot \epsilon_t^G, \epsilon_t^G)}{\mathbb{V}(\epsilon_t^G)} \\
&= \mathcal{M}(\Theta) \frac{Cov(\epsilon_t^G, \epsilon_t^G)}{\mathbb{V}(\epsilon_t^G)} \\
&= \mathcal{M}(\Theta)
\end{aligned}
$$

So the 2SLS estimator recovers the true impact of government spending. Note that the true impact depends on the deep parameters of the model. As in the last subsection, the degree of pro/counter-cyclicality will influence the multiplier effect of government expenses. In contrast, I show in the Appendix that the OLS estimator is given by

$$
\begin{aligned}
\beta^{OLS} &= \frac{Cov(y_t, g_t)}{\mathbb{V}(g_t)} \\
&= \frac{\mathcal{M}(\Theta)(1 - \eta \mathcal{M}(\Theta))}{1 + \eta \mathcal{M}(\Theta)(\eta \mathcal{M}(\Theta) - 2) + \frac{\sigma_{ME}^2}{\tilde{\sigma}^2}}, \qquad (9)
\end{aligned}
$$

where $\tilde{\sigma}^2 = \sigma_G^2 / (1 - p^2)$. Notice that absent any feedback mechanism from output to government spending and measurement error, the OLS and 2SLS estimators coincide. Many empirical studies have shown that this is generally not the case, and (9) explains how these two features influence this mismatch. First, as is well known, the presence of measurement error will bias the OLS estimate towards zero. The influence of the feedback parameter η is more complicated.

First, if government spending automatically increases while the economy enters a recession, this will reduce the covariance between y_t and g_t. This is the usual explanation for why endogeneity of spending my bias OLS estimates downward. But there is another effect that goes through the variance of total government spending. Indeed, unless the parameters are such that $\eta \mathcal{M}(\Theta) > 2$, the presence of feedback will give a denominator $\mathbb{V}(g_t) < \mathbb{V}(\epsilon_t^G)$. This will have the exact opposite effect of measurement error and will bias the OLS estimator upward.

In the next section, I will set up a framework to estimate η and σ_{ME}^2. Before doing that, however, we can use the definition of total government spending to gain some insights about η. The main unknown is whether this parameter is positive or negative. Using equation (6), we get that

$$\eta = \frac{Cov(g_t^{ex}, y_t) - Cov(g_t, y_t)}{\mathbb{V}(y_t)} \tag{10}$$

Since, by definition $\mathbb{V}(y_t) > 0$, if one observes a higher correlation of output with exogenous government spending than endogenous, the estimation of η will give a positive coefficient. Since η is a ratio of covariances over variance, in any dataset these objects will come with sampling error. Therefore, given the sign obtained for η, whether it is significantly different from 0 or not will depend on the particular sample. Another way to see this is that η is just the difference of i) the slope coefficient β_{gx} in a linear regression of g_t^{ex} on y_t minus ii) the slope coefficient β_g in a linear regression of total spending g_t on y_t. Both estimates come with a standard error and so η will inherit this uncertainty. More specifically, assuming that errors in both regressions are normally distributed, then we have

$$\hat{\eta} \sim \mathcal{N}(\beta_{gx} - \beta_g, \sigma_{gx}^2 + \sigma_g^2)$$

which we can use to construct a confidence interval around $\hat{\eta}$. The problem with this is that regressors are correlated with errors in both regressions so that β_{gx} and β_g will most likely be inconsistent. In addition, this method does not exploit all the information contained about η since it does not require $\mathbb{V}(g_t)$. I set up an estimation method that overcomes these shortcomings in the next section.

Before moving along, it should be said that there were multiple attempts to estimate this kind of feedback parameters[10]. Most of these attempts usually run regressions like

$$\Delta g_t = \gamma_1 \Delta y_t + \gamma_2 C_t + v_t,$$

where $\Delta y_t = y_t - y_{t-1}$ and C_t is a set of control variables. The problem that arises is that y_t is clearly endogenous and needs to be instrumented for. In Fatás & Mihov (2010), they instrument Δy_t for the Euro Area with its lag and the current value of this object for the U.S. In Appendix B, I assume that the full, open-economy model is the true DGP and study whether these methods will recover the "true" value for η. I find that all these methods fare quite poorly in this task.

[10] See for example Lane (2003) andFatás & Mihov (2010)

4 General Method of Moments Estimation

To reliably estimate η and others important parameters jointly, I will use a Generalized Method of Moments (GMM) estimation. More specifically, I will choose moments from the dataset that I will try to match using the open economy DSGE model. The choice of these moments will be guided by the discussion of last section. The data that I will use for estimation is the one used in Nakamura & Steinsson (2014)—henceforth NS. They use annual data for GDP, employment and military spending at the state level. While military spending occurs at the state level, it is financed at the Federal level. Furthermore, while we can reasonably argue that the U.S does not embark on a military buildup because there is a recession, this is not necessary true at the state level. Indeed, political lobbying (see **?**) can influence how Federal military spending is allocated so that states that are experiencing relatively higher unemployment receive more. Because of this endogeneity concern, an instrument is needed for studying the impact of this item of government spending.

The main empirical specification in NS is

$$\Delta_2 Y_{s,t} = \alpha_s + \gamma_t + \beta \Delta_2 G_{s,t} + \epsilon_{s,t}, \quad \Delta_2 X_{s,t} \equiv \frac{X_{s,t} - X_{s,t-2}}{X_{s,t-2}} \tag{11}$$

where $Y_{s,t}$ (resp. $G_{s,t}$) is output or employment (resp. government spending) for state s at year t. Their specification allows for state and year fixed effects. For each variable X, let

$$\begin{aligned} \tilde{x}_{s,t} &= \Delta_2 X_{s,t} - \frac{1}{S}\sum_{s=0}^{S} \Delta_2 X_{s,t} \\ \check{x}_{s,t} &= \tilde{x}_{s,t} - \frac{1}{T}\sum_{t=0}^{T} \tilde{x}_{s,t} \end{aligned}$$

Now assume that we have a good exogenous instrument $\check{z}_{s,t}$ for $\check{g}_{s,t}$. Then it follows that we can compute both OLS and 2SLS estimators as

$$\hat{\beta}^{OLS} = \frac{Cov(\check{y}_{s,t}, \check{g}_{s,t})}{\mathbb{V}(\check{g}_{s,t})} \quad \text{and} \quad \hat{\beta}^{2SLS} = \frac{Cov(\check{y}_{s,t}, \check{z}_{s,t})}{\mathbb{V}(\check{z}_{s,t})}.$$

For the data used in Nakamura & Steinsson (2014), they find a 2SLS estimate of 1.44 (significant) and and OLS of 0.16 (non significant). This gap tells us that there is potentially some variation to estimate η, which can drive a wedge between these two estimators. Of course, this gap can also be explained by the fact that $\check{g}_{s,t}$ is mis-measured, while $\check{z}_{s,t}$ is not —in fact Nakamura & Steinsson

(2014) contend that this likely explains most of the gap. Instead of trying to match directly the OLS and 2SLS estimates, I will set up to match separately the variances and covariances that are used to construct the estimates. This is actually a weaker assumption as it is easier to match the ratio of covariances to variances than themselves separately. Since the variables have been demeaned both across year and states to account for fixed effects, they have a mean of roughly zero. It is then straightforward to compute the covariances and variances as mean of products.

Let m_k, $k \in \{1, \dots, S \cdot T\}$ be the vector of moments that I set up to match. The GMM estimator $\hat{\Theta}^{SMM}$ solves

$$\min_{\Theta} G(\Theta) W G(\Theta)', \tag{12}$$

where W is the variance-covariance matrix of the empirical moments and

$$G(\Theta) = \frac{1}{ST} \sum_{k=1}^{ST} m_k - \mathbb{E}(m(\Theta)),$$

where $m(\Theta)$ is the vector of moments[11] computed from the DSGE model and m_k is defined as

$$m_k = \left[\check{y}_k \cdot \check{g}_k, \;\; \check{y}_k \cdot \check{z}_k, \;\; \check{g}_k^2, \;\; \check{l}_k \cdot \check{g}_k, \;\; \check{l}_k \cdot \check{z}_k \right]',$$

where $\check{l}_k$ is state employment at year t that has been demeaned to account for fixed effects. Using the data in NS, I also find a substantial gap between OLS and 2SLS estimators of multiplier effects on employment and so I use these additional moments in the estimation.

Now I need to construct the theoretical moments that will be matched to the empirical ones just described. Let all endogenous variables (resp. stochastic shocks) of the model be regrouped in the vector s_t (resp. u_t). Remembering that all the parameters are collected in the vector Θ, a rational equilibrium solution of the open economy DSGE model is given by:

$$s_t = \Psi_s(\Theta) s_{t-1} + \Psi_u(\Theta) u_t. \tag{13}$$

There are several methods available to compute this kind of solution. Here, I use the Sims (2001) method. Once we have this solution, we can compute the

[11] To match their empirical counterpart, for each variable we take the two year growth rate of the home economy minus the same variable for the foreign economy.

variance covariance matrix $\Gamma(\Theta)$ of s_t as follows:

$$\mathbb{E}(s_t \cdot s_t) \equiv \Gamma(\Theta) \tag{14}$$
$$= \Psi_s(\Theta)\Gamma(\Theta)\Psi_s(\Theta)' + \Psi_u(\Theta)\Sigma\Psi_u(\Theta)', \tag{15}$$

where Σ is the variance covariance matrix of the stochastic shocks. It follows that $\Gamma(\Theta)$ is the solution to a classic Lyapunov equation, for which numerical routines are readily available in Matlab. I then use $\Gamma(\Theta)$ to construct the theoretical counterparts of the empirical moments as

$$\mathbb{E}(m(\Theta)) = \left[\Gamma_{yg}(\Theta), \Gamma_{y\epsilon^G}(\Theta), \Gamma_{gg}(\Theta), \Gamma_{lg}(\Theta), \Gamma_{l\epsilon^G}(\Theta)\right]',$$

where, for instance, $\Gamma_{yg}(\Theta)$ denotes the covariance of output and total government spending. In their paper, NS set up the DSGE model at quarterly frequency, simulate it and aggregate at annual frequency. I could potentially follow this route and estimate Θ using a Simulated Method of Moments instead. This requires solving the model several times and can be needlessly time consuming. Therefore, I choose to set up the model directly at annual frequency so that I can compute the moments of the model without the simulation step. It should also be said that the simulation step will include an additional term in the variance covariance matrix of the estimated Θ, resulting in mechanically less precise estimates —see Ruge-Murcia (2007) for a detailed exposition.

Under the regularity conditions spelled out in Hansen (1982), we have

$$\sqrt{ST}(\hat{\beta}^{GMM} - \beta) \rightarrow \mathcal{N}\left(0, \left(D'W^{-1}D\right)^{-1}\right),$$

where $D = \partial\mathbb{E}(m(\Theta))/\partial\Theta$ is a $q \times p$, full-rank matrix, p is the number of estimated parameters and q the number of moments to be matched. This matrix is very useful insofar as it tells us which parameters actually shape the theoretical moments and in which manner they do it. For example, if the second column of D is composed only of zeros, it means that the second parameter in Θ does not contribute at all to the theoretical moments and is not identifiable. This will show up as very large diagonal elements in $(D'W^{-1}D)^{-1}$. This provides some guidance as to which parameters can be estimated or not and even the moments that can be matched.

To illustrate this, notice that I do not attempt to match the variance of exogenous government spending $\mathbb{V}(\check{z}_{s,t})$. Given a generic $AR(1)$ process with persistence ρ_g for its theoretical counterpart, the variance of exogenous spending can be computed as

$$\mathbb{V}(\epsilon^G) = \tilde{\sigma}^2 = \sigma_G^2/(1-\rho_g^2). \tag{16}$$

By inspecting matrix D, I find that both σ_G and ρ_g are not identified. I then proceed as follows : first I use the NS data to regress exogenous spending on its lag, including state and year fixed effects. That gives me an estimate of $\hat{\rho}_g = 0.72$. Given this estimate, I use equation (16) to calibrate σ_G so that empirical and theoretical variances are exactly equal. Following these guidelines, I estimate (1) the feedback parameter η (2) the standard deviation of the measurement error σ_{ME} and (3) the degree of returns to scale a.

The other parameters are calibrated and reported in Table 1. Except for the Calvo (1983) probability, most of the parameters are borrowed from Nakamura & Steinsson (2014) and converted to annual frequency. This follows from the findings in Del-Negro et al. (2014), who show that very sticky prices are needed to explain the importance of demand shocks. Since I am trying to match a demand shock here, I convert their estimated Calvo (1983) probability to an annual frequency. I nevertheless also estimate the model under the assumption that the annual Calvo (1983) probability takes a conventional value in the robustness section and get very similar results. For the specification of the technology shock, I follow Petrosky-Nadeau & Zhang (2013). I report the results of the estimation in Table 2.

Table 1: Calibration

Parameter	Symbol	Value
Gov Spending % of total output	G/Y	0.2
Discount factor	β	0.96
Calvo probability	α	0.84
Risk aversion	σ	1
Elast. of subst. between goods	ϵ	7
Elast. of subst. between H/F goods	λ	2
Taylor rule : Response to inflation	ϕ_π	1.5
Taylor rule : Response to output	ϕ_y	0.5
Taylor rule : persistence	ρ_R	0.8
Size of home country	n	0.1
Weight of home goods	ψ_h	0.69
Gov. spending : persistence	ρ_g	0.72
Gov. spending : st. dev	σ_g	$\sqrt{.079/2}$
Technology : persistence	ρ_a	0.98
Technology : st. dev	σ_a	0.05

Table 2: Estimation Results

Moments	Data	Model
$Cov(y, g)$	0.09	0.072
$Cov(y, \epsilon^G)$	0.11	0.112
$Var(g)$	0.67	0.672
$Cov(l, g)$	0.04	0.057
$Cov(l, \epsilon^G)$	0.09	0.089
Parameters	Estimate	P-value
η	0.23	0.099
σ_{ME}	0.8	0.000
a	0.89	0.000
	Stat	P-value
Hansen (1982) J-test	0.25	0.88

For a simple model, it does a reasonably good job at matching the target moments. This is further corroborated by the Hansen (1982) J-test results. Specifically, the null that the model is correctly specified cannot be rejected at a conventional level.

The estimate for η reveals that the endogenous part of government spending is *counter-cyclical* : when employment decreases by 1%, it increases by 0.39%. Looking at the impact of varying η using the model, I find that increasing it from 0 to its estimated value *decreases* the variance of total government spending. Therefore, the estimation procedure calls for a positive measurement error in order to replicate the relatively high variance of total government spending.

Now that I have estimates for both the feedback parameter and the standard deviation of the measurement error, I can dissect the measured IV estimate in Nakamura & Steinsson (2014). As the model matches very well $Cov(y, \epsilon^G)$ and matches $Var(\epsilon^g)$ exactly, it yields an 2SLS estimate for the spending multiplier of 1.42 which falls just short of the 1.44 estimated using NS data. Assuming away both feedback and measurement error, both OLS and 2SLS estimates are identical and are equal to 2.21. In line with equation (8), getting rid of counter-cyclical fiscal policy generates a higher multiplier effect.

As counter-cyclical fiscal policy decreases the variance of total government spending, if the latter was perfectly measured ($\sigma_{ME} = 0$), then the OLS estimate would actually be biased *upwards* because of its lower denominator. In this specific case, the OLS estimator would be 2.207, which is much higher than the 2SLS one. It follows that measurement error is the main reason why NS report an OLS estimate close to zero in their paper.

Now that I have a Data Generating Process that can reproduce both employment OLS and 2SLS multipliers, I can ask the following question : how do they relate to the *true* multipliers? Given that the multipliers are estimated by regressing the two year percent change of output on the one of exogenous spending, it is not a given that this will yield the true multiplier effect. What I find is that it slightly over-estimates the true impact multiplier, which is 1.39. However, since government spending is usually not a one-off increase and has persistent effects on output, a better measure of the multiplier could be the ratio of cumulative changes. indeed, many researchers (among which Uhlig (2010) and Ramey & Zubairy (2014)) argue that this is the metric that we should care about when gauging the effects of a fiscal stimulus. NS even cite this as a reason to consider the two year percent change in their empirical specification as it would capture the dynamic effects of government spending. To see whether this is the case, I plot in Figure 1 the cumulative change in output after an increase in government spending

$$\mathcal{M}_h = \frac{\sum_{s=1}^{h} y_{H,t+s}}{\sum_{s=1}^{h} \epsilon^{g}_{H,t+s}} \tag{17}$$

for the horizon $h = 1, \ldots, 20$. To highlight the role of cyclical policy, I take explicitly into account the fact that the estimate of η comes with inherent uncertainty to construct 90% confidence intervals around the cumulative multipliers. One can see from Figure 1 that, notwithstanding uncertainty about η the impact multiplier is generally higher than 1. For larger horizons, the cumulative multiplier effect reaches a plateau slightly below 1. At the end of the day, the empirical specification in Nakamura & Steinsson (2014) seems to mostly recover the short-run effect of increases in government spending and over-estimates the long run impact of a government spending stimulus.

I have shown in the introduction that the effects of a monetary policy shock depend on how cyclical fiscal policy is. In particular, the simple model of section 3 gave the following prediction : the more counter cyclical fiscal policy, the lower the magnitude impact of a monetary policy shock. I now consider the effects of a one time realization of the monetary policy shock. It is assumed to be *i.i.d* and lasts only for one period. I produce a scatter plot of the impact effect of a contractionary monetary policy shock as a function of the feedback parameter in Figure 2.

Figure 1: Cumulative GDP Multiplier

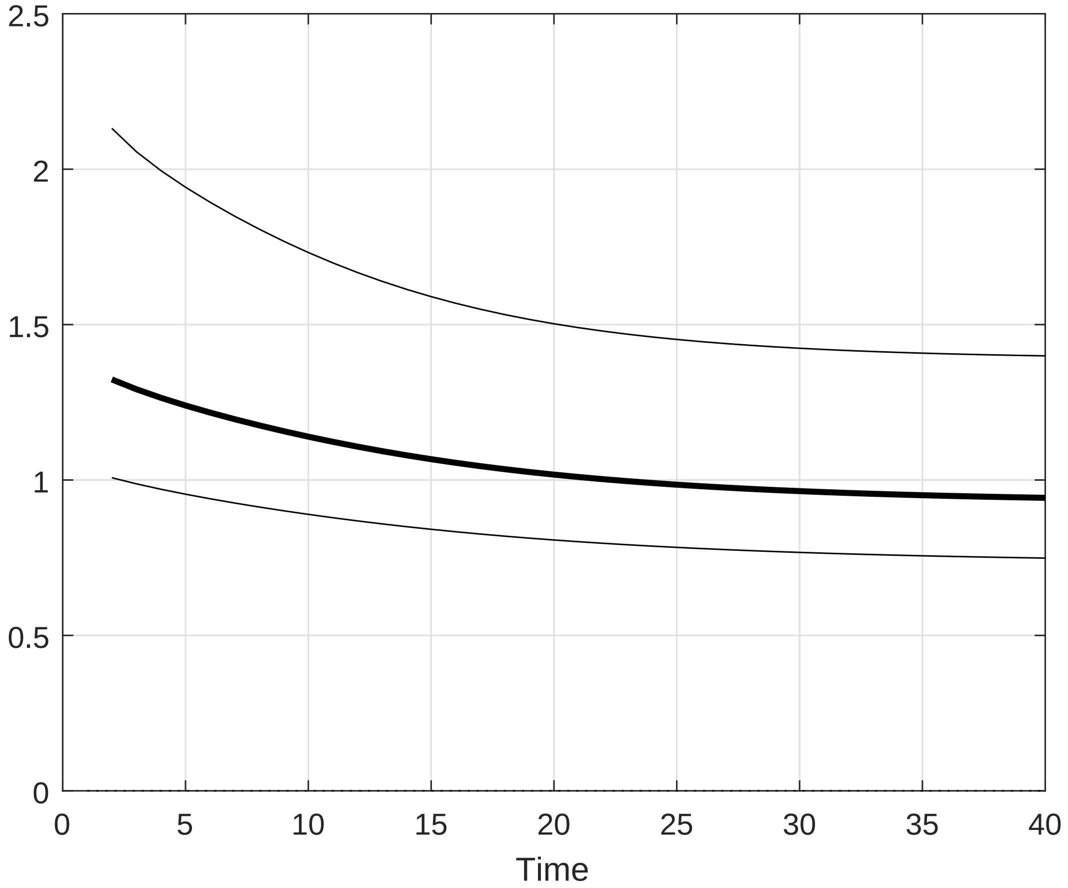
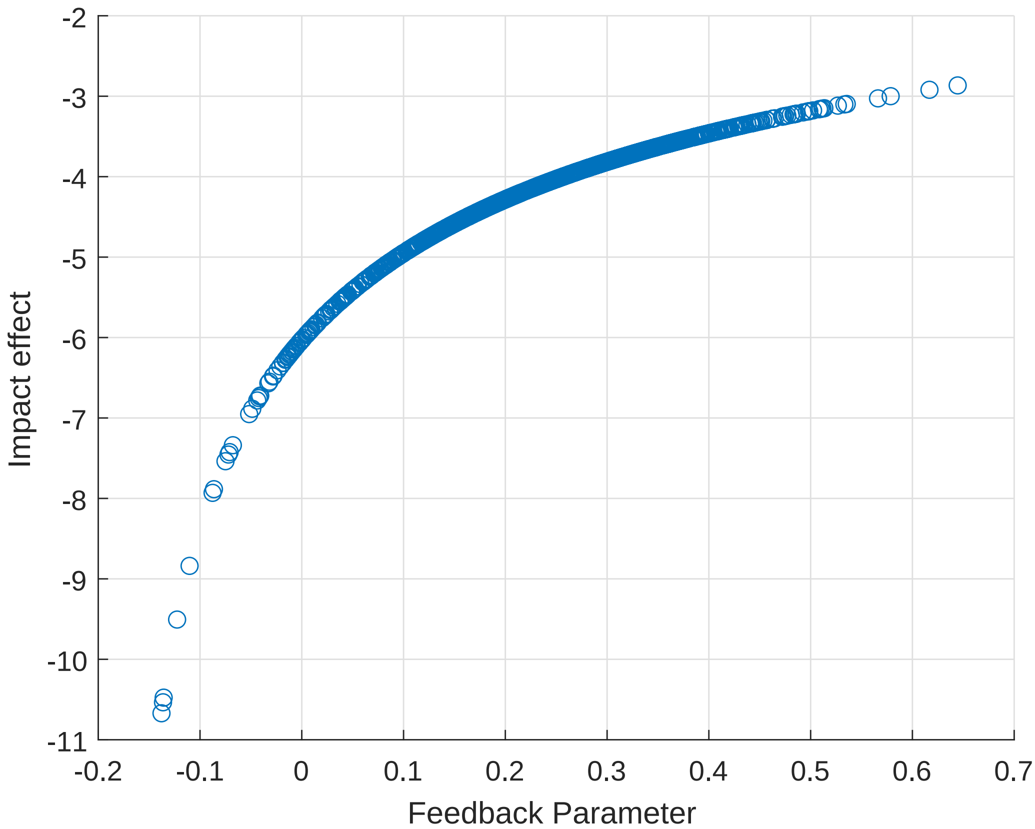


Figure 2: Impact Multiplier effect of Monetary Policy



Since one period is one year in my model, what I have in Figure 2 is the impact on *aggregate* output in year t of an increase in the nominal interest rate the lasts the whole year. As a consequence, this impact effect is not readily comparable to the estimates that can be found in the literature. Indeed, monetary policy shocks estimated from VARs tend to produce a reaction of output that is much smaller. On the other hand, Romer & Romer (2004) report a peak impact of -4%. Given that the data used to estimate the model is at the state level, it should not come as a surprise if the model does not fit precisely the effects of monetary policy. With this in mind, it gives us a reliable estimate of fiscal policy cyclicality and as can be seen in Figure 2, the latter seems to matter a lot for the impact of monetary policy shocks. In particular, pro-cyclical fiscal policy substantially magnifies the effects of an increase in the nominal interest rate.

5 Robustness and Sensitivity Exercises

5.1 Sensivity tests

As stated earlier, I used a rather large value for the Calvo (1983) probability parameter. I now re-estimate the two parameter assuming that this probability is set to 0.4 to match a quarterly probability of 0.85 as in Christiano et al. (2011). With this parameter value, I estimate $\hat{\eta} = 0.06(0.186)$ and $\hat{\sigma}_{ME} = 0.78(0.047)$, where the standard deviations are in parentheses. Consistent with the discussion in the main text, this version of the model is less able to capture the dynamics in the data as the J-stat is now lower at 0.7.

The results of the last section were also derived under a specification in which endogenous government spending reacts to the *current* deviation of employment from its steady state level. This begs two questions : why employment as the baseline indicator of business cycle fluctuations? Why consider the *current* state of the business cycle instead of the last period's one? To answer the first question, I report GMM estimation results under the assumption that endogenous government spending responds to output deviations from its steady state in Table 3

Eyeballing the results, it is easy to see that this version of the model produces results that are in line with the baseline, except that the standard deviation of the feedback parameter is higher now. It nevertheless does slightly worse as evidenced by the Hansen (1982) J-test p-value which is lower in this

Table 3: Estimation Results

Moments	Data	Model
$Cov(y,g)$	0.09	0.071
$Cov(y,\epsilon^G)$	0.11	0.112
$Var(g)$	0.67	0.672
$Cov(l,g)$	0.04	0.058
$Cov(l,\epsilon^G)$	0.09	0.089
Parameters	**Estimate**	**P-value**
η	0.26	0.166
σ_{ME}	0.80	0.000
a	0.89	0.000
	Stat	P-value
Hansen (1982) J-test	0.27	0.87

case. Versions of the model in which endogenous spending reacts to lagged versions of output or employment deliver J-test p-values that are close to zero and thus provide a fit that is much worse. Not surprisingly, versions of the model with separable preferences yield J-test p-values that are also close to zero. In these two cases case, the null hypothesis of the model being correctly specified can be rejected at conventional confidence levels.

5.2 Robustness Exercise

As a robustness exercise, I estimate an enriched version of the model using Bayesian techniques. I remain agnostic about prior distributions of both η and σ_{ME} and assume a Uniform distributions. Prior distributions for the other parameters are standard and reported in Table 5 in the Appendix. The enriched model features private capital with investment adjustment costs. I again try different specifications for the business cycle indicator in the feedback equation. Given a data vector $\mathcal{Y}_T$, I can compute the marginal density $\mathbb{P}(\mathcal{Y}_T|\mathcal{F})$ of the model with feedback function $\mathcal{F}$ and posterior odds as

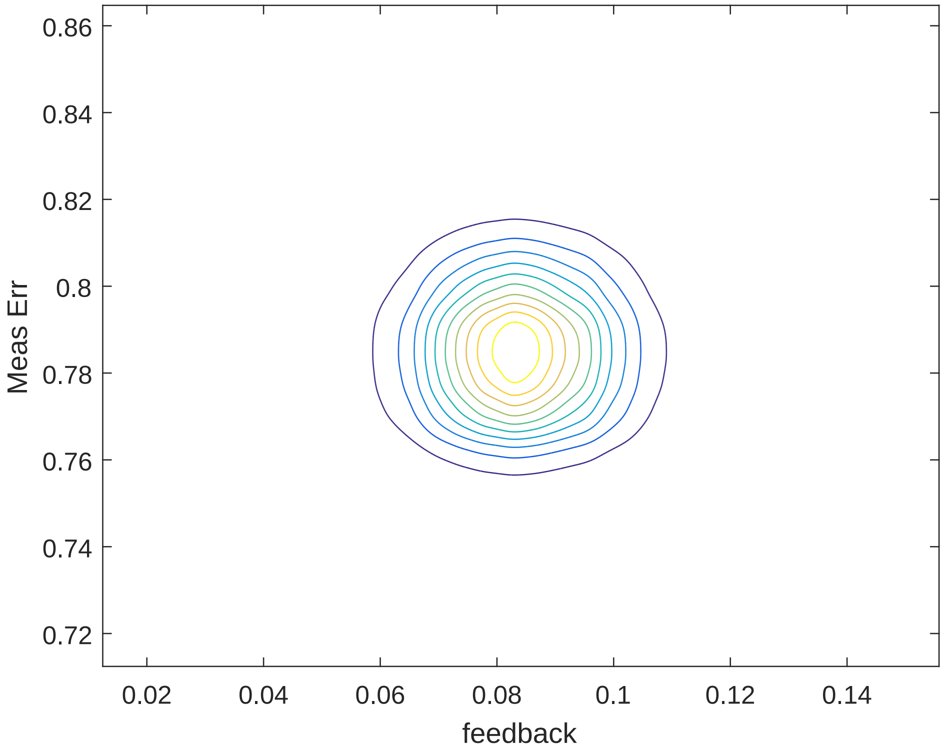
$$\mathbb{P}(\mathcal{F}|\mathcal{Y}_T) = \frac{\mathbb{P}(\mathcal{F})\mathbb{P}(\mathcal{Y}_T|\mathcal{F})}{\sum_{\mathcal{F}} \mathbb{P}(\mathcal{F})\mathbb{P}(\mathcal{Y}_T|\mathcal{F})}.$$

I report the posterior odds in Table 4

Table 4: Posterior Odds

$\mathcal{F}(\cdot)$	$y_{H,t}$	$y_{H,t-1}$	$l_{H,t}$	$l_{H,t-1}$
$\mathbb{P}(\mathcal{F}\|\mathcal{Y}_T)$	0	0.01	0	99.99

Distribution of Parameters of Interest



This richer model gives calls for a different business cycle indicator : lagged employment. That being said, the model still estimates a significantly positive value for both η and σ_{ME}. While the estimate for σ_{ME} is very close to the one obtained before, the estimate for η is lower. To the extent that they can be compared given that they pertain to two different business cycle indicators, the value obtained with Bayesian estimation falls within the 90% confidence interval derived for η in the baseline GMM estimation. I plot the joint distribution of η and σ_{ME} in Figure 5.2. It should be said that this estimation method takes roughly 12 hours on a standard laptop.

6 Conclusion

Fiscal policy as a stabilization tool is routinely criticized in that it always comes too late, since increasing *discretionary* spending involves legislative lags. For this reason, a systematic component of fiscal policy that reacts to business cycle fluctuations might be warranted because it is more likely to get the timing right. While such a feature has been studied extensively in the case of monetary policy, it was lacking for fiscal policy. I have shown that a systematic component for fiscal policy is important in shaping how the economy responds to fiscal policy and other shocks.

In addition, a theoretical setup with a systematic response of fiscal policy suggests new ways to estimate how fiscal policy actually reacts to business cycle fluctuations. Using these insights, I estimate that government spending expenses are clearly counter-cyclical in the United States.

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A Derivation of OLS Expression

I first derive an analytical expression for the covariance term.

$$\begin{aligned} Cov(y_t, g_t) &= Cov(y_t, \epsilon_t^g - \eta y_t + u_t^{ME}) \\ &= Cov(\mathcal{M}(\Theta)\epsilon_t^g, \epsilon_t^g - \eta\mathcal{M}(\Theta)\epsilon_t^g) \\ &= \mathcal{M}(\Theta)(1 - \eta\mathcal{M}(\Theta))\mathbb{V}(\epsilon_t^g) \end{aligned} \tag{18}$$

I now derive an expression for the variance of total government spending.

$$\begin{aligned} \mathbb{V}(\epsilon_t^g) &= \mathbb{V}(\epsilon_t^g - \eta y_t + u_t^{ME}) \\ &= \mathbb{V}(\epsilon_t^g) + \eta^2\mathcal{M}(\Theta)^2\mathbb{V}(\epsilon_t^g) - 2\eta\mathcal{M}(\Theta)\mathbb{V}(\epsilon_t^g) + \mathbb{V}(u_t^{ME}) \\ &= \mathbb{V}(\epsilon_t^g)\left[1 + \eta\mathcal{M}(\Theta)(\mathcal{M}(\Theta) - 2)\right] + \mathbb{V}(u_t^{ME}) \end{aligned} \tag{19}$$

Dividing equation (18) by equation (19) one obtains equation (9) in the main text.

B Comparison of Estimation Methods for Feedback Coefficient

I assume that the open-economy DSGE model is the true Data Generating Process. As in the main text, the feedback rule for government spending is given by

$$g_{H,t} = \epsilon_{H,t}^g - \eta l_t \tag{20}$$

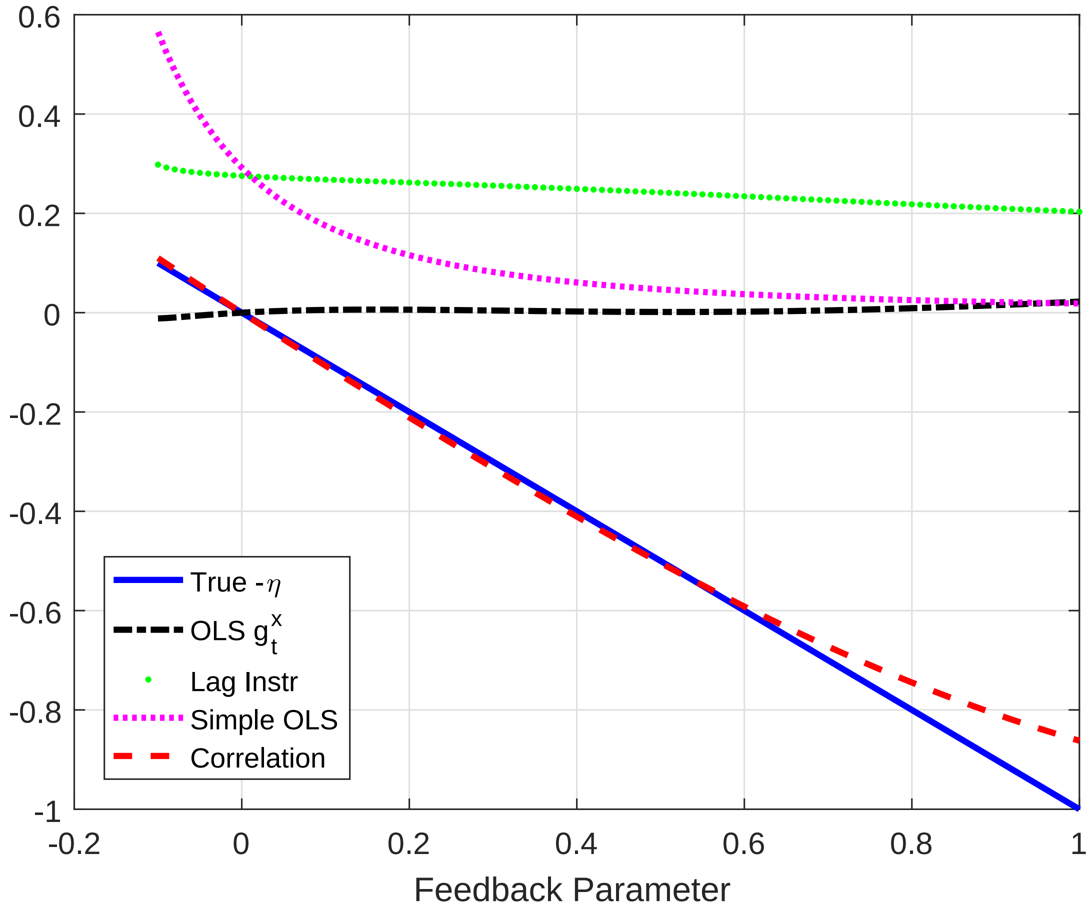
where I have a assumed that there is no measurement error with respect to government spending. The question then is, given that total government spending is perfectly measured, how can we estimate the parameter η? Given equation (20), it seems natural to estimate the following specification:

$$g_{H,t} = \gamma_1\epsilon_{H,t}^g + \gamma_2 l_{H,t} + \vartheta_t. \tag{21}$$

The problem is that ϑ_t potentially contains monetary policy and demand shocks that will have an effect on employment. Furthermore, we do not always have access to exogenous government spending. In this case, a reasonable specification could be

$$g_{H,t} = \mu l_{H,t} + v_t \tag{22}$$

Figure 3: Different Estimation Methods for η



as in Lane (2003). Again because $l_{H,t}$ is endogenous, we want to instrument it. To mimick what is usually done in the literature (see for example Fatás & Mihov (2010)), I use $l_{H,t-1}$ to instrument for $l_{H,t}$. Finally, I also use the simple correlation method that leads to equation (10) in the main text. I plot all of these estimation results for different values of the true value of η in Figure 3.

One can see that the regression based methods, even when instrumenting for $l_{H,t}$ fare quite poorly, especially when endogenous government spending is strongly counter-cyclical. In sharp contrast, the simple correlation method shows that taking advantage of the structure of equation (20) is key. This latter tracks quite well the true value of η. Because the simple correlation measure uses the two-year growth rate of the variables, it comes with additional terms that explain the discrepancy with the true value of η.

C Priors for Bayesian Estimation

Estimated Parameters

Table 5: Prior/Posterior distributions

		Prior	Posterior distribution			
		distribution	Mode	Mean	10%	90%
Risk aversion	σ	$\mathcal{N}(1.5, 0.37)$	0.68	0.76	0.53	1.03
Calvo Probability	α	$Beta(0.5, 0.1)$	0.66	0.66	0.61	0.7
Frisch elasticity	ν	$\mathcal{N}(2, 0.75)$	2.47	2.5	1.84	3.12
Taylor rule : inflation	ϕ_π	$\mathcal{N}(1.5, 0.25)$	1.5	1.5	1.1	1.9
Taylor rule : output	ϕ_y	$\mathcal{N}(0.12, 0.05)$	0.12	0.12	0.04	0.2
Taylor rule : persistence	ρ_R	$Beta(0.75, 0.1)$	0.78	0.74	0.59	0.91
Investment adj. cost	s	$\mathcal{N}(4, 1.5)$	1.77	1.92	1.45	2.4
Feedback parameter	η	$\mathcal{U}[-5, 5]$	**0.08**	0.08	0.06	0.1
AR(1) Gov. spending	ρ_G	$Beta(0.5, 0.2)$	0.74	0.74	0.72	0.76
AR(1) tech. shock	ρ_A	$Beta(0.5, 0.2)$	0.78	0.72	0.73	0.76
Std. gov. meas. error	$\sigma_{\epsilon,g}$	$\mathcal{U}[0, 10]$	**0.78**	0.79	0.76	0.81