Mr. Keynes meets the Classics: Government Spending and the Real Exchange Rate*

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Abstract

In economies with fixed exchange rates, the adjustment to government spending shocks is asymmetric. Expansionary shocks are absorbed by the real exchange rate, contractionary shocks by output. This result emerges in a small open economy model with downward nominal wage rigidity and is supported by new empirical evidence based on panel data from different exchange-rate regimes. The exchange-rate regime, economic slack, inflation, and how spending is financed all matter for the fiscal transmission mechanism in the way predicted by the model. Estimates that fail to distinguish between the effects of positive and negative shocks are subject to a "depreciation bias".

Keywords: downward nominal wage rigidity, government spending shocks, exchange-rate peg, balanced budget, taxes, asymmetric adjustment, depreciation bias

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1 Introduction

How does government spending affect economic activity and the real exchange rate in open economies? Keynesian theories in the tradition of the Mundell–Fleming model emphasize that—if the exchange rate is fixed—changes in government spending affect output strongly because prices and wages, and eventually the real exchange rate, are slow to adjust (Farhi and Werning, 2016; Nakamura and Steinsson, 2014). An increase in public spending stimulates output, while a reduction is detrimental to economic activity. In both cases, the real exchange rate adjusts very little or not at all. According to the Classical account, in contrast, the adjustment of the real exchange rate takes center stage (Backus et al., 1994). Raising spending does not stimulate output much because the real exchange rate appreciates, crowding out the demand for domestic goods. Likewise, a cut in government spending depreciates the real exchange rate, but affects output very little.

In this paper, we attempt to reconcile Keynesian and Classical views.[1] For this purpose, we rely on a new paradigm for thinking about macroeconomic adjustment in open economies put forward by Schmitt-Grohé and Uribe (2016), or SGU for short. Its key feature is downward nominal wage rigidity (DNWR).[2] A direct implication is that economies with an exchange-rate peg adjust asymmetrically to shocks. Expansionary shocks are largely absorbed by rising wages and an appreciation of the real exchange rate, while contractionary shocks are absorbed by output. In the first part of the paper, we formalize this idea for shocks to government spending, which we introduce to the original model of SGU. In the second part, we provide supporting evidence based on panel data from different exchange-rate regimes. We identify fiscal shocks following Mountford and Uhlig (2009) and contrast the effects of positive and negative government spending shocks, both under the restriction that taxes adjust immediately to balance the government budget and without.

The main result of our analysis—both in terms of theory and evidence—is that the short-run effects of positive and negative government spending shocks are indeed asymmetric under an exchange-rate peg, unless taxes are required to balance the budget in every period. The real exchange rate does not adjust to a negative government spending shock: In line with the Keynesian view, DNWR prevents the adjustment, output and employment contract. In response to a positive government spending shock, instead, the exchange rate appreciates. In line with the Classical view, higher demand pushes up wages and prices. This crowds out private expenditure: Output and employment remain unchanged. In sum, our analysis reconciles Keynesian and Classical views about the short run by distinguishing between expansionary and contractionary shocks—rather than by distinguishing between the short and the long run, as the neoclassical synthesis does.

[1] What we label "Keynesian view" is perhaps not giving full justice to Keynes' original ideas, following a long tradition in macroeconomics starting with Hicks (1937). Galí (2013) offers a contemporary account based on a more rigorous reading of Keynes. Classical (or neoclassical) treatments of fiscal policy in a closed economy include Barro (1989) and Baxter and King (1993). Corsetti and Müller (2006) analyze the role of international relative prices for fiscal policy transmission in the classical open-economy framework of Backus et al. (1994). Similarly, Sinn (2014) stresses the implications of fiscal adjustments for competitiveness, see also the discussion in Lambertini and Proebsting (2023).

[2] For recent discussions on the empirical prevalence of downward nominal wage rigidity see Elsby and Solon (2019), Grigsby et al. (2021), Jo (2021), and references therein.

Our model-based analysis builds on SGU. We extend the original two-sector model as we allow the government to consume an exogenously determined amount of non-traded goods. To finance its purchases, the government levies taxes so that its budget is balanced at all times. However, in the baseline scenario, taxes are lump sum so that the sequence of taxes is irrelevant and government spending may just as well be debt-financed. Our first contribution is to flesh out the fiscal transmission mechanism in the model. For this purpose, we contrast the case of an exchange-rate peg with a floating exchange-rate regime. As a natural benchmark, we consider a float where monetary policy lets the exchange rate adjust to offset the effect of DNWR altogether. As a result, output is always stabilized at the efficient level and the real exchange rate responds symmetrically to government spending shocks. A spending increase appreciates the real exchange rate because it raises the relative price of non-traded goods. This, in turn, crowds out private demand for non-traded goods. In contrast, a cut to government spending lowers the relative price of non-traded goods, which stimulates private spending up to the point where economic activity is completely stabilized.

Under a peg, instead, the adjustment is asymmetric. The response to a spending increase is the same as under a float because wages increase and the real exchange rate appreciates. Yet, in response to a cut, the real exchange rate cannot adjust because of DNWR. The output of non-traded goods as well as employment fall. We stress an important qualification of this result: it obtains only if taxes are lump sum or, equivalently, spending is debt-financed. Once we assume that the budget is balanced through a payroll tax, the effects of government spending shocks are symmetric—even under a peg. In this case, the spending cut comes with a tax reduction, which brings about real depreciation even in the presence of nominal rigidities (Farhi et al., 2014). We derive these results in closed form for a bare-bones version of the model. For this version of the model, we also establish the equivalence of taxing traded-goods consumption and government spending on non-traded goods: Both measures raise, all else equal, relative expenditure on non-traded goods. Still, in the bare-bones version of the model, traded-goods consumption and net exports do not change in equilibrium in response to government spending shocks. We thus turn to the full model, which we calibrate and solve numerically. It features richer dynamics, notably for net exports. They decline in response to positive spending shocks and increase in response to negative shocks, reflecting the differential impact of the shock on traded-goods consumption.

As a second contribution, we provide empirical evidence for the asymmetric effects of government spending shocks. In a first step, we identify fiscal shocks in a large set of countries using a variant of the Mountford and Uhlig (2009) sign restriction approach due to Caldara and Kamps (2017). This approach offers the advantage relative to the widely used approach of Blanchard and Perotti (2002) that it does not rule out a contemporaneous response of government spending to the business cycle. Ex post, it turns out that the estimated response is moderate in our sample and, hence, results under the Blanchard-Perotti identification scheme are very similar to what we obtain in the baseline. Importantly, we also control for fiscal foresight by including professional forecasts for government spending growth in our baseline specification. In this way, we address concerns that government spending shocks may at times be anticipated (Ramey, 2011).

In a second step, we use local projections to estimate how the identified shocks impact government spending and tax revenues, as well as the real exchange rate, output, nominal wages, consumption, and net exports. Local projections are particularly well suited for our purpose because they allow us to estimate distinct responses for positive and negative shocks. For our baseline, we focus on a sample of euro area (EA) countries, because these countries are fairly homogeneous and operate a fixed-exchange-rate regime. In line with the predictions of the theoretical model, we find that the adjustment is not symmetric in the sign of the shock. Negative shocks induce a contraction of output but leave the real exchange rate and wages largely unchanged. Positive shocks, instead, induce an appreciation of the real exchange rate and push up wages, but they leave output basically unaffected. In addition, following earlier work by Miyamoto et al. (2019), we turn to annual data on military spending for a larger set of countries with fixed exchange rates and find that our results are not specific to EA countries. We directly use changes in military spending in the local projection, thus verifying that our results are not sensitive to the two-step approach on which we rely in the baseline.

Our results are, however, sensitive to assumptions of how taxes respond to changes in spending. To see this, we follow Mountford and Uhlig (2009) and use our estimates to construct a scenario in which the impact of government spending shocks on the government budget is immediately offset via tax changes. In this case, the effects of positive and negative government spending shocks turn out to be symmetric, as predicted by the model under the payroll tax. In addition, we provide further empirical evidence which is consistent with the model along a number of other dimensions, including the role of the exchange-rate regime, economic slack, and high inflation. Inflation alters the effects of negative shocks, slack the effects of positive shocks, a flexible exchange rate alters the effects of both.

That said, we note that the model predictions are not fully borne out by the evidence along every dimension. For instance, the response of wages to positive spending shocks is somewhat delayed compared to what the model predicts, and output responds to a balanced-budget shock when the model says it would not. These failures are perhaps unsurprising given the very stylized nature of the model. Nevertheless, we take the model seriously. It allows us to identify stark and extreme cases that serve as a prelude to the empirical analysis, where things are a matter of degree rather than absolutes. Without firm guidance by theory, the empirical analysis would necessarily lack structure given the many dimensions we identify to matter for the effects of spending shocks: their sign, the exchange rate regime, how they are financed, the level of inflation, and the extent of slack. The main contribution of the paper lies not in the model or evidence alone but in the simultaneous examination and comparison of theory and evidence along these dimensions.

As we zoom in on the exchange rate response to government spending shocks, we further aim to bridge the gap between theory and evidence that has puzzled researchers for some time. Most studies find, using various identification schemes, that government spending depreciates the real exchange rate. We discuss this literature in some detail below and assess why our results differ. For this purpose, we consider a constrained empirical specification that imposes positive and negative shocks to have symmetric effects. We estimate this specification on our sample and detect a "depreciation bias": the symmetric estimate implies too little appreciation in response to positive government spending shocks and too much depreciation in response to spending cuts. Similarly, we consider longer US time series and compare a symmetric estimator to our baseline specification. Like much of the earlier literature, the symmetric estimator predicts that (positive) government spending shocks depreciate the US real exchange rate. Based on our baseline specification, we instead find appreciation, at least in the short run. Of course, the US does not operate an exchange rate peg. Yet the asymmetry which shapes the transmission mechanism in our model is potentially also present under flexible exchange rates if monetary policy provides less than full stabilization in the face of contractionary shocks. We further corroborate the depreciation bias by means of a simple Monte Carlo experiment.

During the last two decades, countless studies have investigated the effect of government spending on output, as the survey by Ramey (2019) illustrates. However, except for Giavazzi et al. (2000), the sign of fiscal shocks has been largely ignored as a distinct feature up until very recently. Barnichon et al. (2022) show that this is a serious omission. They find for US time-series data that the sign of a shock to government spending has a first-order effect on the fiscal multiplier. It is larger than one for negative shocks, but it is substantially smaller than one for positive shocks. They rationalize this finding in a model with financial frictions and DNWR.[3] Other recent closed-economy models also assume DNWR in order to generate asymmetries in fiscal transmission (Burgert et al., 2021; Jo and Zubairy, 2022; Shen and Yang, 2018). Schmitt-Grohé and Uribe (2021) develop micro-foundations to the internal balance schedule of the Salter-Swan policy framework in an open-economy DNWR model.

Our analysis differs from these studies in two ways. First, in terms of empirical analysis because we use a cross-country data set rather than time series for the US only. This is essential for our analysis, because, second, our focus is on the real exchange-rate response to government spending shocks and, in particular, their interaction with the exchange-rate regime. Our analysis thereby assigns a key role to monetary policy for the fiscal transmission mechanism, as in earlier work with a focus on the zero lower bound (Christiano et al., 2011; Woodford, 2011). Against this background, we stress that our analysis brings to the fore a very intuitive notion: monetary policy matters for the fiscal transmission mechanism to the extent that nominal rigidities bind. However, this need not always be the case. In related work, Cox et al. (2020) use a multi-sector New Keynesian model to highlight the importance of relative price stickiness for fiscal policy transmission.

The remainder of the paper is organized as follows. Section 2 introduces the model in general terms, which is then solved in Section 3, both in closed form and numerically. Section 4 introduces our empirical framework, our identification strategy, and our data set, while Section 5 presents estimation results. Section 6 concludes.

[3]The implications of DNWR for macroeconomic dynamics have recently been spelled out in several contexts. Benigno and Ricci (2011) focus on the nonlinearity of the Phillips curve. Dupraz et al. (2020) put forward a "plucking model" of the business cycle. Bianchi et al. (2022) study optimal fiscal policy in the presence of sovereign risk, while Liu (2022) focuses on sudden stops.

2 A small open economy model with DNWR

We consider a small open economy with two types of goods: one produced by a representative firm with labor as the only production factor and not traded internationally; the other an endowment good traded internationally by a representative household. Wages are flexible upwards and rigid downwards.[4] The innovation relative to SGU is that we allow for government consumption—determined exogenously and financed through lump-sum taxes (in the baseline). Government consumption is exhaustive and distinct from transfers, which are neutral in our setup. Conceptually, government consumption is equivalent to the government simply hiring government workers.[5] Finally, we assume that the government consumes only domestically produced goods. This enhances the tractability of the model and is warranted not least because of explicit buy-local provisions in public procurement.[6]

2.1 The household

The representative household is endowed with $\bar{h}$ hours of time, which are inelastically supplied to the market. The household's preferences are given by:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma} - 1}{1-\sigma} , \tag{2.1}$$

where $\mathbb{E}_t$ is the conditional expectations operator, c_t denotes private consumption in period t, $\beta \in (0,1)$ is the discount factor, and $1/\sigma$ the intertemporal elasticity of substitution. The preference specification does not feature disutility of labor.[7] Consumption, in turn, is an aggregate of traded goods, c_t^T, and non-traded goods, c_t^N:

$$c_t = \left[a \left(c_t^T\right)^{\frac{\xi-1}{\xi}} + (1-a) \left(c_t^N\right)^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}} , \tag{2.2}$$

where ξ is the (intratemporal) elasticity of substitution and $a \in (0,1)$ determines the weight of traded goods in aggregate consumption. The consumer price index (CPI) is given by:

$$P_t = \left[a^{\xi} \left(P_t^T\right)^{1-\xi} + (1-a)^{\xi} \left(P_t^N\right)^{1-\xi} \right]^{\frac{1}{1-\xi}} , \tag{2.3}$$

where P_t^T and P_t^N denote the domestic-currency prices of traded and non-traded goods, respectively.

[4]This assumption is key for the asymmetric adjustment dynamics in response to positive and negative government spending shocks. Relaxing it and allowing for some (moderate) upward rigidity would reduce the asymmetry but not alter our main result.

[5]We show for the bare-bones version of the model introduced in Section 3.1 that government employment and government consumption of private-sector goods yield identical allocations, see Appendix A.2.

[6]For instance, public procurement laws feature explicit domestic preference clauses in eight of the countries included in our sample according to the World Bank's Global Public Procurement Database. More generally, the import share in government spending tends to be very low (Corsetti and Müller, 2006).

[7]As a result, the model does not predict that government spending boosts the economy by making households poorer. With disutility of labor, higher government spending and taxes would cause households to work harder due to an adverse income effect (Baxter and King, 1993).

The household receives labor income and firm profits as well as an endowment of traded goods. It may borrow using a discount bond that pays one unit of the traded goods with foreign-currency price P_t^{T*}. The household pays taxes, τ_t, and spends its income on traded and non-traded goods. Formally, the period budget constraint expressed in domestic currency reads as follows:

$$\mathcal{E}_t P_t^{T*} d_t + P_t^T c_t^T + P_t^N c_t^N = \mathcal{E}_t P_t^{T*} \frac{d_{t+1}}{1+r_t} + P_t^T y_t^T + W_t h_t + \phi_t - \tau_t \ , \tag{2.4}$$

where $\mathcal{E}_t$ is the nominal exchange rate defined as the domestic currency price of one unit of foreign currency. d_t denotes the level of foreign debt assumed in period $t-1$ and due in period t. W_t is the nominal wage, h_t denotes hours worked. ϕ_t denotes firm profits. The world interest rate r_t and the endowment of traded output y_t^T are exogenous and stochastic. We assume that the law of one price holds for traded goods, $P_t^T = \mathcal{E}_t P_t^{T*}$, and normalize the foreign-currency price of traded goods to unity such that $P_t^T = \mathcal{E}_t$. Under the small open economy assumption, we may also set $P_t^* = 1$. The household maximizes (2.1), subject to (2.4) and a borrowing limit:

$$d_{t+1} \leq \bar{d}, \text{ where } \bar{d} > 0 \, . \tag{2.5}$$

Given the relative price of non-traded goods, $p_t^N \equiv P_t^N / P_t^T$, the optimality conditions are

$$c_t^N : \quad p_t^N = \frac{1-a}{a} \left(\frac{c_t^T}{c_t^N} \right)^{\frac{1}{\xi}} \tag{2.6}$$

$$c_t^T : \quad \lambda_t = a \left[a \left(c_t^T \right)^{\frac{\xi-1}{\xi}} + (1-a) \left(c_t^N \right)^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}\left(\frac{1}{\xi}-\sigma\right)} \left(c_t^T \right)^{-\frac{1}{\xi}} \tag{2.7}$$

$$d_{t+1} : \quad \frac{\lambda_t}{1+r_t} = \beta \mathbb{E}_t \lambda_{t+1} + \mu_t \tag{2.8}$$

$$\mu_t \geq 0 \ \wedge \ d_{t+1} \leq \bar{d} \ \text{ with } \ 0 = \mu_t (d_{t+1} - \bar{d}) \ , \tag{2.9}$$

as well as a suitable transversality condition for bonds. Here, λ_t / P_t^T and μ_t are the Lagrange multipliers associated with (2.4) and (2.5), respectively, and (2.9) is the complementary slackness condition.

2.2 The firm

Non-traded output y_t^N is produced by a representative competitive firm via the following technology:

$$y_t^N = h_t^{\alpha} \ , \tag{2.10}$$

where $\alpha \in (0, 1]$. The firm chooses labor input to maximize profits ϕ_t, taking wages as given:

$$\phi_t \equiv P_t^N y_t^N - W_t h_t \ . \tag{2.11}$$

Optimality requires the following condition to hold:

$$p_t^N = \frac{W_t/\mathcal{E}_t}{\alpha y_t^N/h_t} \ . \tag{2.12}$$

This condition is key to understanding the mechanics of the model. To maintain full employment, a drop in the demand for non-traded goods requires their relative price to fall. This, in turn, requires a decline in the firm's marginal costs, either via declining wages or an exchange rate depreciation.

2.3 The labor market

The household meets labor demand to the extent that it does not exceed the labor endowment:[8]

$$h_t \leq \bar{h} \ . \tag{2.13}$$

Hours worked are determined in equilibrium by the firm's labor demand. Even though the labor market is competitive, it generally does not clear because of downward nominal wage rigidity. Specifically, as in SGU, we assume that in any given period, nominal wages cannot fall below a fraction γ of the wage in the previous period. Formally,

$$W_t \geq \gamma W_{t-1} \ . \tag{2.14}$$

As a result, there may be involuntary unemployment $h_t < \bar{h}$ whenever the DNWR constraint is binding. This is captured by the following complementary slackness condition that must hold in equilibrium for all dates and states:

$$(\bar{h} - h_t)(W_t - \gamma W_{t-1}) = 0 \ . \tag{2.15}$$

When the wage constraint is not binding, that is, whenever $W_t > \gamma W_{t-1}$, the economy will be at full employment. In what follows, we use

$$w_t \equiv W_t/\mathcal{E}_t \tag{2.16}$$

to express the real wage in terms of traded goods and $\epsilon_t \equiv \frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}$ to denote the gross rate of devaluation of the domestic currency. Equation (2.14) can then be rewritten as

$$w_t \geq \gamma \frac{w_{t-1}}{\epsilon_t} \ . \tag{2.17}$$

This expression illustrates that downward nominal wage rigidity operates by effectively constraining real wages. It also shows how a currency devaluation (an increase of ϵ_t) loosens the constraint.

[8] We abstract from the nonnegativity constraint that wages and hours worked must be weakly positive.

2.4 The real exchange rate

We define the real exchange rate as the price of foreign consumption (expressed in domestic currency) relative to the price of domestic consumption:

$$RER_t \equiv \frac{\mathcal{E}_t P_t^*}{P_t} , \tag{2.18}$$

where P_t^* denotes the price of foreign consumption. Note that under the assumptions made above, we can rewrite the numerator as $\mathcal{E}_t P_t^* = P_t^T$. Using the definition of the CPI, given by equation (2.3), we find that the real exchange rate is inversely related to the relative price of non-traded goods in the following way:

$$RER_t = \left[a^\xi + (1-a)^\xi (p_t^N)^{1-\xi}\right]^{-\frac{1}{1-\xi}} . \tag{2.19}$$

2.5 Government spending and taxes

The government consumes only non-traded goods g_t^N and balances its budget at all times:

$$\tau_t = P_t^N g_t^N . \tag{2.20}$$

Government spending g_t^N is assumed to follow an exogenous process. Equivalently to balancing the period budget constraint with lump-sum taxes, we could allow the government to issue debt domestically to fund its spending without altering the effects of spending. We consider distortionary taxes in Section 3.3 below.

2.6 Market clearing and equilibrium

Market clearing in the non-traded goods sector requires

$$y_t^N = c_t^N + g_t^N , \tag{2.21}$$

while the market-clearing condition for traded goods is given by:

$$c_t^T = y_t^T - d_t + \frac{d_{t+1}}{1+r_t} . \tag{2.22}$$

Labor-market equilibrium is characterized by equations (2.12)–(2.15). Appendix B.1 lists the full set of equilibrium conditions and provides a definition of the equilibrium for a given exchange rate policy $\{\epsilon_t\}_{t=0}^{\infty}$, specified next.

2.7 Exchange rate policy

To specify the exchange rate policy, we first define the full-employment real wage:

$$w_t^f \equiv \frac{1-a}{a}\left(\frac{c_t^T}{\bar{h}^\alpha - g_t^N}\right)^{\frac{1}{\xi}} \alpha \bar{h}^{\alpha-1} \ . \tag{2.23}$$

This expression is obtained by combining the demand and supply schedules of non-traded goods, (2.6) and (2.12), respectively, the definition of the real wage (2.16), the production technology (2.10), and the market-clearing condition (2.21) when the labor market is operating at full employment. w_t^f is the unique real wage associated with the first-best allocation.

Whether the actual real wage equals its full-employment counterpart depends on the nominal exchange rate, as expression (2.17) shows. This gives a role to monetary policy, which can stabilize economic activity by setting the nominal exchange rate. However, there are infinitely many combinations of the nominal wage and the nominal exchange rate which imply the same real wage—see equation (2.16)—and, therefore, the same real exchange rate. Hence, any exchange rate policy that satisfies

$$\epsilon_t \geq \gamma \frac{w_{t-1}}{w_t^f} \tag{2.24}$$

makes the wage constraint slack and ensures full employment.

Below we follow Liu (2022) and specify a parametric family of exchange rate rules of the type

$$\epsilon_t = \max\left\{\gamma \frac{w_{t-1}}{w_t^f}, 1\right\}^{\phi_\epsilon} \ , \tag{2.25}$$

with $\phi_\epsilon \in [0,1]$. $\phi_\epsilon = 1$ implements a full-employment stabilizing float ("float") which keeps fluctuations of the nominal exchange rate to a minimum. Intuitively, if the full-employment wage is above the lower bound γw_{t-1}, the nominal exchange rate is not adjusted at all. Otherwise, it increases by just enough to alleviate the constraint. $\phi_\epsilon = 0$ corresponds to a peg.

3 The fiscal transmission mechanism

In this section, we first consider a simplified version of the model, solve it in closed form under perfect foresight, and establish conditions under which the effects of government spending shocks are asymmetric. Importantly, this "bare-bones version" of the model is very stylized and delivers stark predictions. Hence, it may serve as a proof of concept in light of our empirical findings below. But we also present simulation results for a calibrated version of the full model in Section 3.4 below.

3.1 A bare-bones version of the model

For the bare-bones version of the model, we assume unitary values for the preference parameters in (2.1) and (2.2): $\sigma = \zeta = 1$, such that $U(c_t^T, c_t^N) = a \log c_t^T + (1-a)\log c_t^N$ and $RER_t = a^a(1-a)^{1-a}\left(p_t^N\right)^{\alpha-1}$. Regarding the production function, we assume that $\alpha = 1$, so that the marginal product of labor is constant. We assume that the world interest rate, r, and the endowment of traded goods, y^T, are also constant. We set $\gamma = 1$ such that wages are perfectly downwardly rigid. Furthermore, we fix $\beta(1+r) = 1$ and assume for initial debt $d_0 < \bar{d}$. Under these assumptions, the complete set of equilibrium conditions can be summarized compactly as follows:

$$c_t^T = y^T - d_t + \frac{d_{t+1}}{1+r} \quad \text{and} \quad 0 = \lim_{j\to\infty} \left(\frac{1}{1+r}\right)^j d_{t+j} \;, \tag{3.1}$$

$$c_t^T = c_{t+1}^T \;, \tag{3.2}$$

$$y_t^N = h_t = c_t^N + g_t^N \;, \tag{3.3}$$

$$p_t^N = \frac{1-a}{a}\frac{c_t^T}{c_t^N} \;, \tag{3.4}$$

$$p_t^N = w_t \;, \tag{3.5}$$

$$w_t^f = \frac{1-a}{a}\frac{c_t^T}{\bar{h} - g_t^N} \;, \tag{3.6}$$

$$w_t \geq \frac{w_{t-1}}{\epsilon_t} \wedge h_t \leq \bar{h} \quad \text{with} \quad 0 = (\bar{h} - h_t)\left(w_t - \frac{w_{t-1}}{\epsilon_t}\right) \;, \tag{3.7}$$

$$\epsilon_t = \max\left\{\frac{w_{t-1}}{w_t^f}, 1\right\}^{\phi_\epsilon} \;. \tag{3.8}$$

For ease of exposition, we consider a one-time shock ε_t occurring in period t to the initial level of government spending, g_0^N:

$$g_t^N = g_0^N + \varepsilon_t \;. \tag{3.9}$$

However, whether the shock is temporary, permanent, or followed by other shocks does not affect the model solution in the impact period because non-traded goods cannot be transferred across periods. Section 3.4 studies the adjustment over time for the full model with intertemporal propagation.

For the bare-bones version, we first note that the budget constraint and transversality condition in (3.1) together with the Euler equation (3.2) imply that traded-goods consumption and debt are insulated from ε_t and constant over time:

$$c_t^T = y^T - \frac{r}{1+r}d_0 \quad \text{and} \quad d_t = d_0 \;. \tag{3.10}$$

Further note that because the government balances its budget in each period, changes in government spending translate one-for-one into tax changes. The effect of government spending on current non-traded consumption then depends on whether government spending impacts pre-tax income as well. In this regard DNWR and the exchange-rate regime are key. We highlight this below by distinguishing between a Classical and a Keynesian scenario. These scenarios will unfold depending on a) initial conditions and b) which exchange-rate regime is in place.

First, for the **Classical scenario**, which arises in the case of a floating exchange rate, the solution for traded-goods consumption and output is given by

$$c_t^N = \bar{h} - (g_0^N + \varepsilon_t) \quad \text{and} \quad y_t^N = \bar{h}\,. \tag{3.11}$$

A number of observations are in order. First, government spending completely crowds out private consumption of non-traded goods. Intuitively, higher government spending implies higher taxes and hence fewer resources available for private consumption, and conversely for a reduction of government spending. Second, non-traded output is completely insulated from changes in government spending: the fiscal multiplier is zero. This is different from other classical accounts of fiscal policy because our model does not feature disutility from labor, see again footnote 7 above. Lastly, we observe that the solution is symmetric in the sign of the fiscal shock ε_t.

To prove that (3.11) is indeed a solution to the bare-bones version of the model, we verify that it satisfies all equilibrium conditions. First, we note that the solutions for c_t^N and y_t^N jointly satisfy the market clearing condition (3.3). Substituting for consumption in equation (3.4) implies for the relative price of non-traded goods:

$$p_t^N = \frac{1-a}{a}\frac{c_t^T}{\bar{h} - (g_0^N + \varepsilon_t)}\,. \tag{3.12}$$

Intuitively, the price adjusts in response to the shock so as to incentivize the household to adjust the composition of the consumption basket and for markets to clear. Condition (3.6), in turn, specifies the full employment wage. For $w_t = w_t^f$ to be consistent with the complementary slackness condition (3.7), we require monetary policy to pursue a float ($\phi_\epsilon = 1$). Equation (3.8) together with (3.12) then implies

$$\epsilon_t = \max\left\{\frac{\bar{h} - (g_0^N + \varepsilon_t)}{\bar{h} - g_0^N}, 1\right\}. \tag{3.13}$$

The expression shows that the *nominal* exchange rate remains unchanged if government spending is raised. The *real* exchange rate appreciates in this case because wages are upwardly flexible. Instead, the nominal exchange rate increases (meaning it depreciates) if government spending is cut. In this way, it undoes the effect of the DNWR and restores the full employment allocation. The bottom line is that (3.11) solves the model for all ε_t, provided monetary policy operates a float. As we will see shortly, the Classical scenario may also unfold under a peg, but only for $\varepsilon_t \geq 0$.

Second, for the **Keynesian scenario**, which unfolds under a peg, we conjecture the following solution:

$$c_t^N = h_0 - g_0^N, \quad \text{and} \quad y_t^N = h_0 + \varepsilon_t, \tag{3.14}$$

where $h_0 \leq \bar{h} - |\varepsilon_t|$ is the initial level of employment. Hence, we assume that the economy initially operates below full capacity and, moreover, that government spending shocks do not make the capacity constraint binding. Note first that non-traded consumption is now constant: there is no longer crowding out. Intuitively, in the Keynesian scenario income *before* taxes changes one-for-one with government spending such that, accounting for taxes, household income remains unchanged.

As a result, private consumption remains unchanged as well. Second, the fiscal multiplier is 1: larger (smaller) than in the New Keynesian (textbook IS-LM) model—see, e.g., Woodford (2011). Lastly, the response of non-traded output is symmetric in the sign of the fiscal shock.

We then verify that (3.14) is also a solution, albeit supported by a different monetary policy than in the Classical scenario. Equation (3.3) is satisfied by construction. Substituting for consumption in equation (3.4) gives for the relative price of non-traded goods:

$$p_t^N = \frac{1-a}{a}\frac{c_t^T}{h_0 - g_0^N} \ , \tag{3.15}$$

meaning that the relative price (and the real exchange rate) is unresponsive to the shock—the key difference to the Classical scenario in (3.12). Next, we observe that the equilibrium conditions for the labor market are satisfied. Equation (3.15) implies that the full-employment wage w_t^f in (3.6) is below its lower bound w_{t-1}. Hence, the wage constraint is binding, and the complementary slackness condition in (3.7) satisfied with $h_t = h_0 < \bar{h}$ and $w_t = w_{t-1}$. Equation (3.7) therefore implies that for the Keynesian scenario to unfold, the exchange rate must not change:

$$\epsilon_t = \frac{w_{t-1}}{w_t} = 1 \ . \tag{3.16}$$

Substituting for w_t and w_t^f in the monetary policy rule (3.8) yields

$$\epsilon_t = \max\left\{\frac{\bar{h} - g_0^N}{h_0 - g_0^N}, 1\right\}^{\phi_\epsilon} \ , \tag{3.17}$$

which is only consistent with (3.16) if $\phi_\epsilon = 0$. The peg prevents the adjustment of the nominal exchange rate in response to government spending that we observe in the Classical Scenario.

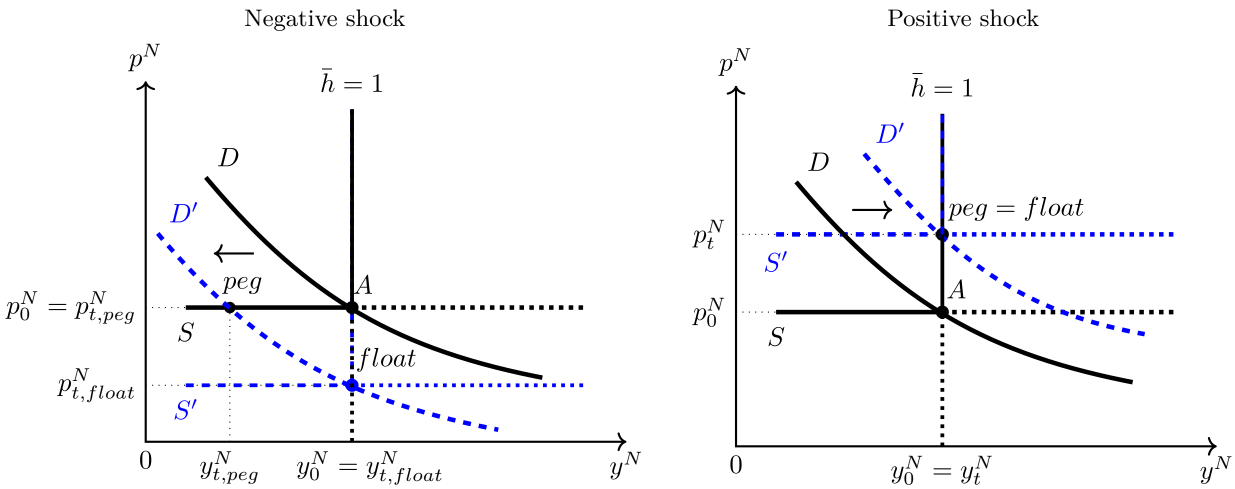
We are now ready to consider a specific situation where the Classical and the Keynesian scenario overlap. Consider a peg (as in the Keynesian scenario above) and assume that, initially, for a given level of government spending, g_0^N, the economy runs at full capacity: $h_0 = \bar{h}$ (as in the Classical scenario above). In this case, it is important to distinguish between the effects of positive and negative spending shocks. Specifically, the solution is given by

$$c_t^N = \begin{cases} \bar{h} - g_0^N \\ \bar{h} - (g_0^N + \varepsilon_t) \end{cases} , \quad y_t^N = \begin{cases} \bar{h} + \varepsilon_t \\ \bar{h} \end{cases} , \text{ and } p_t^N = \begin{cases} \frac{1-a}{a}\frac{c_t^T}{\bar{h} - g_0^N} & \text{if } \varepsilon_t < 0 \\ \frac{1-a}{a}\frac{c_t^T}{\bar{h} - (g_0^N + \varepsilon_t)} & \text{if } \varepsilon_t > 0 \ . \end{cases} \tag{3.18}$$

It is straightforward to check that this solution satisfies all equilibrium conditions (see Appendix A.1). Importantly, we now observe an asymmetric adjustment to negative and positive shocks. Negative shocks lower output but leave consumption of non-traded goods unchanged: the Keynesian scenario. Positive shocks crowd out consumption but do not impact output: the Classical scenario.

Figure 1 illustrates the workings of the model further, assuming that the economy is initially at full employment in $t = 0$ while distinguishing between peg and float. Both panels show the

Figure 1: The Impact Response to Government Spending Shocks



Notes: Horizontal axis measures the production of non-traded output, vertical axis measures its price. The downward-sloping curves represent the demand for non-traded goods prior to the shock (D) and after the shock (D'). The kinked lines represent the effective supply of non-traded goods prior to the shock (S) and after the shock (S').

market for non-traded goods, focusing on negative (left) and positive shocks (right). The level of production of non-traded goods is measured along the horizontal axis. The vertical axis measures the relative price of non-traded goods, an increase of which corresponds to a real appreciation. In both panels, the initial equilibrium is given by Point A, the intersection of the supply curve (3.5) and the downward-sloping demand curve (3.4). Note that the effective supply of non-traded goods is kinked: Once the economy operates at full capacity ($h_t = \bar{h}$), as is the case in Point A, output of non-traded goods cannot be raised any further. But it may decline, which in turn depends on how the price of non-traded goods (or, equivalently, the real exchange rate) responds to the shock.

Consider a negative government spending shock. For a given price of non-traded goods, the demand for non-traded goods declines, visualized by the shift from curve D (black solid line) to D' (blue dashed line). Under a peg with DNWR, the real wage cannot fall. As a consequence, the supply curve S stays put, and so does the relative price. The new equilibrium, indicated by "peg", is characterized by a lower level of non-traded output and the presence of involuntary unemployment—the Keynesian scenario. In contrast, under a float, the nominal exchange rate depreciates. This reduces the real wage and shifts the supply curve S (solid) downward to S' (dashed). The extent of depreciation is determined by the need to maintain full employment. Hence, the level of output in the non-traded goods sector remains unaffected by the shock—the Classical scenario.

Consider now a positive government spending shock. As shown in the right panel, it shifts the demand schedule to the right, starting again from the full-employment equilibrium A. Since the economy already operates at full capacity, the additional demand is fully absorbed by an increase in the price of non-traded goods under both, the peg and the float. Likewise, for both exchange-rate regimes, private consumption of non-traded goods is completely crowded out. In the new equilibrium, the production of non-traded goods and the employment level are unchanged, while the relative price of non-traded goods is higher—that is, there is a real appreciation.

3.2 Taxing traded-goods consumption: an equivalence result

A distinct feature of government spending is that it falls on domestically produced goods only: a shift in government spending not only alters the level but also the composition of aggregate demand. To highlight this aspect, we establish formally that the production level in the market for non-traded goods associated with a specific level of permanent government spending may also result from taxing traded-goods consumption. Such a tax also twists the composition of aggregate demand by altering the marginal rate of substitution between traded and non-traded consumption.[9]

To establish this point formally, we consider an economy without government spending where the government charges a tax τ_t^c on traded-goods consumption and rebates the proceeds to the household in a lump-sum manner. Denote with $\tilde{c}_t^N$ a specific level of non-traded goods consumption in the baseline model associated with a permanent level of spending, g_t^N. Then setting the tax equal to the ratio of marginal utilities of non-traded goods consumption in the tax model and the baseline model, that is,

$$1 + \tau_t^c = \frac{U_{\tilde{c}_t^N}}{U_{c_t^N}} = \frac{c_t^N}{\tilde{c}_t^N} \; , \tag{3.19}$$

ensures that the equilibrium allocation is the same as in the baseline model. The only difference is private non-traded consumption. The household also consumes non-traded goods otherwise consumed by the government: $c_t^N = \tilde{c}_t^N + g_t^N$. Rule (3.19) ensures that the price of non-traded goods and, hence, the rest of the economy behaves just like in the baseline, see equation (3.4) in particular. We provide details and a formal proof in Appendix A.3.

3.3 A payroll tax: restoring symmetry

Our baseline model assumes that government spending is financed through lump-sum taxes. Because Ricardian equivalence holds, the timing of taxes is irrelevant—our results carry over to a scenario where government debt absorbs the change in government spending. Here, we relax the assumption of lump-sum taxes and assume instead that the government balances the budget in each period by means of a payroll tax, τ_t^w. Real firm profits ϕ_t^r are then given by

$$\phi_t^r = p_t^N y_t^N - (1 + \tau_t^w) w_t h_t \tag{3.20}$$

and the government budget constraint becomes

$$\tau_t^w w_t h_t = p_t^N g_t^N \; . \tag{3.21}$$

[9] We thank the editor for suggesting this perspective to us. In the case of *temporary* government spending shocks, a tax on traded-goods consumption is not sufficient to replicate the "government spending equilibrium" since one would need to manipulate the intertemporal margin as well. In this case, equivalence could be restored by access to a consumption tax on non-traded goods.

It turns out that, under these assumptions, the effects of government spending are no longer asymmetric. Intuitively, as in Farhi et al. (2014) and Schmitt-Grohé and Uribe (2016), when the nominal exchange rate is fixed, changes in the payroll tax alter the real exchange rate. In fact, as we show formally for our setup in Appendix A.4, the payroll tax fully insulates the real wage from changes in government spending, thus undoing the DNWR. At the same time, the tax wedge allows the price of non-traded goods to fully adjust in both directions.

3.4 The full model: simulation results

We now relax the simplifying assumptions of Section 3.1 and solve the full model numerically. In this way, we can study the quantitative relevance of the asymmetry in the fiscal transmission mechanism in the impact period and beyond. We can also explore the impact of fiscal shocks on international trade, which is zero in the bare-bones model because of the unitary elasticities.

We calibrate the model to capture key features of the Greek economy. This is for two reasons. First, Greece is a small open economy that operates within the euro area. From the perspective of the model, this corresponds to an exchange-rate peg as far as the transmission of government spending shocks is concerned. Second, while SGU calibrate their model to Argentina, they also consider an alternative calibration to Greece. We thus tie our hands by adopting their calibration—except in those instances where we explicitly account for government spending (since they do not)—see Appendices B.2 to B.4 for further details. In what follows, a period corresponds to one quarter, during which wages may effectively fall by at most 0.78%.

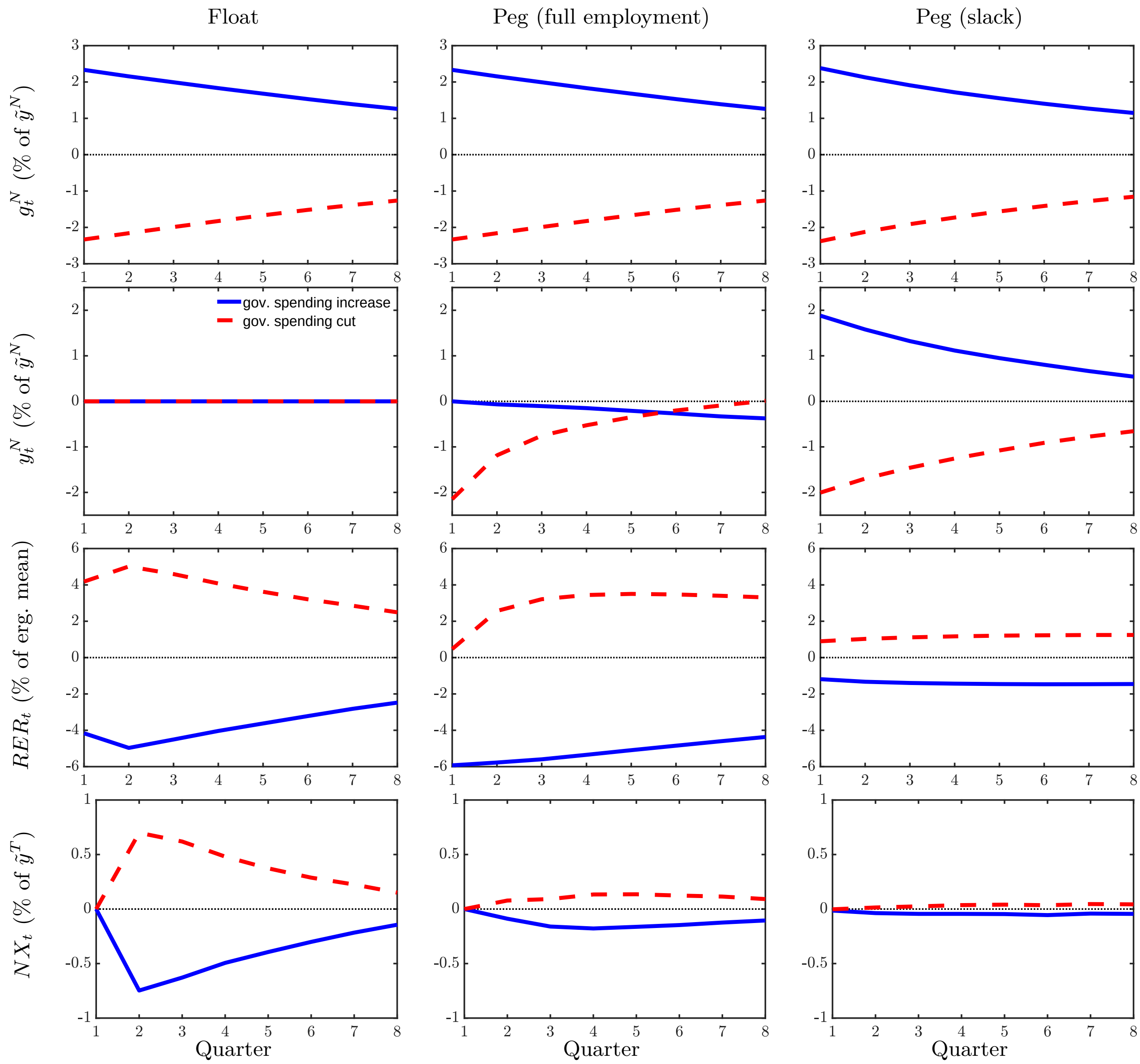
Figure 2 displays the impulse responses functions (IRF) to positive and negative government spending shocks of ± 2.2 percentage points of steady-state non-traded output (a one-standard-deviation shock).[10] In the figure, the solid lines represent the dynamics triggered by a spending increase, while the dashed lines correspond to a spending cut. We study the responses over the first 8 quarters after a shock. In the left column, we show results for flexible exchange rates, where output is stabilized at full employment. In the middle column, we show results for an economy that features an exchange-rate peg and initially operates at full capacity. In the right column, we consider an exchange-rate peg with economic slack, captured by simulations with an average unemployment rate of 14%.[11] The panels in the top row of Figure 2 show the dynamics of government spending. Since government spending is determined exogenously, the dynamics are the same across all columns. The second and third rows show the adjustment of non-traded output, y_t^N, and the real exchange rate, RER_t, respectively.[12] As before, a decline of RER_t represents a

[10] We employ generalized impulse response functions (GIRFs) that, for a given initial point in the state space, compare how variables evolve in response to a shock relative to a baseline scenario without the shock. We average over one million replications to integrate out the effect of future shocks.

[11] Using different initial conditions for the scenarios allows us to capture the role of economic slack. See Appendix B.5 for details. Appendix B.6 provides summary statistics of the ergodic distribution.

[12] The exchange rate is measured in percent of the ergodic mean. Government spending and non-traded output are measured in percent of non-traded output under full employment. The latter normalization is used for better comparability. If we were to use the ergodic mean for non-traded output, the scaling of the IRFs would be affected by the different unemployment rates in the ergodic distribution across exchange-rate regimes.

Figure 2: Quantitative model irf



Notes: Generalized impulse responses to one-standard-deviation government spending shocks in the quantitative model. Blue solid line: spending increase, red dashed line: spending cut. Left column: flexible exchange rate. Middle column: exchange-rate peg and full employment. Right column: peg and economic slack. Top row: government spending; second row: non-traded output; third row: real exchange rate; bottom row: trade balance. Vertical axis: effect of shocks in percent of full employment non-traded output, $\tilde{y}^N$, of the ergodic mean of the RER, and traded output, $\tilde{y}^T$, respectively.

real appreciation. The last panel shows the response of net exports (in percent of mean traded output).

Several points are particularly noteworthy. First, as established for the Classical scenario in Section 3.1, under a float the adjustment to the shock is perfectly symmetric, not only on impact but also over time (left column). The real exchange rate adjusts and output is insulated from the shock. Second, the shock is asymmetric under a peg with full employment (middle column). The exchange rate appreciates strongly in response to positive shocks but depreciates only mildly in response to negative spending shocks. Over time the depreciation continues because we no longer restrict wages to be completely downwardly rigid. There is also a strong asymmetry in the output response. In fact, in response to a positive shock, output declines somewhat over time as the shock process reverts to the mean. Third, we find that under a peg the adjustment of output and the real exchange rate is symmetric if there is slack (right column). Schmitt-Grohé and Uribe (2021) analyze this case in more detail while studying the response of fiscal policy to an adverse terms-of-trade shock. They, too, find that changes in government spending have symmetric effects in a model with DNWR, provided the economy is not operating at its full-employment level.

Finally, we turn to the response of net exports shown in the bottom panels of the figure and defined as the difference between traded output and domestic consumption of traded goods. Net exports decline in response to a spending increase but increase in response to a spending cut—reflecting, in each instance, an increase and a decrease in traded-goods consumption, respectively (traded output is exogenous). Recall that traded-goods consumption and thus net exports are not responding to government spending shocks in the bare-bones version of the model, which assumes Cobb-Douglas preferences (unitary elasticities). The simulation of the full model instead follows SGU in assuming that $\sigma = 5$ and $\xi = 0.44$, which implies that the intertemporal elasticity of substitution ($1/\sigma$) is smaller than the intratemporal elasticity of substitution. As a result, traded-goods consumption rises as higher government spending lowers non-traded-goods consumption, consistent with recent evidence by Lambertini and Proebsting (2023).

4 Empirical strategy

In order to confront the predictions of the model with the data, we rely on a panel of countries with fixed and flexible exchange rates. The predictions of the theoretical model pertain to the short run: They are sharpest for the impact period (Section 3.1), but extend to several quarters after impact, see Figure 2. Our empirical strategy is thus centered around estimating the short-run impulse responses to government spending shocks.

4.1 Identification and estimation

We proceed in two steps. First, we identify fiscal shocks—exogenous variation in government spending and taxes—denoted by $\varepsilon^{g}_{i,t}$ and $\varepsilon^{tax}_{i,t}$, respectively. The indices i and t refer to country i and period t. In terms of identification, we follow the sign-restriction approach of Mountford and Uhlig (2009). It rests on the notion that the largest share of business cycle fluctuations is caused by non-fiscal shocks and employs a criterion function approach to identify those before identifying the fiscal shocks. While fiscal shocks are required to be orthogonal to the business cycle shock, their identification allows for contemporaneous feedback from output to government spending and taxes. Explicitly identifying tax shocks also helps to alleviate concerns that tax shocks cause spending changes (for instance, due to balanced budget rules) which would then be misclassified as spending shocks. As we explore the robustness of our results below, we also report results that are based on the approaches of Blanchard and Perotti (2002) and Miyamoto et al. (2019), respectively.

In our baseline specification, we control for fiscal foresight by requiring that fiscal shocks are orthogonal to movements in government spending growth forecasts (Auerbach and Gorodnichenko, 2012). We further control for default-risk spreads, a forward-looking financial market variable. Specifically, our vector of endogenous variables, $X_{i,t}$, includes government spending growth forecasts, the logs of real tax revenues, real government spending, real output, and the effective real exchange rate, plus the level of the default-risk spread on government bonds. We pool observations across countries as we estimate a panel VAR model—while allowing for country-fixed effects and country-specific time trends—because the time series for individual countries are sometimes short. We verify that shock series are similar once we estimate the VAR on a country-by-country basis.

Given the vector of observables, we estimate the reduced-form panel VAR:

$$X_{i,t} = \alpha_i + \eta_t + \gamma_i T_t + A(L) X_{i,t-1} + \nu_{i,t} \ , \tag{4.1}$$

where $A(L)$ is a lag polynomial, α_i and η_t denote country- and time-fixed effects and $\gamma_i T_t$ is a country specific linear time trend. $\nu_{i,t}$ is a vector of reduced-form disturbances with covariance matrix $E(\nu_{i,t}\nu'_{i,t}) = \Omega$. As shown in Uhlig (2005) and Mountford and Uhlig (2009), we may recover the structural shocks from the reduced form VAR by finding the columns associated with each shock of an appropriate orthonormal rotation matrix Q applied to the lower Cholesky factor of Ω.

In our baseline specification, we identify four shocks sequentially: two more shocks in addition to $\varepsilon^g_{i,t}$ and $\varepsilon^{tax}_{i,t}$. The first of these is a forecast shock, which is assumed to be the only shock that contemporaneously affects the government spending growth forecasts. The second is a business cycle shock. It is required to be orthogonal to the forecast shock and maximizes the impact response of output and tax revenues, subject to the constraint that both responses have a positive sign.[13] We rely on the simple-rule approach of Caldara and Kamps (2017) to subsequently identify $\varepsilon^g_{i,t}$ and $\varepsilon^{tax}_{i,t}$. They are restricted to be orthogonal to the forecast and the business cycle shock and yield the maximum impact response of the respective fiscal instrument. At the same time, these instruments may respond contemporaneously to output. We finally orthogonalize the government spending and the tax shock by means of a Cholesky decomposition. Government spending is ordered first but we verify that results are robust if we switch the ordering. As a practical matter, we estimate the reduced-form VAR with four lags using Bayesian techniques. We employ a weak Minnesota dummy variable prior and retrieve the structural shocks at the posterior mean.[14]

For our sample of floaters, the lack of government spending growth forecast and tax revenues data forces us to identify government spending shocks in the first stage based on a variant of the Blanchard-Perotti approach only. Specifically, in this case, we assume that government spending

[13]Formally, this is achieved by finding the column of Q that minimizes the penalty function $\Psi = -\sum_{j\in\{Y,T\}} [\mathbb{I}_{IRF>0} IRF_{j0} + 100\mathbb{I}_{IRF<0} IRF_{j0}]$, where IRF_{j0} denotes the impact response of variable j and $\mathbb{I}$ is an indicator function conditioning on the sign of the response.

[14]Our dummy variable prior employs the hyperparameter vector $\lambda = [0.2, 2.5, 0, 0.5, 0.5]$, see Chapter 2.2. of Del Negro and Schorfheide (2011).

is predetermined to achieve identification.[15]

In the second step, we estimate local projections, which are particularly suited to account for potentially asymmetric effects of positive and negative shocks. Following Kilian and Vigfusson (2011), we sort government spending shocks according to their sign and define $\varepsilon^{g+}_{i,t} = \varepsilon^{g}_{i,t}$ if $\varepsilon^{g}_{i,t} \geq 0$ and 0 otherwise, and analogously for negative shocks, $\varepsilon^{g-}_{i,t}$.[16] Letting $x_{i,t+h}$ denote the variable of interest in period $t+h$, we estimate how it responds to government spending shocks in period t on the basis of our baseline specification:

$$x_{i,t+h} = \alpha_{i,h} + \eta_{t,h} + \psi_h^{+}\varepsilon^{g+}_{i,t} + \psi_h^{-}\varepsilon^{g-}_{i,t} + \gamma Z_{i,t} + u_{i,t+h} \ . \tag{4.2}$$

Here, the coefficients ψ_h^{+} and ψ_h^{-} provide a direct estimate of the impulse response at horizon h to a positive and negative government spending shock, respectively. When we study the effects of spending shocks under the balanced-budget restriction below, we include positive and negative tax shocks $\varepsilon^{tax+}_{i,t}$ and $\varepsilon^{tax-}_{i,t}$ as additional regressors. Throughout we include the vector of control variables, $Z_{i,t}$, which features four lags of our main variables of interest: the logs of real government spending, output, tax revenues, and the effective real exchange rate.[17] The error term $u_{i,t+h}$ is assumed to have a mean of zero and strictly positive variance. $\alpha_{i,h}$ and $\eta_{t,h}$ denote country- and time-fixed effects. We compute standard errors that are robust with respect to heteroskedasticity as well as serial and cross-sectional correlation (Driscoll and Kraay, 1998).

Finally, we note that while specification (4.2) allows the effects of positive and negative shocks to differ, the VAR model (4.1) does not. One may thus worry that the VAR captures only the type of government spending shock that has symmetric effects on the variables in the VAR. Still, the VAR will be able to capture also shocks that impact the economy asymmetrically for as long as the underlying fiscal rule is linear in the observed variables (even if these follow a nonlinear process). We verify this by means of a Monte Carlo exercise in Section 5.3. In addition, we check below that our main result also obtains under the one-step approach of Miyamoto et al. (2019).

4.2 Data

We estimate our baseline specification on EA countries, using quarterly observations for the period 1999–2017 with data provided by Eurostat.[18] We use the CPI-based intra-EA real effective exchange rate and let an increase indicate a depreciation. As in Born et al. (2020), we measure default risk as

[15]As shown by Caldara and Kamps (2017), it is the estimated output elasticity of government spending that distinguishes the sign restriction approach from the Blanchard and Perotti (2002) approach, where the feedback elasticity is set to zero based on ex-ante arguments.

[16]The estimated shocks $\hat{\varepsilon}^{g}_{i,t}$ enter the second-stage equation (4.2) as generated regressors. However, as shown in Pagan (1984), the standard errors on the generated regressors are asymptotically valid under the null hypothesis that the coefficient on these regressors is zero. See also Coibion and Gorodnichenko (2015), footnote 18, on this point.

[17]These controls are by construction orthogonal to the shocks, but by potentially purging the regression residual $u_{i,t+h}$ of predictable variation, they allow for sharper inference. We remove country-specific linear time trends for logs of real output, government spending, and tax revenues on both sides of the equation. Doing the same for the real exchange rate does not alter our results.

[18]Appendix C provides detailed data sources.

the yield spread of domestic government debt vis-à-vis a riskless foreign benchmark, denominated in the same currency. In the case of euro area countries, our sample is restricted by data availability for spending growth forecasts. Here we rely on proprietary data on quarter-on-quarter government spending growth rate projections provided by *Oxford Economics*.[19]

In addition, we consider a panel of countries with floating exchange rates. Here we use the broad real effective exchange rate index compiled by the Bank for International Settlements (BIS), complemented by data for Ecuador and Uruguay, based on the data for 38 trading partners compiled by Darvas (2012). We obtain quarterly values as the average of the monthly index values. We use the classification scheme of Ilzetzki et al. (2019) to identify countries as "floats": countries that operate a "pre-announced crawling band that is wider than or equal to +/-2%" or a more flexible arrangement qualify. For floats, our sample is constrained by the limited availability of data for the default-risk spread. We report details on the country coverage in Table C.3 in the appendix.

5 Empirical evidence

We now present estimates for the effects of government spending shocks—distinguishing between positive and negative shocks. As established in Section 3, this distinction is important for understanding the effects of fiscal shocks in open economies, provided that additional conditions are met. Most importantly, the model predicts the effects of positive and negative spending shocks to differ only for exchange-rate pegs. Second, the state of the business cycle matters for the response under a peg: in cases with sufficient slack, the model predicts the response to be symmetric and, while not formally studied in our model analysis above, whether the response is asymmetric should also depend on the level of inflation. If inflation is high, the effect of DNWR on the transmission of government spending shocks—which is the root cause of the asymmetry—should largely be undone. Finally, once the assumption of lump-sum taxation is relaxed, the effects of spending shocks are no longer asymmetric under a balanced-budget restriction. In our empirical analysis, we account for these complications step-by-step. Our main results are based on the individual countries of the euro area (EA). These countries are de facto operating like economies under an exchange-rate peg because they cannot resort to monetary policy to bring about a nominal exchange-rate adjustment in response to country-specific (fiscal) shocks.[20]

5.1 Baseline estimates

Before we present results for EA countries, we address several concerns regarding our sample upfront. First, the nominal exchange rate of each EA member is fixed as far as the other EA

[19] *Oxford Economics* is a large forecasting firm serving a wide range of clients, including large corporations and institutions. We focus on growth *rate* rather than *level* predictions because there are irregular base-year changes for the countries in our sample. They would show up as structural breaks if we were considering levels.

[20] At least to the extent that country-specific developments in individual member states have little bearing on the conduct of the area-wide monetary policy by the ECB. We restrict our sample to observations for euro area countries after their exchange rates vis-à-vis the euro have been "irrevocably" fixed. See Table C.3 for the sample coverage.

countries are concerned. At the same time, the euro is floating against many non-euro currencies. For our baseline specification, therefore, we use the *intra*-EA real effective exchange rate, computed as the CPI in the other EA countries relative to the CPI in the domestic economy (a decline represents an appreciation). Second, because EA countries may be subject to common shocks and events, equation (4.2) features time-fixed effects, thus controlling for EA monetary policy shocks. As a result, identification is not driven by EA-wide developments but by country-specific fluctuations relative to the common component.[21] Still, and this is a third complication, a fiscal shock that occurs in a big EA country such as Germany, France, or Italy or a very large shock in a small country such as Greece may still have a non-negligible impact on EA-wide aggregates. This may induce an adjustment of monetary policy that is ruled out in our stylized model of an exchange-rate peg. We, therefore, verify that results are not driven by specific countries in the sample.

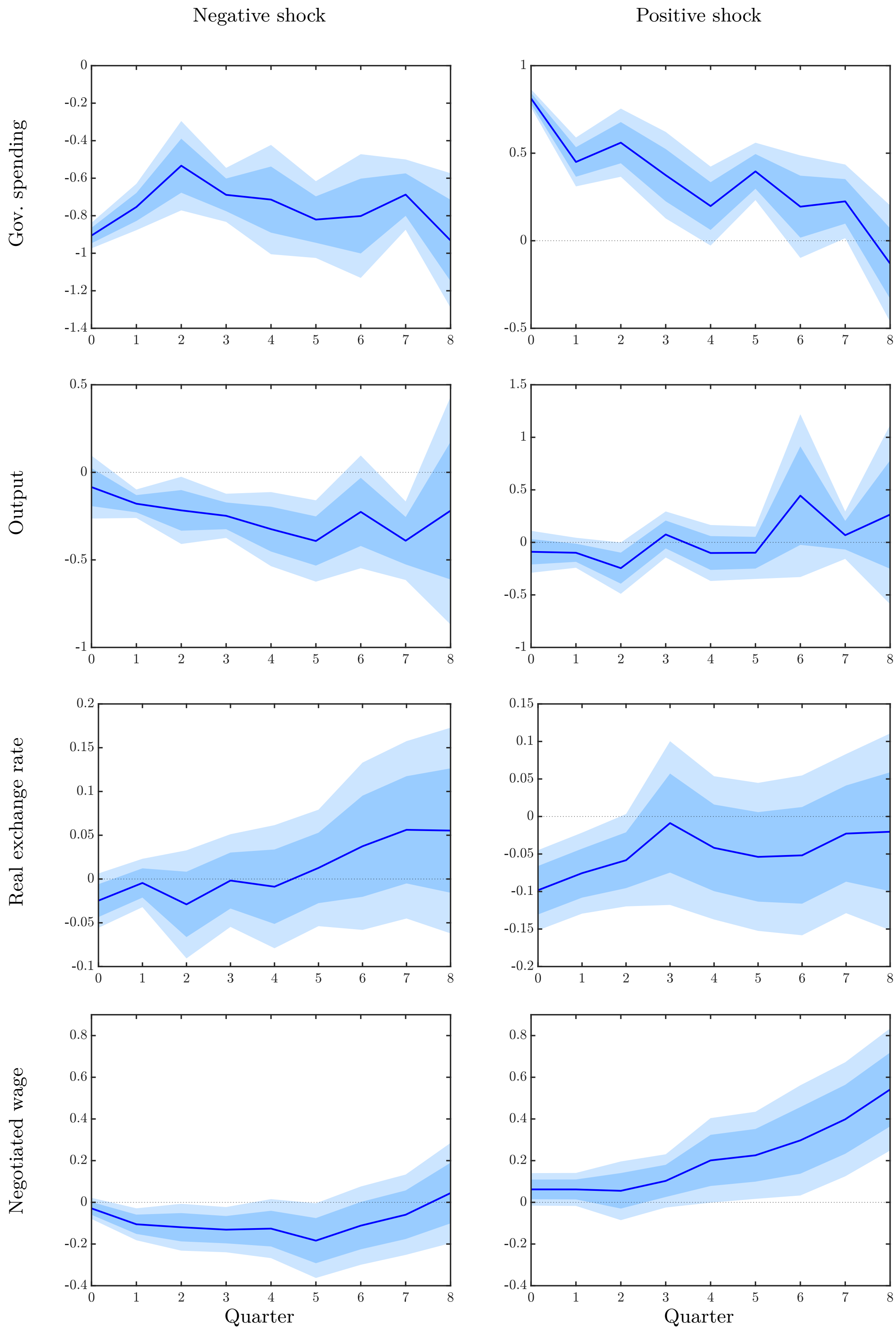
We show results for our baseline specification in Figures 3.A and 3.B. In these figures, and in what follows, solid lines represent point estimates, while light (dark) shaded areas represent 90 (68) percent confidence intervals. While our focus is on the impact response and the short-run adjustment, measured in percentage deviation from the pre-shock level/trend along the vertical axis, we show results for a two-year period after impact, measured along the horizontal axis in quarters. The left column shows responses to a negative government spending shock and the right column responses to a positive shock. The response of government spending, shown in the top row of Figure 3.A, is fairly persistent in both cases; somewhat more so in case of a spending cut but also in this case spending gradually reverts back to the pre-shock level at longer horizons (not shown). Also, recall that the prediction of the bare-bones model for the impact responses does not depend on the persistence of the spending shock.

The panels in the second and third rows show the responses of output and of the real exchange rate, respectively. We find that the predictions of the model are fully borne out: output drops in response to a spending cut (left), but it is virtually unchanged if government spending is raised (right). The real exchange rate, instead, does not respond to a spending cut, but it appreciates (declines) on impact and in the short run in response to a spending increase. Because it is the key point of our analysis, we also perform a formal statistical test of whether the impulse responses are indeed asymmetric in the sign of the government spending shock. The coefficients that capture the effects of positive and negative shocks are simultaneously estimated in specification (4.2). One may thus simply test the null hypothesis that these two coefficients are the same. Table 1 reports the difference between the estimated coefficients in the top row. When the difference is significantly different from zero, we reject the null of symmetric effects of positive and negative shocks. For the real exchange rate (right panel) we do so for the impact response as well as for the first quarter; for output (left panel) we reject symmetry in quarters 1 and 2 (at least at the 10 percent level).

In sum, the evidence supports the theory: A negative shock is absorbed by economic activity, while a positive shock is absorbed by relative prices—Mr. Keynes meets the Classics. It is also

[21] We also compute the cross-country correlation of shocks. This is of particular interest because, during the sovereign debt crisis in the EA, there were some considerable shifts in fiscal policy, possibly correlated across countries. We find, however, that most cross-country correlations are moderate, see Table C.4 in the appendix.

Figure 3.A: Adjustment to government spending shocks



Notes: Estimates for panel of EA countries. Solid lines represent point estimates, light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from the pre-shock trend/level in percent.

Table 1: Differences in response coefficients across states and shock signs

	Output					Real exchange rate				
	0	1	2	3	4	0	1	2	3	4
$\psi_h^- - \psi_h^+$	0.17	0.28***	0.46*	0.17	0.43	0.12***	0.08*	0.09	0.01	0.05
$\psi_h^+ \vert u^h - \psi_h^+ \vert u^l$	0.11	-0.02	0.14	0.32**	0.73**	0.16***	0.01	-0.01	-0.10	-0.03
$\psi_h^- \vert u^h - \psi_h^- \vert u^l$	-0.02	0.12	0.11	0.05	-0.21	-0.06	-0.06	-0.14	-0.12	-0.18
$\psi_h^+ \vert \pi^h - \psi_h^+ \vert \pi^l$	-0.50	-0.21	-0.37	-0.15	-0.43	0.03	0.11	0.09	0.11	0.17
$\psi_h^- \vert \pi^h - \psi_h^- \vert \pi^l$	0.70	0.40**	0.40	0.31	0.32	-0.21***	-0.25***	-0.24***	-0.23**	-0.34**

Notes: entries report differences of estimated response coefficients across signs and states for $h = \{0, \ldots, 4\}$, see equation (4.2). A decline in response to a negative shock requires a positive coefficient, see Figure 3.A. Top line: baseline effect of cut v hike. Middle panel: response coefficients for hike and cut, comparing high and low slack (unemployment state u). Bottom panel: same but for high v low inflation π. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively.

worth commenting briefly on the fiscal multiplier implied by our estimates. For positive spending shocks, the (impact and peak) multiplier is essentially zero. In response to a negative spending shock, the strongest output effect obtains between 1 and 1.5 years after impact. Afterward, output starts to revert to its pre-shock trend. Given that government consumption accounts for about 20 percent of GDP on average, our finding that a change in government spending of one percent affects output by some 0.3 percent implies a multiplier of about 1.5.[22]

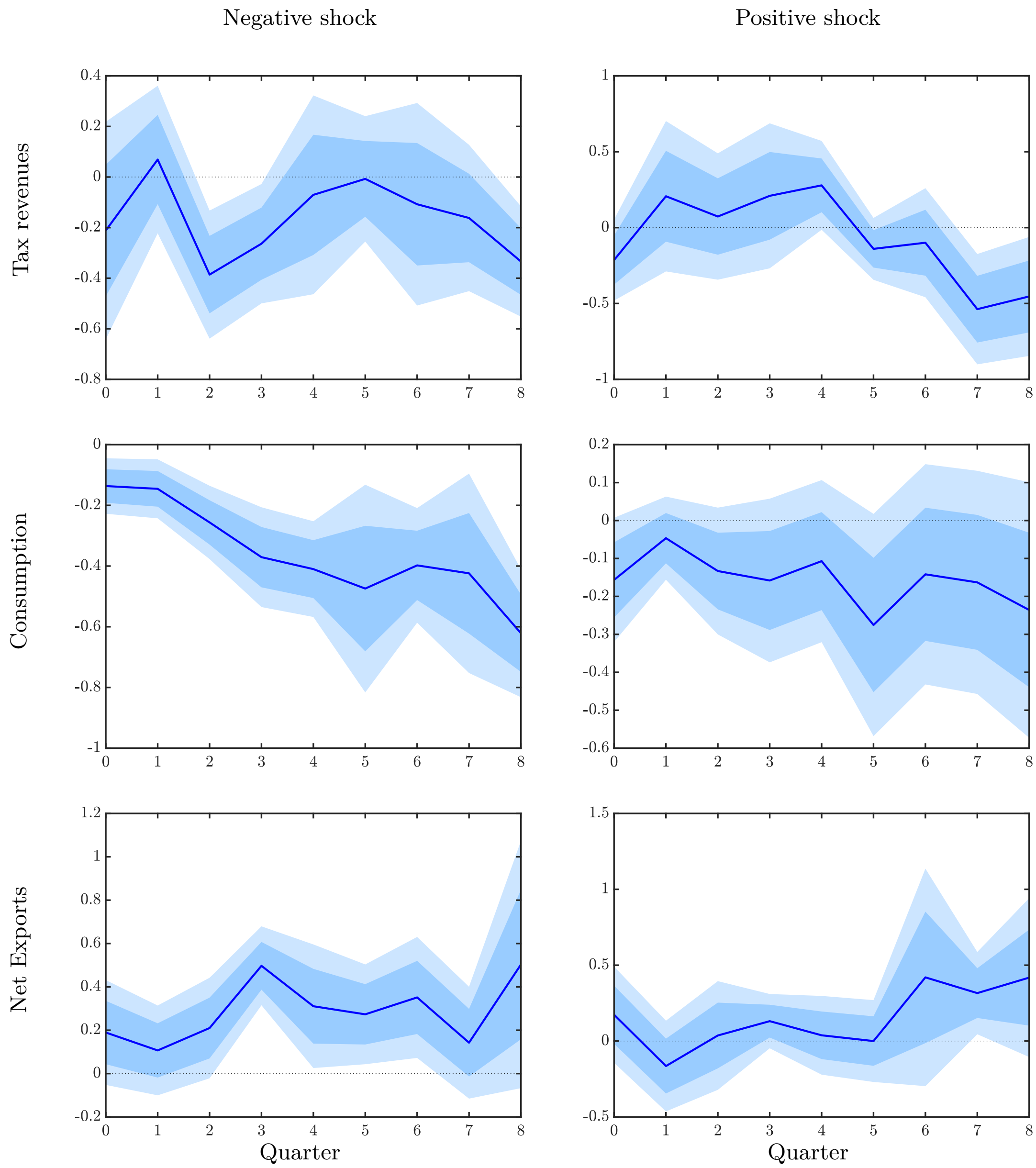
The key to the transmission mechanism in the model is the asymmetric responses of nominal wages: rigid downwards, flexible upwards. In principle, the response of wages offers a stringent test of the theory. Yet genuine quarterly time-series data for nominal wages are only available for a limited number of countries in our sample.[23] We, therefore, estimate the response of negotiated wages on a sub-sample of 8 EA countries and show results in the bottom panel of Figure 3.A. And indeed, wages do hardly decline in response to spending cuts but rise in response to spending increases. The asymmetric wage response supports the mechanism which operates at the heart of the model. However, we acknowledge that wages start to increase in response to a spending increase only with a delay of about one year, presumably because actual wages are often renegotiated only once per year.

Figure 3.B shows the estimates (based on the full EA sample) for the responses of additional variables to both negative and positive shocks, starting with tax revenues in the top row. They decline somewhat in response to the spending cut and go up in response to the spending increase—showing that the change in spending is neither completely absorbed via debt nor entirely through an adjustment of taxes. It is therefore of particular interest to study the effect of spending shocks under the constraint that the full impact of the spending shock on the budget is neutralized through

[22]With this ex-post conversion, we mean to provide only a ballpark for the multiplier. It is not the focus of the present paper. Ramey and Zubairy (2018) provide a detailed discussion of how to estimate output multipliers.

[23]We use national data for negotiated wages that is the basis of the ECB's negotiated wage tracker (ECB, 2002). See Appendix C for details.

Figure 3.B: Adjustment to government spending shocks cont'd



Notes: Estimates for panel of EA countries. Solid lines represent point estimates, light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from the pre-shock trend/level in percent.

an appropriate adjustment of taxes. We do so in Section 5.4 below.

In the middle row of the figure, we show the response of private consumption. Consumption drops in response to a spending increase (right panel). This response, albeit only marginally significant, is in line with the predictions of the model according to which higher government spending crowds out private consumption. In response to a spending cut (left panel), consumption also declines. While this is a (broadly understood) Keynesian type of adjustment, we note that in our model, consumption does not respond at all to a spending cut. This suggests that, while absent from our model, an additional amplification mechanism is operative. Yet, what seems remarkable in light of earlier empirical work is that the co-movement of government spending and private consumption changes in the sign of the shock. Standard models of both, the neoclassical and the New Keynesian variety, predict a negative co-movement (Baxter and King, 1993; Linnemann and Schabert, 2003), a prediction which does not square well with the evidence put forward in influential studies based on linear time-series models (Blanchard and Perotti, 2002; Mountford and Uhlig, 2009; Ramey, 2011).

We show the estimated response of net exports in the bottom row of Figure 3.B. Consistent with the prediction of the model, we find that negative shocks raise net exports (Section 3.4). But while the model predicts a decline in net exports after a positive shock, the estimated response is flat.[24] Furceri et al. (2022), too, find that net exports are unresponsive when they estimate the macroeconomic effects of tariff shocks in a large country panel. This is noteworthy because raising tariffs (on traded-goods consumption) is equivalent to raising government spending (on non-traded goods) in our model (Section 3.2). Furceri et al. (2022) also find that tariff shocks have virtually no bearing on output in the short run but induce real appreciation.[25]

Our results are robust with respect to a number of variations. Once we employ a variant of the Blanchard-Perotti approach to identification, extended to control for fiscal foresight, we obtain results that are very similar to the baseline, see Figure D.1. They are similar because the estimated output elasticity of government spending is only 0.07 in the baseline, see Figure C.1 for a comparison of the identified shocks. We also verify that our results are not driven by individual countries. In a first set of regressions, we drop the big three economies in the EA from our baseline sample: France, Germany, and Italy. Figure D.2 shows that results are similar to the baseline. Next, we drop Greece from the sample, since fiscal policy in Greece was at the center stage of the sovereign debt crisis in the EA.[26] Results are shown in Figure D.3, again together with those for the baseline. Once more the results are quite similar, notably as far as the exchange-rate adjustment is concerned.[27]

As an additional robustness test, we follow Miyamoto et al. (2019) and consider annual military spending in 125 countries over the period from 1989 to 2013 as a measure of government spending. Since military spending is arguably exogenous to the business cycle, we may thus directly estimate an annual-frequency version of the asymmetric local projection (4.2), replacing the VAR-based shocks with the change in military spending (measured in percent of last year's output). We focus

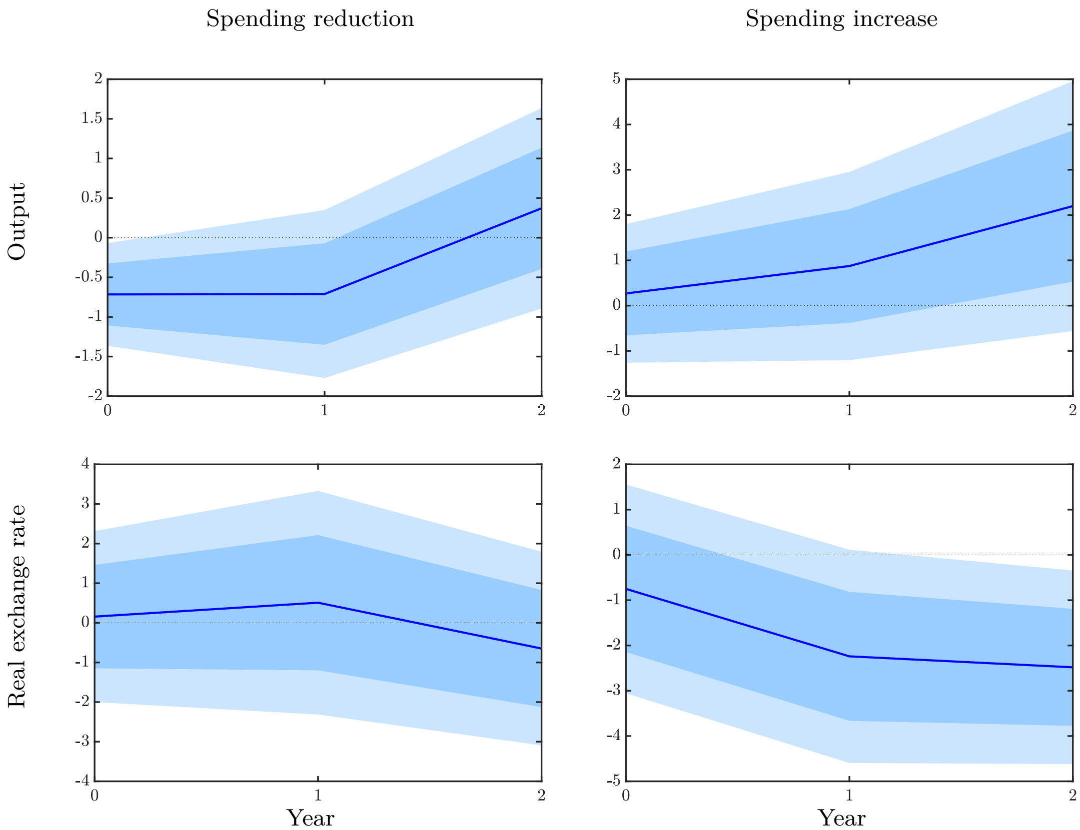
[24]Earlier work on the response of net exports to government spending shocks has obtained conflicting results based on linear models. Some studies find an increase of net exports in response to (positive) spending shocks (e.g. Corsetti and Müller, 2006; Kim, 2015; Kim and Roubini, 2008) others find a decline (e.g., Ilzetzki et al., 2013; Monacelli and Perotti, 2010; Ravn et al., 2012).

[25]See their Figure 1, which is based on a symmetric model. Furceri et al. (2022) also condition the effect of tariffs on expansions and recessions. Consistent with the predictions of our model, they find that tariff shocks are expansionary during recessions but not during expansions (their Figure 4). Furceri et al. (2022) also consider the possibility that positive and negative tariff shocks have different output effects and find that positive tariff shocks tend to lower output, in contrast to what our model predicts. However, a more systematic analysis would need to simultaneously account for the exchange-rate regime. We leave this for future work.

[26]Note that any default episodes like the Greek ones (2012Q1–2012Q2, 2012Q4) are excluded from the sample.

[27]We also consider an alternative measure for the real exchange rate since it is the focus of our analysis. Our baseline estimates are based on the intra-EA real effective exchange rate. We find that using a broader real effective exchange rate measure yields similar results, see Figure D.4.

Figure 4: Adjustment to changes in military spending

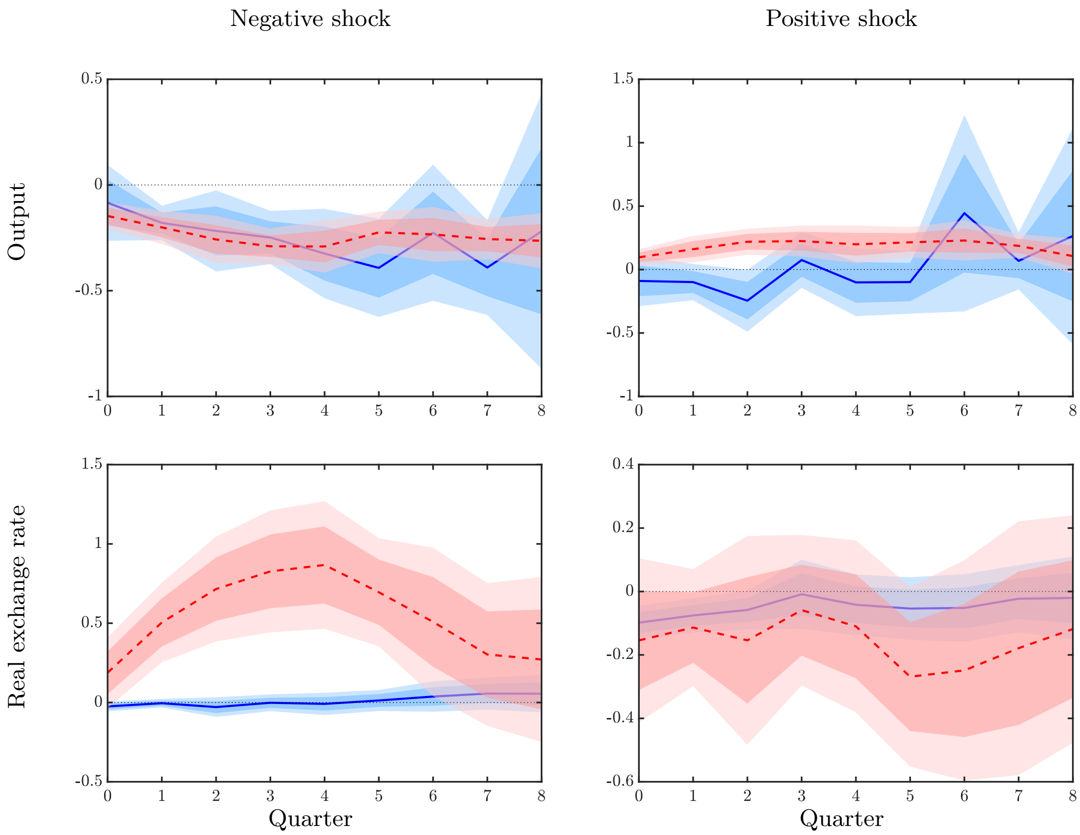


Notes: Effect of government spending measured on the basis of military spending in a large panel of countries with fixed exchange rates, following Miyamoto et al. (2019). Annual observations. Solid lines represent point estimates, and light (dark) shaded areas represent 90 (68) percent confidence intervals based on clustered standard errors. Vertical axis measures deviation from the pre-shock trend/level in percent.

on the countries with fixed exchange rates, relying on the exchange-rate regime classification of Miyamoto et al. (2019), which in turn rests on Klein and Shambaugh (2008), and distinguish again between positive and negative changes. As in our baseline local projection, we control for lagged government spending, output, and the real exchange rate. In addition, as in Miyamoto et al. (2019), we include a war dummy that indicates when a country is in a conflict, and control for the monetary policy stance by including the lagged central bank policy rate. This specification allows us to verify robustness along two dimensions. First, it does not rely on a two-step approach. Second, it considers a much broader class of pegged economies than the EA countries in the baseline.

Figure 4 shows the results, again for a cut in government spending in the left column and for a hike in the right column. Overall, the pattern is similar to our findings for the EA baseline specification. The exchange rate does not respond to a cut of military spending while output falls immediately. In response to a spending increase, the exchange rate appreciates, although significantly so only after the first year. The initial output response is also more subdued than in the case of a spending reduction.

Figure 5: Floats v baseline



Notes: Blue solid lines show results for the baseline sample (shown in Figure 3.A), and red dashed lines show results for the panel of floaters. Solid lines represent point estimates, and light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from the pre-shock trend/level in percent.

5.2 Flexible exchange rates, slack, and inflation

The baseline estimates shown in Figures 3.A and 3.B are based on a sample of EA countries, which lack exchange rate flexibility (just like the countries for which we show estimates in Figure 4). In what follows, we contrast these estimates with results for a panel of countries with floating exchange rates (listed in Table C.3). The red dashed lines in Figure 5 show the results for output and the exchange rate while the blue solid lines correspond to the baseline estimate for EA countries, reproduced from Figure 3.A. In countries with floating exchange rates, the real exchange rate depreciates sharply in response to a spending cut (left), exactly as our model predicts. However, this depreciation is not sufficient to insulate output fully from the shock. GDP declines in response to spending cuts for floaters just like in the baseline. Yet after 3 or 4 quarters, the decline is somewhat weaker than under a peg. Importantly, under a float, the adjustment to a positive shock (right) basically mirrors that to a negative shock.

We now turn to additional predictions of the model which follow directly from the way it operates. First, the response to positive spending shocks should also depend on economic slack. Earlier work has focused on the role of slack in the transmission of fiscal shocks and obtained partly conflicting results (Auerbach and Gorodnichenko, 2012; Ramey and Zubairy, 2018). Our stylized model suggests a refinement—economic slack does alter the effect of positive spending shocks but not those of negative shocks: raising government spending in times of slack will affect output rather than the exchange rate (as opposed to when the economy is operating at full capacity). Second, just like slack, high inflation periods should alter fiscal transmission—in this case, however, the effects of negative rather than those of positive shocks. In the model, DNWR prevents real wages from declining in response to a spending cut; it does not constrain their rise in response to a spending hike. In times of high inflation, DNWR has arguably less of a bearing on the adjustment because, in that case, wages are adjusting in real terms, even if they are nominally rigid.

We, therefore, assess empirically how slack and inflation alter the impact of government spending shocks. We use the unemployment rate to identify as periods of slack those observations in our EA sample for which it is above a country's median unemployment rate, as in Barro and Redlick (2011).[28] Similarly, we define high inflation periods in our EA sample as periods where inflation exceeds 3 percent. According to this definition, 44 percent of the observations qualify as episodes of slack, and 23 percent as episodes of high inflation in our sample. Based on these thresholds, we define dummy variables for high/low slack and high/low inflation and interact them with the fiscal shocks in an extended version of specification (4.2). This allows us to formally test whether high slack and inflation indeed alter the effects of negative and positive spending shocks.

Table 1 above reports the results, with entries corresponding to differences in response coefficients due to slack (middle panel) and inflation (bottom panel). For positive shocks (second line) we find that, as predicted by the model, the output effects tend to be stronger and the exchange rate appreciates less in case there is slack. Consistent with the model predictions, the difference is significant for the real exchange rate on impact. The difference for output becomes significant with a delay only, suggesting a richer empirical transmission than in our still fairly stylized model. The third row in the table reports results for positive spending shocks. Here, in line with theory, slack does not make a significant difference.

Turning to the effect of inflation, we find, again consistent with theory, no significant difference in how positive spending shocks play out (fourth line). The effect of negative spending shocks, however, changes with inflation. The real exchange rate appreciates relatively more in response to spending cuts if inflation is high. The output response also becomes stronger in response to spending cuts when inflation is high, a result at odds with the predictions of the model. But the response is significant only in period 3 after impact. Figure D.5 in the appendix illustrates how slack and inflation alter the effects of positive and negative spending shocks, respectively.

5.3 Depreciation bias

Our results are consistent with theory but at odds with a large body of work that finds, robustly across alternative identification schemes—but based on symmetric time-series models—that an

[28] We find that our results are robust once we instead use the cyclical indicator of Bachmann and Sims (2012) to measure slack, see Figure D.6.

unanticipated increase in government spending depreciates the real exchange rate (e.g., Corsetti et al., 2012; Enders et al., 2011; Forni and Gambetti, 2016; Kim, 2015; Kim and Roubini, 2008; Monacelli and Perotti, 2010; Ravn et al., 2012).[29] Ilzetzki et al. (2013) and Miyamoto et al. (2019), too, find a depreciation for high-income countries and for countries with flexible exchange rates. Once they focus on countries with fixed exchange rates, both studies find the response of the real exchange rate to be flat.[30]

Why do our results differ? Not because of the identification strategy, for, as shown above, our results also obtain under the Blanchard-Perotti approach, which has been used in some of the earlier work. Our results may differ, however, because a) we distinguish between positive and negative shocks and b) our sample may be special. To assess the possibility a), the top panels of Figure 6 contrast our baseline estimates (reproduced by the blue solid lines) with results for a restricted specification which constrains the effects of the shocks to be symmetric but is estimated on the same sample (dashed red lines). It turns out that the estimates for the restricted model exhibit a "depreciation bias": the restricted model fails to predict the extent of appreciation we observe for the baseline in response to positive spending shocks. At the same time, it predicts too much depreciation in response to negative spending shocks (again, compared to the baseline).

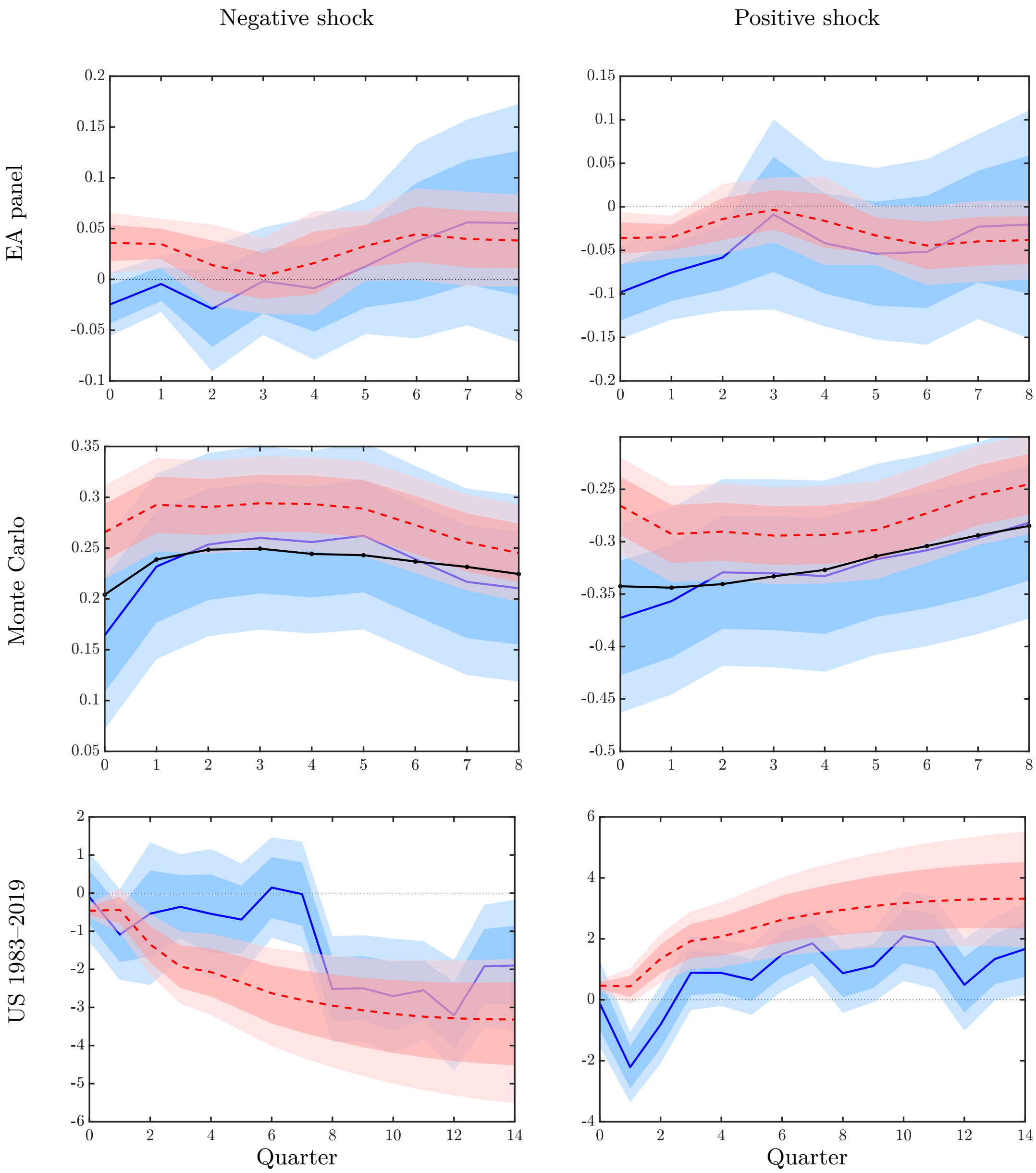
Assuming that the model in Section 2 is the data-generating process, the depreciation bias in the symmetric specification is intuitive. If negative spending shocks actually induce very little depreciation, while positive shocks lead to a sizeable appreciation, a symmetric regression model is misspecified: It delivers an estimate for the response to a spending cut that is too strong (that is, too much depreciation) and an estimate for the response to a spending increase that is too weak (that is, too little appreciation). To illustrate this more systematically, we perform a simple Monte Carlo analysis for which we rely on the quantitative model specified in Section 3.4, extended with a fiscal rule with endogenous feedback as the data-generating process. We estimate both a linear specification and our baseline specification with asymmetric shock effects on the simulated data and show results for the real exchange rate in the middle panels of Figure 6. Appendix B.7 provides further details. The blue solid line represents the baseline estimate. The red dashed line, in turn, shows the estimates for the symmetric specification. We benchmark the estimates against the model-implied responses for a situation of full employment given by the black line with circles and find a sizeable depreciation bias for the symmetric specification. Instead, our baseline specification comes close to recovering the responses accurately.[31]

[29] There are a few noteworthy exceptions. Born et al. (2013) find an appreciation for a panel of floaters, but the response is only marginally significant. Ferrara et al. (2021) obtain an appreciation in a proxy SVAR estimated on US time series. However, their analysis is restricted to a specific sample period for which a suitable instrument is available. Forni and Gambetti (2016) find that *anticipated* spending shocks appreciate the exchange rate, as do Auerbach and Gorodnichenko (2016) when analyzing defense spending *announcements*. Lastly, earlier work based on annual data for EU and EA countries finds that higher government spending appreciates the real exchange rate (Beetsma and Giuliodori, 2011; Bénétrix and Lane, 2013).

[30] Lambertini and Proebsting (2023) likewise find that the terms-of-trade are unresponsive to government spending shocks in a sample of EA countries. However, according to their estimates, the price of non-traded goods increases in response to positive spending shocks.

[31] See Figure B.2 for the results for government spending and output: while in this case the symmetric estimator naturally fails to recover the asymmetric output response, our estimator somewhat overstates it.

Figure 6: Exchange rate response in symmetric specifications



Notes: Top row contrasts symmetric model (red dashed) with baseline (blue solid) for EA sample. Middle row: Black line with circles represents model GIRF from Monte Carlo exercise, blue solid (red dashed) lines represent asymmetric (symmetric) estimates based on simulated data. Bottom row: baseline (blue solid) v symmetric model response (red dashed) based on post-1982 US sample. Solid lines represent point estimates, and light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from pre-shock trend/mean in percent.

Our model simulations assume an exchange rate peg. If monetary policy is instead unconstrained by an exchange rate target, it could adjust the nominal exchange rate to fully absorb the shock. The response to shocks would be symmetric as a result. Yet several of the studies referred to above have established the "depreciation result" for countries with floating exchange rates. For our panel of floats, instead, we find that positive spending shocks appreciate the exchange rate and, more generally, that the effects of shocks are fairly symmetric, see again Figure 5. Yet our float sample includes very few high-income countries, which may explain the absence of a "depreciation result" in light of the earlier work (Ilzetzki et al., 2013; Miyamoto et al., 2019).

Because the depreciation result has been established for the US by many of the studies referenced above, we turn to US data in order to assess the relevance of the depreciation bias for countries with flexible exchange rates. To set the stage, we estimate a parsimonious VAR model on quarterly observations for the log of real tax revenues, government spending, and output, as well as the real exchange rate for the period from 1983 to 2019. We identify spending shocks based on the same sign restrictions as above. The red dashed lines in the bottom panels of Figure 6 show the estimated exchange rate response. Here, as in much of the earlier work, (positive) government spending shocks depreciate the exchange rate. However, once we estimate the effects of the identified shocks on the basis of our baseline model, positive US spending shocks appreciate the exchange rate in the short run (blue solid line). Negative shocks no longer appreciate the exchange rate in the short run. In sum, allowing for asymmetric effects appears to be important to capture the response to government spending shocks more accurately—not only for countries with fixed exchanges rates but even for the US, consistent with recent evidence put forward by Barnichon et al. (2022).

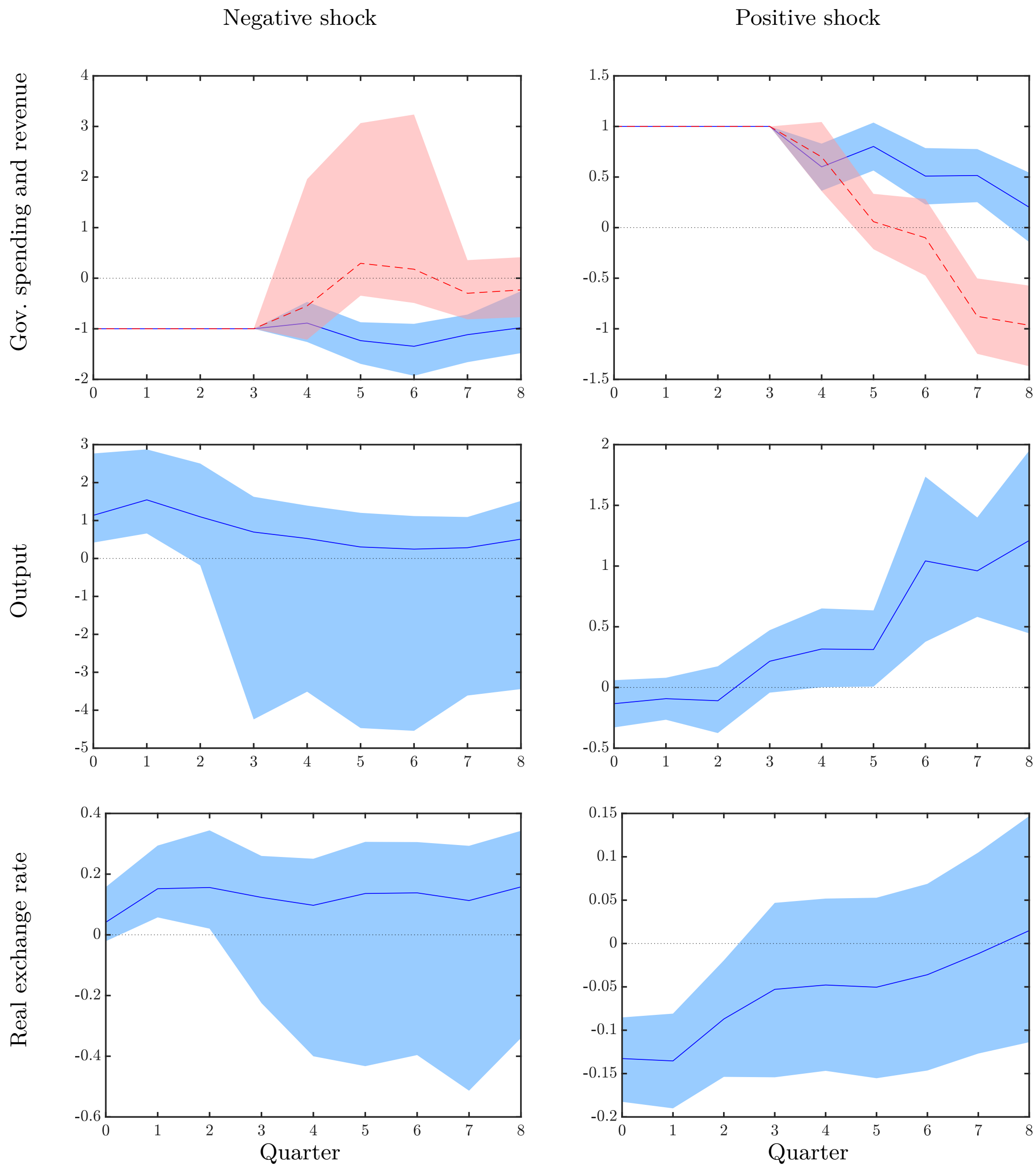
5.4 The case of a balanced budget

The effects of government spending shocks depend on how they are financed. In Section 3.3, we assume a payroll tax (instead of lump sum taxes) and find the effects of government spending are no longer asymmetric. Instead, negative spending shocks depreciate the real exchange rate, just like spending increases appreciate it. We confront this model prediction with new evidence. Specifically, we estimate impulse response coefficients based on a version of specification (4.2) which includes government spending and tax shocks. We then construct a balanced-budget government spending shock as in Mountford and Uhlig (2009): We compute the linear combination of identified tax and government spending shocks required to keep the government budget balanced after a cut/increase in government spending for four quarters and compute the impulse responses to such a joint shock.

Figure 7 shows the results.[32] The responses of spending and taxes are shown in the top panels. The left column corresponds to the case of a spending cut, and the right column to the case of a spending increase, as before. Now, however, the spending cut comes with an immediate tax cut and the spending increase with an immediate tax increase. And indeed, output, shown in the second row, now increases in response to the spending (tax) cut in the short run but declines in response to the spending (tax) increase. The stylized model in Section 3.3 predicts that output remains unchanged at the full employment level in both instances. However, our result squares well with earlier work. Mountford and Uhlig (2009) also find that output declines in response to a balanced-budget spending shock and, more generally, earlier work has frequently found that tax multipliers are considerably larger than spending multipliers (Ramey, 2019). Finally, we show the

[32] We only report 68 percent confidence intervals, because the response of tax revenues to a tax cut is rather imprecisely estimated and we may not reject very small values. If coefficients are close to zero, balancing the budget requires extremely large tax changes. As a result, 90 percent confidence bands can become arbitrarily large in the bootstrap and are, therefore, unappealing on a-priori grounds.

Figure 7: Balanced budget government spending shock



Notes: Balanced budget government spending shock of 1 percent for four periods, with shocks identified using sign restrictions in the first stage, while allowing for asymmetric effects in the second stage. Sample: EA countries. Lines represent point estimates, shaded areas represent 68 percent confidence intervals based on 10,000 bootstrap draws. Blue solid (red dashed) line in top panels represents spending (taxes). Vertical axis measures deviation from pre-shock trend/level in percent.

responses of the real exchange rate in the bottom panels of Figure 7. The exchange rate depreciates in the short run in response to a spending (tax) cut but appreciates in response to a spending (tax) increase. The responses are fairly symmetric—just like the model predicts them to be once we relax the assumption that taxes are lump sum while requiring the budget to be balanced.

6 Conclusion

Our analysis reconciles Keynesian and Classical views on the short-run effects of government spending in open economies. The Keynesian view holds that spending shocks affect economic activity strongly if the nominal exchange rate is fixed. According to the Classical view, spending shocks affect mostly prices. In a sense, both views are correct—it is just a matter of the sign of the fiscal impulse. Our analysis is limited to government spending shocks, but the mechanism that we highlight should also govern the adjustment to other shocks. Investigating that systematically appears to be a very promising avenue for future research. In terms of policy implications, our results reinforce the case for a strongly countercyclical fiscal policy when exchange rates are fixed. After all, cutting government spending during booms is highly effective in reducing inflationary pressures, while raising spending in deep recessions boosts output and employment considerably. However, we also acknowledge that our analysis is purely positive and any policy conclusion is therefore tentative. We leave a rigorous analysis of optimal fiscal policy in this framework for future work.

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Online Appendix

A Bare-bones model

Here we provide additional details and proofs for the arguments of Section 3 in the main text.

A.1 Baseline model

The equilibrium conditions for the baseline version of the bare-bones model are stated in Section 3. We repeat them here with their original equation numbers for convenience.

$$
\begin{aligned}
c_t^T &= y^T - d_t + \frac{d_{t+1}}{1+r} \quad \text{and} \quad 0 = \lim_{j\to\infty} \left(\frac{1}{1+r}\right)^j d_{t+j} \ , && (3.1)\\
c_t^T &= c_{t+1}^T \ , && (3.2)\\
y_t^N &= h_t = c_t^N + g_t^N \ , && (3.3)\\
p_t^N &= \frac{1-a}{a}\frac{c_t^T}{c_t^N} \ , && (3.4)\\
p_t^N &= w_t \ , && (3.5)\\
w_t^f &= \frac{1-a}{a}\frac{c_t^T}{\bar{h} - g_t^N} \ , && (3.6)\\
w_t &\geq \frac{w_{t-1}}{\epsilon_t} \wedge h_t \leq \bar{h} \quad \text{with} \quad 0 = (\bar{h} - h_t)\left(w_t - \frac{w_{t-1}}{\epsilon_t}\right) \ , && (3.7)\\
\epsilon_t &= \max\left\{\frac{w_{t-1}}{w_t^f}, 1\right\}^{\phi_\epsilon} \ . && (3.8)
\end{aligned}
$$

Having $d_0 < \bar{d}$ in the first period allows us to abstract from the borrowing limit as it will not become binding, as is easily verified. We first note that the constant values for traded-goods consumption and debt

$$c_t^T = y^T - \frac{r}{1+r} d_0 \quad \text{and} \quad d_t = d_0 \tag{3.10}$$

satisfy conditions (3.1) and (3.2) for all the cases subsequently considered.

In what follows we verify for the case of a peg ($\phi_e = 0$) with initial full employment $h_0 = \bar{h}$ and the government spending process

$$g_t^N = g_0^N + \varepsilon_t \ , \tag{3.9}$$

that the asymmetric solution of the bare-bones model given by

$$c_t^N = \begin{cases} \bar{h} - g_0^N \\ \bar{h} - (g_0^N + \varepsilon_t) \end{cases} , \quad y_t^N = \begin{cases} \bar{h} + \varepsilon_t \\ \bar{h} \end{cases} , \text{ and } p_t^N = \begin{cases} \frac{1-a}{a}\frac{c_t^T}{\bar{h} - g_0^N} & \text{if } \varepsilon_t < 0 \\ \frac{1-a}{a}\frac{c_t^T}{\bar{h} - (g_0^N + \varepsilon_t)} & \text{if } \varepsilon_t > 0 \end{cases} \tag{3.18}$$

actually satisfies the equilibrium conditions (3.1)–(3.8). That is, when $\varepsilon_t < 0$, one obtains the Keynesian solution: private consumption stays put and output declines one-for-one with government spending. When $\varepsilon_t > 0$, the Classical solution obtains: private consumption is crowded out and output is unaffected. Note that for a zero shock, the two cases trivially coincide.

We start by noting that the non-traded goods market clearing condition (3.3) and the demand equation (3.4) hold by construction. The exchange rate rule (3.8) sets $\varepsilon_t = 1$ for the peg. The downward nominal wage constraint in (3.7) therefore becomes

$$w_t \geq w_{t-1} \,. \tag{A.1}$$

Given our assumption of initial full employment $h_0 = \bar{h}$, equations (3.5) and (3.6) imply for the past wage

$$w_{t-1} = w_0^f = \frac{1-a}{a} \frac{c_t^T}{\bar{h} - g_0^N} \,. \tag{A.2}$$

At the same time, combining equations (3.4)–(3.6) with the postulated solution for p_t^N shows that the actual wage and its full employment counterpart are given by

$$w_t = \begin{cases} \frac{1-a}{a} \frac{c_t^T}{\bar{h} - g_0^N} & \text{if } \varepsilon_t < 0 \\ \frac{1-a}{a} \frac{c_t^T}{\bar{h} - (g_0^N + \varepsilon_t)} & \text{if } \varepsilon_t > 0 \end{cases} \quad \text{and} \quad w_t^f = \frac{1-a}{a} \frac{c_t^T}{\bar{h} - (g_0^N + \varepsilon_t)} \,. \tag{A.3}$$

Comparing the two shows that there is labor market clearing at full employment only in response to a positive shock. What remains to be shown is that the solution also satisfies the complementary slackness condition (3.7).

When $\varepsilon_t > 0$, the current wage w_t is equivalent to its full-employment counterpart w_t^f. The wage constraint (A.1) is not binding, because the full employment wage (and thus the actual wage) is increasing in the level of government spending: $w_t = w_t^f > w_0^f = w_{t-1}$ for $\varepsilon_t > 0$. Intuitively, the price of non-traded goods increases to crowd out private consumption. Even though the nominal exchange rate remains unchanged, we observe real appreciation because wages are upwardly flexible. Consequently, there is full employment $h_t = \bar{h}$, and the complementary slackness condition (3.7) is satisfied.

By the same logic, there is unemployment in response to a negative spending shock $\varepsilon_t < 0$. In this case, the actual wage would be required to fall. But wages cannot move, resulting in the Keynesian scenario. The wage is constrained at its old level, $w_t = w_{t-1}$, which is above the (counterfactual) full-employment wage w_t^f for $\varepsilon_t < 0$. Thus, the wage constraint (3.7) binds with $w_t = w_{t-1} > w_t^f$ and there is unemployment $h_t < \bar{h}$. Again, the complementary slackness condition (3.7) is satisfied, which completes the proof.

Summarizing, we observe that the price of non-traded goods and, therefore, the real exchange rate does not adjust in response to a negative government spending shock. In contrast, the price of non-traded goods increases in response to a positive spending shock, that is, the real exchange appreciates.

A.2 Model variant 1: Government employment

In what follows, we establish for the bare-bones model that government consumption of private-sector goods and direct government employment of workers yield the same allocation, provided the labor market is competitive. As in Finn (1998), we assume that the government directly hires h_t^g workers in each period, rather than consuming the output,

$$g_t^N = h_t^g \, , \tag{A.4}$$

they would have produced. Hours worked in the labor market need to satisfy

$$h_t = h_t^p + h_t^g \leq \bar{h} \, , \tag{A.5}$$

where h_t^p denotes hours employed in the private sector and h_t denotes total hours worked. The government budget constraint is given by

$$\tau_t^r = w_t h_t^g \, , \tag{A.6}$$

where we make the assumption that perfect competition equalizes wages across private and public sectors and τ_t^r denotes real tax revenue. Market clearing and the linear production function in the non-traded goods sector imply

$$c_t^N = y_t^N = h_t^p = h_t - h_t^g \overset{(A.4)}{=} h_t - g_t^N \, , \tag{A.7}$$

which is identical to (3.3). By combining this equation with the household's budget constraint in real terms,

$$c_t^T + p_t^N c_t^N = y_t^T + w_t h_t^p + w_t h_t^g + \phi_t^r + \frac{d_{t+1}}{1+r} - d_t - \tau_t^r \, , \tag{A.8}$$

where ϕ_t^r denotes real profits

$$\phi_t^r = p_t^N y_t^N - w_t h_t^p \, , \tag{A.9}$$

and the government's budget constraint (A.6), one obtains the same resource constraint for traded goods as in the baseline model:

$$c_t^T = y^T - d_t + \frac{d_{t+1}}{1+r} \, . \tag{3.1}$$

All the other equilibrium conditions are also identical to the baseline model, which completes the proof.

A.3 Model variant 2: Consumption tax on traded goods

Section 3.2 shifts the focus to taxes while making minimal changes to the bare-bones model. In this new setup, rather than spending on non-traded goods, the government raises a tax on traded goods τ_t^c and hands back the revenues in a lump-sum fashion to the household:

$$\tau_t^c c_t^T = \tau_t^y \, . \tag{A.10}$$

Market clearing in the non-traded goods sector requires

$$y_t^N = c_t^N . \tag{A.11}$$

Again, combining this equation with the household's budget constraint in real terms,

$$(1+\tau_t^c)c_t^T + p_t^N c_t^N = y_t^T + w_t h_t + \phi_t^r + \frac{d_{t+1}}{1+r} - d_t + \tau_t^y \, , \tag{A.12}$$

the government's budget constraint, and the definition of a firm's profits real profits,

$$\phi_t^r \equiv p_t^N y_t^N - w_t h_t \, , \tag{A.13}$$

one obtains the resource constraint for traded goods:

$$c_t^T = y^T - d_t + \frac{d_{t+1}}{1+r} \, . \tag{A.14}$$

The optimality conditions of the household are given by:

$$c_t^N : \lambda_t p_t^N = \frac{1-a}{c_t^N} \tag{A.15}$$

$$c_t^T : \lambda_t (1+\tau_t^c) = \frac{a}{c_t^T} \tag{A.16}$$

$$d_{t+1} : \lambda_t = \lambda_{t+1} \, . \tag{A.17}$$

For a given process for $\{\tau_t^c\}$, the complete list of equilibrium conditions can be condensed to:

$$c_t^T = y^T - d_t + \frac{d_{t+1}}{1+r} \text{ and } 0 = \lim_{j\to\infty} \left(\frac{1}{1+r}\right)^j d_{t+j} \tag{A.18}$$

$$\frac{c_{t+1}^T}{c_t^T} = \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \tag{A.19}$$

$$y_t^N = h_t = c_t^N \tag{A.20}$$

$$p_t^N = (1+\tau_t^c)\frac{1-a}{a}\frac{c_t^T}{c_t^N} \tag{A.21}$$

$$p_t^N = w_t \tag{A.22}$$

$$w_t^f = (1+\tau_t^c)\frac{1-a}{a}\frac{c_t^T}{\bar{h}} \tag{A.23}$$

$$w_t \geq \frac{w_{t-1}}{\epsilon_t} \wedge h_t \leq \bar{h} \text{ with } 0 = (\bar{h} - h_t)\left(w_t - \frac{w_{t-1}}{\epsilon_t}\right) \tag{A.24}$$

$$\epsilon_t = \max\left\{\frac{w_{t-1}}{w_t^f}, 1\right\}^{\phi_\epsilon} . \tag{A.25}$$

Proof of equivalence. Section 3.2 establishes an equivalence result between a consumption tax on traded goods and permanent changes in government spending. Denote with $\tilde{c}_t^N$ the non-traded goods consumption level in the bare-bones model. We verify that with the tax rule

$$1 + \tau_t^c = \frac{c_t^N}{\tilde{c}_t^N} \tag{3.19}$$

in place, the equilibrium conditions (A.18)–(A.25) implement the same allocation as the baseline bare-bones model (3.1)–(3.8). The only exception is private non-traded consumption, which needs to pick up the non-traded goods freed by the government not consuming them:

$$c_t^N = \tilde{c}_t^N + g_t^N . \tag{A.26}$$

Intuitively, the tax rule (3.19) implements the same ratio of marginal utilities between traded and non-traded goods as in the bare-bones version of the model, despite the household consuming more non-traded goods. Given only private consumption of non-traded goods, the market clearing condition becomes

$$y_t^N = h_t = c_t^N = \tilde{c}_t^N + g_t^N , \tag{A.27}$$

which implements the same level of non-traded output as (3.3). First, given that $\tilde{c}_t^N$ and g_t^N in the bare-bones model are time-invariant after the initial permanent shock ε_t, the tax will also be constant in future periods if non-traded goods consumption follows the process in (A.26). Hence, the Euler equation (A.19) yields

$$\frac{c_{t+1}^T}{c_t^T} = \frac{1+\tau^c}{1+\tau^c} = 1 , \tag{A.28}$$

which together with the market clearing condition (A.18) implies an identical allocation of traded goods-consumption $c_t^T = \tilde{c}_t^T$ as (3.1) and (3.2) in the bare-bones model. Finally, substituting the tax rule into (A.21) yields

$$p_t^N = (1+\tau_t^c)\frac{1-a}{a}\frac{c_t^T}{c_t^N} = \frac{1-a}{a}\frac{c_t^T}{\tilde{c}_t^N} , \tag{A.29}$$

which shows that the wage level and the relative price also coincide in the two models. Thus, (A.24) and (3.7) as well as (A.25) and (3.8) also coincide.

□

A.4 Model variant 3: Payroll tax

In what follows, we provide details on the model version outlined in Section 3.3. With payroll taxes, the real government budget constraint is given by

$$p_t^N g_t^N = \tau_t^w w_t h_t \ , \tag{3.21}$$

and real firm profits are given by

$$\phi_t^r = p_t^N h_t - (1+\tau_t^w) w_t h_t \ . \tag{3.20}$$

The associated first-order condition of the firm's labor choice becomes

$$p_t^N = (1+\tau_t^w) w_t \ . \tag{A.30}$$

The payroll tax, therefore, drives a wedge between the price of non-traded goods and the real wage:

$$\frac{p_t^N}{w_t} = (1+\tau_t^w) \ . \tag{A.31}$$

Market clearing in the non-traded goods market requires

$$y_t^N = c_t^N + g_t^N . \tag{A.32}$$

Combining this equation with the household's budget constraint,

$$c_t^T + p_t^N c_t^N = y_t^T + w_t h_t + \phi_t^r + \frac{d_{t+1}}{1+r} - d_t \ , \tag{A.33}$$

and the definition of firm profits (3.20) yields the resource constraint for traded goods:

$$c_t^T = y^T - d_t + \frac{d_{t+1}}{1+r} . \tag{A.34}$$

The complete list of equilibrium conditions can be compactly written as:

$$c_t^T = y^T - d_t + \frac{d_{t+1}}{1+r} \text{ and } 0 = \lim_{j\to\infty} \left(\frac{1}{1+r}\right)^j d_{t+j} \tag{A.35}$$

$$c_{t+1}^T = c_t^T \tag{A.36}$$

$$y_t^N = h_t = c_t^N + g_t^N \tag{A.37}$$

$$p_t^N = \frac{1-a}{a} \frac{c_t^T}{c_t^N} \tag{A.38}$$

$$p_t^N = (1+\tau_t^w) w_t \tag{A.39}$$

$$p_t^N g_t^N = \tau_t^w w_t h_t \tag{A.40}$$

$$w_t^f = \frac{1}{1+\tau_t^w}\frac{1-a}{a}\frac{c_t^T}{\bar{h}-g_t^N} \tag{A.41}$$

$$w_t \geq \frac{w_{t-1}}{\epsilon_t} \wedge h_t \leq \bar{h} \text{ with } 0 = (\bar{h}-h_t)\left(w_t - \frac{w_{t-1}}{\epsilon_t}\right) \tag{A.42}$$

$$\epsilon_t = \max\left\{\frac{w_{t-1}}{w_t^f}, 1\right\}^{\phi_\epsilon}. \tag{A.43}$$

Proof of symmetry. We analyze changes in government spending under a peg ($\phi_\epsilon = 0$) in a situation where the Classical and the Keynesian scenario meet (that is, initially there is full employment $h_0 = \bar{h}$). For the baseline with lump-sum taxes, we have shown that in this case, the solution is asymmetric, see equation (3.18). In contrast, if government spending is financed through payroll taxes, the allocation and the real exchange rate response are symmetric regardless of the sign of the change in government spending and equal to the one in the Classical scenario:

$$c_t^N = \bar{h} - g_t^N, \quad \text{and} \quad y_t^N = \bar{h}\,. \tag{A.44}$$

We now verify that this solution indeed satisfies the equilibrium conditions (A.35)–(A.43).

First, we note that equations (A.35) and (A.36) are identical to the baseline equations (3.1) and (3.2). Thus, the solution for traded goods and debt from the baseline model in Appendix A.1 still applies. Likewise, the solutions for c_t^N and y_t^N in (A.44) by construction satisfy the non-traded goods market clearing condition (A.37). Substituting the conjectured solution (A.44) for non-traded consumption into equation (A.38) shows that the relative price of non-traded goods and the associated wage need to satisfy:

$$p_t^N = \frac{1-a}{a}\frac{c_t^T}{\bar{h}-g_t^N} = (1+\tau_t^w)w_t\,. \tag{A.45}$$

We proceed to show that the tax wedge adjusts to restore full employment and at the same time insulates the real wage from changes in government spending. Under a peg, the nominal exchange rate is fixed, i.e., $\epsilon = 1$ from (A.43). As before, the downward nominal wage constraint in (A.42) becomes

$$w_t \geq w_{t-1}\,. \tag{A.46}$$

In the following, we guess and verify that the wage stays constant at $w_t = w_{t-1} = w_0^f$ and that the complementary slackness condition (A.42) is satisfied with $h_t = \bar{h}$.

Using the conjectured solution, the government's budget constraint (A.40) implies for the tax rate:

$$\tau_t^w = \frac{p_t^N g_t^N}{w_t \bar{h}} \overset{(A.31)}{=} \frac{(1+\tau_t^w)g_t^N}{\bar{h}}\,. \tag{A.47}$$

The first equality shows the direct effect of a cut (increase) in government spending on taxes: a lower (higher) amount of goods needs to be bought at price p_t^N, allowing for a lower (higher) tax rate. The second equality accounts for the effect of the tax change on prices by substituting for

p_t^N. We see that this implies an additional change of taxes in the same direction: the tax rate reduction causes the price of nontraded goods to fall, allowing to lower the tax rate even further (or conversely for a spending/tax increase). Solving for the tax rate in equilibrium shows that taxes react more than one-for-one to changes in g_t^N:

$$\tau_t^w = \frac{g_t^N}{\bar{h} - g_t^N} \, , \tag{A.48}$$

which implies

$$\frac{1}{1+\tau_t^w} = \frac{1}{1 + \frac{g_t^N}{\bar{h}-g_t^N}} = \frac{1}{\frac{\bar{h}}{\bar{h}-g_t^N}} = \frac{\bar{h} - g_t^N}{\bar{h}} \, . \tag{A.49}$$

Using this expression to solve for the real wage via equations (A.38) and (A.39) shows that the real wage is indeed constant for all values of g_t^N because c_t^T is time-invariant:

$$w_t = \frac{\bar{h} - g_t^N}{\bar{h}} \frac{1-a}{a} \frac{c_t^T}{\bar{h} - g_t^N} = \frac{1-a}{a} \frac{c_t^T}{\bar{h}} \, . \tag{A.50}$$

At the same time, equation (A.41) shows that the full employment wage and the actual wage coincide:

$$w_t^f = \frac{\bar{h} - g_t^N}{\bar{h}} \frac{1-a}{a} \frac{c_t^T}{\bar{h} - g_t^N} = \frac{1-a}{a} \frac{c_t^T}{\bar{h}} \, . \tag{A.51}$$

Thus, with $h_t = \bar{h}$ and $w_t = w_t^f$ constant for all t, the complementary slackness condition in (A.42) is always satisfied.

$\square$

B Quantitative model analysis

B.1 Full set of equilibrium conditions

Definition 1. *An equilibrium is defined as a set of stochastic processes* $\{c_t^T, h_t, d_{t+1}, w_t, \lambda_t, \mu_t,\}_{t=0}^{\infty}$ *satisfying*

$$c_t^T = y_t^T - d_t + \frac{d_{t+1}}{1+r_t} \tag{B.1}$$

$$\lambda_t = \omega \left[\omega (c_t^T)^{\frac{\xi-1}{\xi}} + (1-\omega)(h_t^\alpha - g_t^N)^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}\left(\frac{1}{\xi}-\sigma\right)} (c_t^T)^{-\frac{1}{\xi}} \tag{B.2}$$

$$\frac{\lambda_t}{1+r_t} = \beta \mathbb{E}_t \lambda_{t+1} + \mu_t \tag{B.3}$$

$$\mu_t \geq 0 \ \wedge \ d_{t+1} \leq \bar{d} \ \textit{ with } \ 0 = \mu_t (d_{t+1} - \bar{d}) \tag{B.4}$$

$$\frac{w_t}{\alpha h_t^{\alpha-1}} = \frac{1-\omega}{\omega} \left(\frac{c_t^T}{h_t^\alpha - g_t^N} \right)^{\frac{1}{\xi}} \tag{B.5}$$

$$w_t \geq \gamma \frac{w_{t-1}}{\epsilon_t} \tag{B.6}$$

$$h_t \leq \bar{h} \tag{B.7}$$

$$0 = (\bar{h} - h_t) \left(w_t - \gamma \frac{w_{t-1}}{\epsilon_t} \right), \tag{B.8}$$

as well as a suitable transversality condition, given initial conditions $\{w_{-1}, d_0\}$*, exogenous stochastic processes* $\{y_t^T, r_t, g_t^N\}_{t=0}^{\infty}$*, and an exchange-rate policy* $\{\epsilon_t\}_{t=0}^{\infty}$*.*

In the following, we outline how we solve the full model of Section 3.4.

B.2 Model calibration and solution

Table B.1 summarizes the parameters of the model together with the values that we assign to them in our numerical analysis. A period in the model corresponds to one quarter. In the model, we abstract from both foreign inflation and long-run technology growth. Both factors mitigate the effect of downward nominal wage rigidity. Following SGU, we adjust their estimated value of $\gamma = 0.9982$ for Greece provided in their paper by the average quarterly inflation rate in Germany (0.3% per quarter) and the average growth rate of per capita GDP in the euro periphery (0.3%). We set γ to $0.9982/(1.003 \times 1.003) = 0.9922$. This implies that wages can effectively fall at most by 3.1 percent per year. We set the intra- and intertemporal elasticities of substitution between traded and nontraded goods, ξ and σ, to 0.44 and 5, respectively, following again SGU and Reinhart and Végh (1995). In line with the estimate of Uribe (1997), we fix the labor share in the traded goods sector at $\alpha = 0.75$. We set $\bar{d} = 16.5418$, i.e., for numerical reasons, we set the upper limit 1% below the natural debt limit. We normalize the endowment of hours $\bar{h}$ to unity. The subjective discount factor β is set to 0.9375, in line with SGU, to obtain a plausible foreign debt-to-GDP ratio.

We specify a VAR(1)-process for the exogenous states $[y_t^T, r_t]'$ on the basis of the estimates

Table B.1: Parameter values used in model simulation

Parameter	Value	Source/Target
Wage rigidity	$\gamma = 0.9922$	SGU (2016)
Elasticity of substitution	$\xi = 0.44$	SGU (2016)
Risk aversion, private consumption	σ=5	Standard value
Labor exponent production function	$\alpha = 0.75$	Uribe (1997)
Debt limit	$\bar{d} = 16.5418$	99 % of natural debt limit
Endowment of hours worked	$\bar{h} = 1$	Normalization
Steady-state interest rate	$r = 0.011$	Average interest rate
Steady-state traded goods endowment	$y^T = 1$	Normalization
Steady-state government consumption	$g^N = 0.2548$	Greek government-spending share
Discount factor	$\beta = 0.9375$	SGU (2016)
Weight on traded goods in CES	$a = 0.37$	Traded-goods share of 0.26

by SGU for Greece. The steady-state endowment of traded goods is normalized to 1, while the mean quarterly interest rate is $r = 0.011$. We estimate a separate AR(1)-process for the exogenous state g_t^N, using Greek time-series data for the period 1995:Q1-2018:Q4. To remove the growth trend, we regress the logged value on a quadratic trend. The driving process is assumed to be orthogonal to that governing $[y_t^T, r_t]'$. Our empirical measure of government spending g_t^N is real public consumption provided by Eurostat ("Final consumption expenditure of general government", `P3_S13`).

The resulting VAR process is given by

$$\begin{bmatrix} \ln y_t^T \\ \ln \frac{1+r_t}{1+r} \\ \ln \frac{g_t^N}{g^N} \end{bmatrix} = \begin{bmatrix} 0.88 & -0.42 & 0 \\ -0.05 & 0.59 & 0 \\ 0 & 0 & 0.924 \end{bmatrix} \begin{bmatrix} \ln y_{t-1}^T \\ \ln \frac{1+r_{t-1}}{1+r} \\ \ln \frac{g_{t-1}^N}{g^N} \end{bmatrix} + \varepsilon_t,$$

$$\varepsilon_t \overset{iid}{\sim} N\left(0, \begin{bmatrix} 5.36e-4 & -1.0e-5 & 0 \\ -1.0e-5 & 6.0e-5 & 0 \\ 0 & 0 & 0.0228^2 \end{bmatrix}\right).$$

Finally, we pin down two further parameters as we match two key moments of the data. The average value of government spending, $g^N = 0.2548$, is set to match the empirical share of government consumption in GDP, $p^N g^N/(y^T + p^N y^N) = 0.2123$. The weight of traded goods in aggregate consumption is determined by a. We set it to 0.37. This implies an average share of traded goods in total output of 26 percent, in line with the calibration target by SGU.

B.3 Solution procedure

In order to solve the model, we largely follow SGU. In the case of a float, $\phi_\epsilon = 1$, the lagged real wage is not a state variable and the resulting program coincides with the central planner's solution. This simplifies the analysis considerably and we solve the model numerically by value function iteration over a discretized state space. In the case of a less than fully flexible exchange-rate regime, that is, if $\phi_\epsilon < 1$, the lagged real wage is a state variable, as is the external debt position. To solve the model in this case, we resort to Euler equation iteration. Subsection B.4 provides details on the discretization of the state space while Subsection B.6 reports the unconditional moments of the model.

B.4 State-space discretization

We discretize the state space for the past real wage, w_{-1} using 800 equally-spaced points on a log grid range $[\underline{w}, \bar{w}]$. We set $\underline{w} = 1$ and $\bar{w} = 7.5$. To discretize the current debt state, d_t, we use 501 equally spaced points on the range $[8, 16.5418]$. To model the exogenous driving forces, we discretize the state space using 7 equally spaced points for $\ln y_t^T$ and 5 equally spaced points for $\ln \frac{1+r_t}{1+r}$ over the range $\pm\sqrt{10}\sigma$. We obtain transition matrices on the basis of the simulation approach of Schmitt-Grohé and Uribe (2014) with $T = 5{,}000{,}000$ and a burn-in of 10,000 periods. We trim state pairs $y_t^T(i), r_t(i)$ that occur with probability zero during our simulations. This reduces the transition probability matrix from size 35×35 to 33×33. For the g_t^N-process, we use the Tauchen and Hussey (1991) approach to discretize it to 9 realizations. The full transition probability matrix of the exogenous state vector $[y_t^T, r_t, g_t^N]'$ is finally obtained as the Kronecker product of the two transition matrices. We opt for this two-stage approach for the following reason. While the simulation approach allows us to handle correlated states easily, the convergence of the transition probabilities is relatively slow. As a result, transition matrices for symmetric and partially uncorrelated processes like ours tend to show slight asymmetries and correlations. As we are interested in asymmetries introduced by the model's transmission process, such spurious asymmetries in the exogenous process would be problematic when computing generalized IRFs. We circumvent this issue by relying on an analytical approach for government spending.

B.5 Generalized IRFs

Using different initial conditions in the state space for the scenarios in Figure 2 allows us to capture the role of economic slack. In addition, we also allow for small variations in the initial debt level to minimize the effects of nonlinear interaction between the initial debt level and the government spending shock. We assume values in the range of 98-99% of the ergodic mean. Under the peg with full employment, we set $d_0 = 13.2276$ and $w_{-1} = 1.7637$; for the float, we set $d_0 = 14.1672$. The exogenous states are set to their steady-state values. For the peg with slack, we employ 1,000,000 repetitions using draws from the ergodic distribution. We first simulate the model for a burn-in period of 300 quarters and then hit it with a government spending shock. The reported GIRFs are the average over the draws where we compare the shocked to the unshocked simulation paths.

B.6 Unconditional moments and debt distribution

Table B.2 displays unconditional first and second moments of some macro indicators of interest obtained from a simulation of 1 million quarters. These statistics are in line with the predictions of the model. In particular, mean unemployment is shown to decrease from 14% to nil when moving from a peg to a fully stabilizing float. Analogously, mean (nontraded) consumption and nontraded output increase with exchange-rate flexibility, whereas their respective volatilities are lower. Moreover, the real wage under a peg displays a higher mean but lower standard deviation, a reflection of the fact that the wage constraint tends to be binding more often. The average external debt-to-GDP ratio increases from 90% per year in the peg economy to 122% per year under the float. As shown in figure B.1, this is due to the distribution of external debt being more dispersed under the peg, which requires a higher level of precautionary savings.

Table B.2: First and second moments in the two exchange-rate regimes

	$Mean(peg)$	$Std(peg)$	$Mean(int)$	$Std(int)$	$Mean(float)$	$Std(float)$
$\bar{h} - h_t$	0.141	0.115	0.032	0.040	0.000	0.000
c_t	0.697	0.142	0.753	0.100	0.767	0.092
c_t^N	0.635	0.139	0.721	0.079	0.745	0.070
y_t^N	0.890	0.103	0.976	0.031	1.000	0.000
$y_t^T - c_t^T$	0.153	0.099	0.161	0.117	0.162	0.119
w_t	2.606	0.249	1.946	0.448	1.822	0.486
y_t^T	1.002	0.067	1.002	0.067	1.002	0.067
r_t^{ann}	0.045	0.055	0.044	0.055	0.045	0.055
d_t	13.509	0.076	14.386	0.050	14.463	0.046
$d_t/4(y_t^T + p_t^N c_t^N)$	0.902	0.263	1.165	0.485	1.217	0.524
G/Y	0.213	0.047	0.180	0.051	0.174	0.052

Notes: Statistics are based on a simulation length of 1 million periods and a burn-in of 1,000 periods.

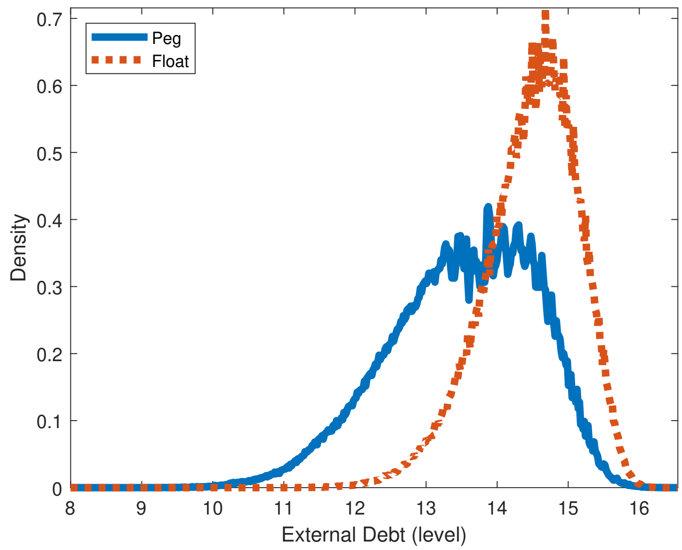
B.7 Monte Carlo experiment

For our Monte Carlo experiment, we use the nonlinear quantitative model employed in Section 3.4 as the data-generating process. In the model government spending is exogenous. Yet in our empirical analysis, we rely on a VAR model to account for a possible response of government spending to the economy. For this reason, we now assume a fiscal rule featuring endogenous feedback to one of the state variables in our model, namely the wage level:

$$g_t = g_t^N - \frac{\phi_{gw}}{g^N} \frac{w_{t-1} - 2.6}{2.6} \,. \tag{B.9}$$

Here, 2.6 corresponds to the average wage level and $\phi_{gw} = 0.2$ corresponds to the elasticity of government spending with respect to the wage. Since our focus is on the asymmetric effects of positive and negative government spending shocks, we assume an exchange-rate peg throughout.

Figure B.1: Quantitative model – ergodic debt distribution



Notes: Distribution of external debt in the two exchange-rate regimes. Blue solid line: peg ($\phi_e = 0$), red dashed line: float ($\phi_e = 1$). Statistics are based on a simulation length of 1 million periods and a burn-in of 1,000 periods.

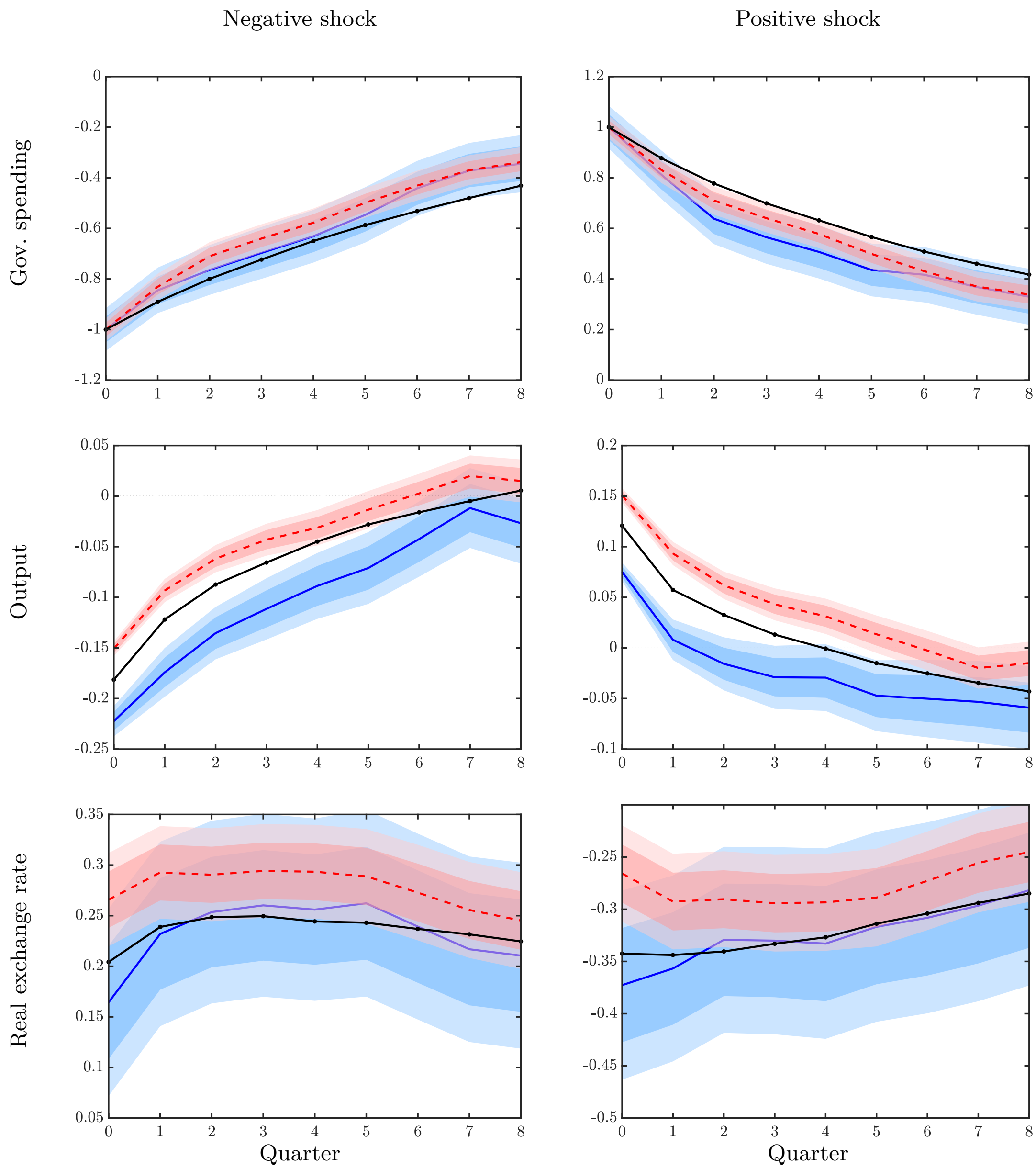
To measure fiscal shocks, we employ a Blanchard-Perotti style regression of government spending g_t on g^N_{t-1} as well as on lagged output and the lagged wage. The reason for presetting the contemporaneous output feedback to 0 instead of employing a full sign restriction approach is that we lack a well-defined business-cycle- and tax-revenue-shock counterpart in the model. Next, we sort shocks into positive and negative realizations, just like we do with the actual data. Last, we estimate the response of the variables of interest to positive and negative government spending shocks using the local projection (4.2). In doing so, we restrict the estimation to observations where unemployment is low because theory predicts asymmetric adjustment dynamics only in the absence of slack—see again the middle column of Figure 2.[33] We initially simulate the model for 40,000 periods and discard the first 10,000 as a burn-in. The conditioning on full employment leaves the estimation with about 3,500 effective observations.

Figure B.2 displays the results. The left column shows the responses to a negative government spending shock and the right column to a positive shock. As a practical matter, we rescale all IRFs so that the size of the shock corresponds to a 1-percent change in government spending and report percentage deviations from the ergodic mean.

We close by noting that the linearity of the fiscal rule (B.9) conditional on the observed regressors is key for the correct identification of fiscal shocks in a linear regression setting. These regressors may in turn follow nonlinear asymmetric processes. But controlling for their observed behavior is sufficient to capture the effect of the nonlinear transmission mechanism on fiscal variables.

[33] We use a threshold for the unemployment rate of 1 percent rather than the median unemployment rate we use with actual data. This is because the model does not feature frictional unemployment, so unemployment is actually zero in the absence of slack.

Figure B.2: Monte Carlo irf – full employment



Notes: Adjustment to negative and positive government spending shocks. Sample: 30,000 observations after burn-in generated by the quantitative model, conditioned on full employment (unemployment rate below 1 percent). Blue solid lines: empirical two-stage estimate allowing for asymmetric effects. Black solid lines with dots: generalized impulse responses of the model under a peg with full employment (scaled to a 1% government spending shock). Red dashed line: empirical two-stage estimate restricted to symmetric effects. Light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviations from the mean in percent.

C Empirical evidence: sample and data sources

The data sources for the EA benchmark model are:

- real GDP: Eurostat mnemonic `B1GQ` (GDP), chain-linked volumes (2010) (`CLV10_MNAC`)
- real government consumption: `P3_S13`, chain-linked volumes (2010)
- real tax revenues: `TR`, chain-linked volumes (2010)
- real private consumption: `P31_S14_S15`, chain-linked volumes (2010)
- net export share: `B11` as a share of `B1GQ` in current prices
- real effective exchange rate: `REER_EA19_CPI` (real exchange rate)
- unemployment rate: unemployment as a percentage of the active population (`PC_ACT`) from the EU-LFS main indicator table (`une_rt_q`)
- inflation rate: log difference of the GDP deflator, which is in turn computed as the ratio of GDP (`B1GQ`) in current prices (`CP_MNAC`) and GPD in chain-linked volumes (`CLV10_MNAC`)

All national accounts data are seasonally and working day adjusted. The default-risk spread is taken from Born et al. (2020). Default episodes like the Greek ones (2012Q1–2012Q2, 2012Q4) are excluded from the sample.

The government spending growth forecasts are provided by *Oxford Economics*. They provide forecasts for the next quarter's government spending on a monthly basis. We use a geometric average over the available monthly values in a given quarter t to arrive at quarterly forecasts for spending growth next period $E_t \Delta g_{i,t+1}$.

For the float sample, we rely on country-specific sources to retrieve national accounts data, following Born et al. (2020). We use the broad real effective exchange rate index compiled by the Bank for International Settlements (BIS), complemented by data for Ecuador and Uruguay, based on the data for 38 trading partners compiled by Darvas (2012). We obtain quarterly values for the real effective exchange rate as the average of the monthly index values.

The following data for the US VAR are obtained from FRED:

- real government consumption expenditures and gross investment: FRED mnemonic `GCEC1`
- real GDP: `GDPC1`
- real effective exchange rate: `RNUSBIS`

The tax revenues are constructed from the BEA NIPA tables following the logic of Mountford and Uhlig (2009) as receipts (`W021RC`) less net transfers (`A084RC` minus `W060RC`) less net interest paid (`A180RC` minus `Y703RC`), deflated with the GDP deflator (`A191RG`).

For negotiated/bargained wages, we rely on the following data sources:

- Austria: Tariflohnindex, Generalindex, 2016=100 from Statistik Austria (`AB001C007`). Starting in 1999.
- Finland: Index of negotiated wages 1995=100 and Index of negotiated wages 2005=100 provided by Statistics Finland. These data are contained in the proprietary Astika database and can therefore not be publicly shared. Starting in 2000.
- France: Negotiated wages, provided by OECD (`STS.Q.FR.N.INWR.000000.2.ANR`). Starting in 1999.
- Germany: Basic pay rates, overall economy, excluding ancillary benefits, excluding one-off payments, on an hourly basis, provided by Bundesbank (`BBK01.DQ7801`). Starting in 1999.
- Italy: Contractual Wages per Hour (NSA, Dec-15=100), provided by Haver Analytics (`ITNEH@ITALY`). Starting in 1999.
- Netherlands: Hourly Contractual Wage Costs (NSA, 2010=100), provided by Haver Analytics (`NLNEWTT@BENELUX`). Starting in 2000.
- Portugal: Remunerações médias implícitas contratação coletiva exc AP-M-Tx, provided by Banco de Portugal (`5739348`). Starting in 2008.
- Spain: Agreed Wage Increases from Collective Bargaining, provided by Haver Analytics (`ESNEWGY@SPAIN`). Starting in 1999.

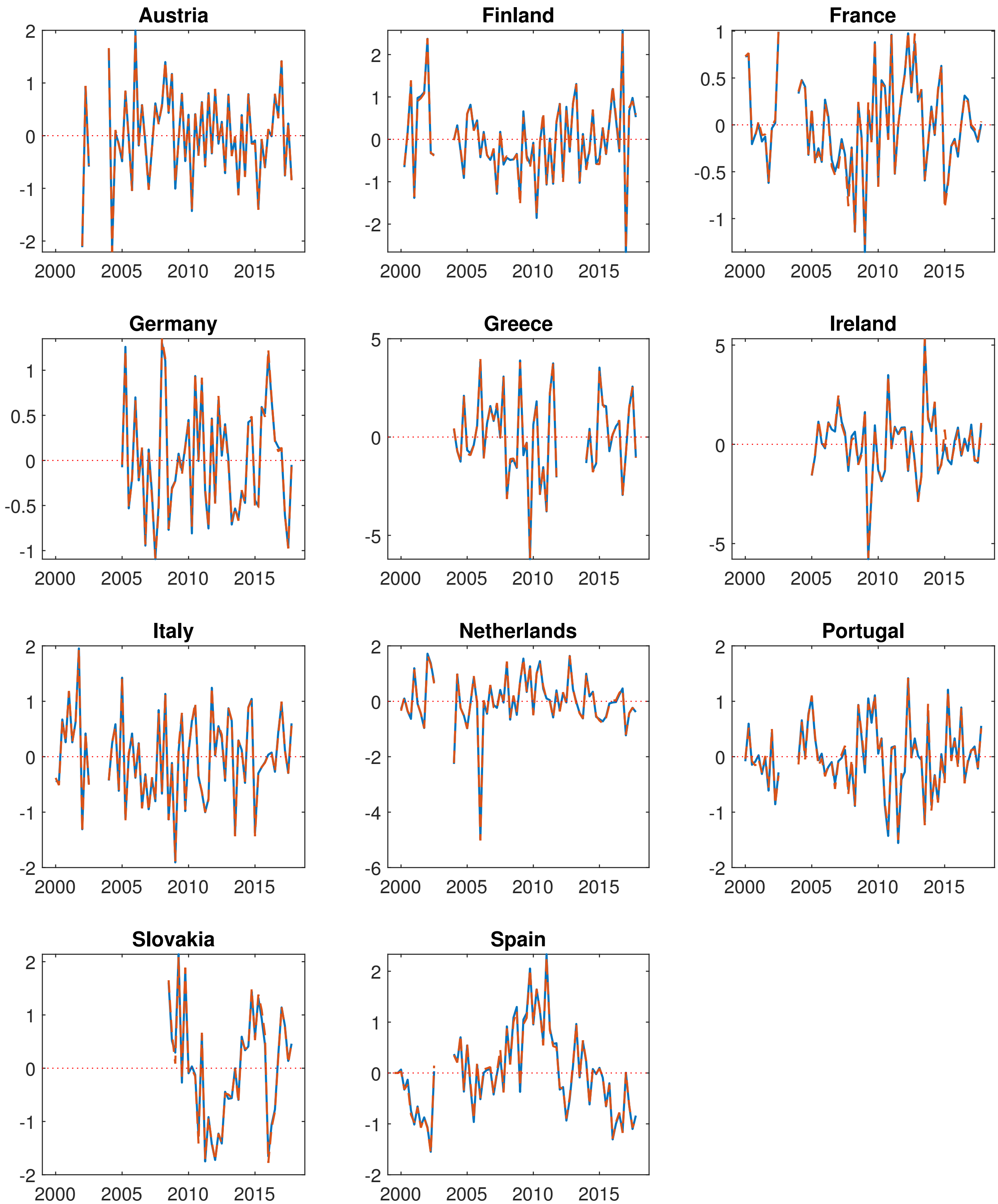
The nominal wage data were transformed into growth rates where appropriate. The IRFs in the text display the wage level.

Table C.3: Sample ranges

	EMU		Float	
Country	Range	T	Range	T
Argentina	-	-	2016Q3-18Q4	10
Australia	-	-	2003Q1-10Q3	28
Austria	2002Q1-17Q4	59	-	-
Brazil	-	-	1999Q1-18Q4	80
Chile	-	-	1999Q2-18Q4	79
Colombia	-	-	2001Q2-17Q4	67
Ecuador	-	-	1995Q1-99Q2	16
Finland	2000Q2-17Q4	66	-	-
France	2000Q1-17Q4	67	-	-
Germany	2005Q1-17Q4	52	-	-
Greece	2004Q1-17Q4	48	-	-
Hungary	-	-	1999Q1-09Q1	41
Ireland	2005Q1-17Q4	52	-	-
Italy	2000Q1-17Q4	67	-	-
Latvia	-	-	2006Q1-09Q2	14
Malaysia	-	-	2005Q3-17Q4	50
Mexico	-	-	1995Q1-18Q4	96
Netherlands	2000Q1-17Q4	67	-	-
Peru	-	-	2003Q1-12Q2	38
Poland	-	-	1996Q2-12Q1	64
Portugal	2000Q1-17Q4	67	-	-
Slovakia	2008Q3-17Q4	38	-	-
South Africa	-	-	1995Q1-17Q4	92
Spain	1999Q3-17Q4	69	-	-
Sweden	-	-	1995Q1-18Q4	57
Thailand	-	-	1997Q3-17Q4	82
Turkey	-	-	1999Q2-17Q4	75
United Kingdom	-	-	1996Q2-18Q4	91
United States	-	-	2007Q4-17Q3	40
Uruguay	-	-	2002Q1-17Q4	63
Total		652		1083

Notes: Range refers to the first and last observation available. Limiting factors for the two samples are the availability of government spending growth forecasts and sovereign bond spreads. T refers to the number of observations used for the particular country after accounting for missing values and lag construction.

Figure C.1: Sign-restriction vs. Blanchard-Perotti government spending shocks



Notes: Blue solid line: government spending shocks identified based on sign restriction identification; red dashed line: government spending shocks identified based on Blanchard-Perotti identification. Sample: EA.

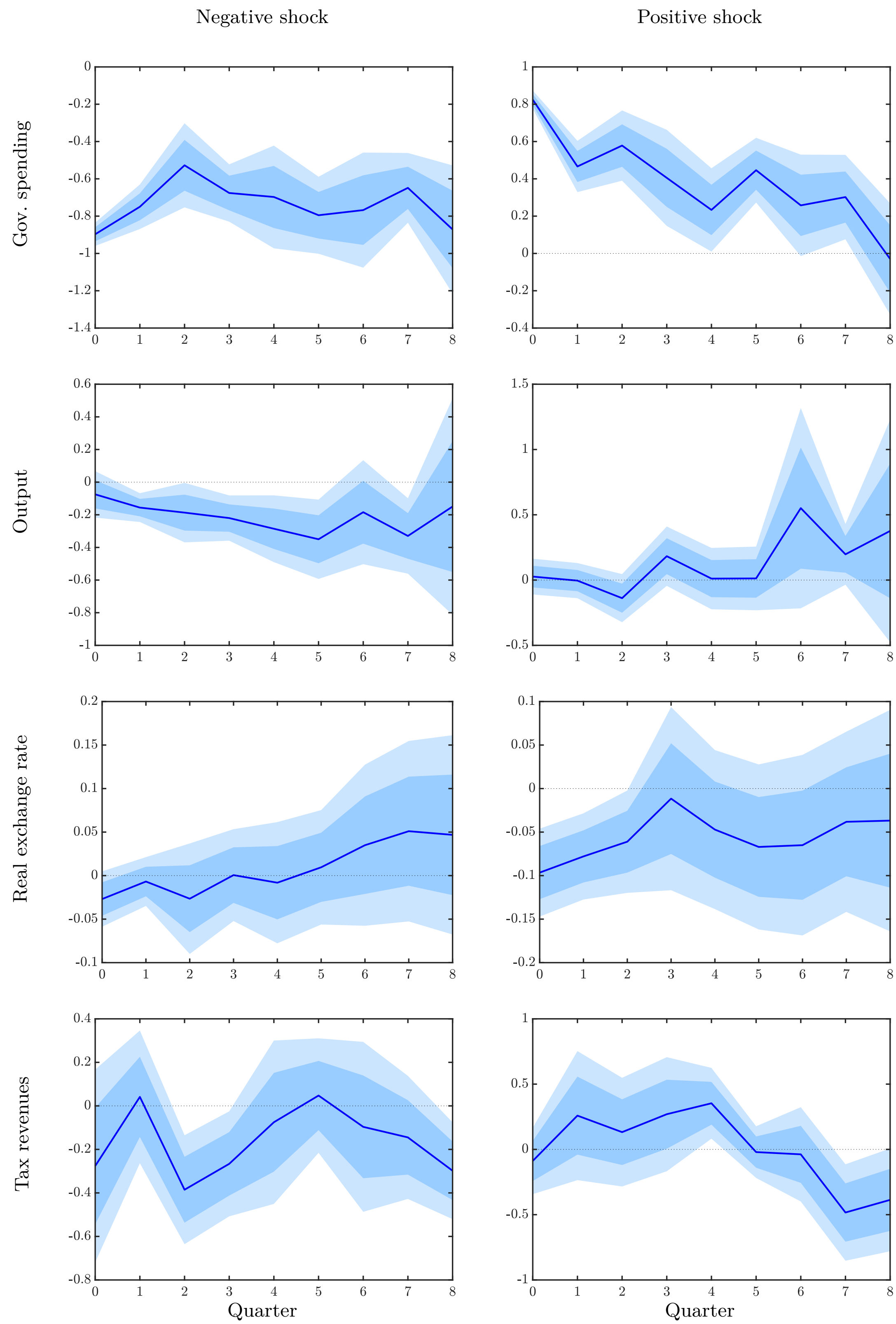
Table C.4: Pairwise correlations between government spending shocks within the EA sample

	Austria	Finland	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Slovakia	Spain
Austria	1.00	-0.18	0.02	0.31	-0.09	-0.13	0.13	-0.42	-0.35	-0.07	0.05
Finland	-	1.00	-0.00	0.07	-0.21	-0.20	0.15	0.06	0.04	-0.26	-0.34
France	-	-	1.00	0.16	-0.57	-0.29	0.16	0.17	0.25	-0.01	0.22
Germany	-	-	-	1.00	-0.43	-0.12	0.16	-0.03	0.03	-0.12	-0.03
Greece	-	-	-	-	1.00	0.00	-0.29	-0.43	-0.17	-0.26	-0.44
Ireland	-	-	-	-	-	1.00	-0.42	-0.13	-0.45	-0.30	-0.22
Italy	-	-	-	-	-	-	1.00	-0.05	-0.02	-0.13	-0.08
Netherlands	-	-	-	-	-	-	-	1.00	0.06	0.03	0.11
Portugal	-	-	-	-	-	-	-	-	1.00	0.31	0.15
Slovakia	-	-	-	-	-	-	-	-	-	1.00	0.25
Spain	-	-	-	-	-	-	-	-	-	-	1.00

Notes: Pairwise correlations for the government spending shocks identified using sign restrictions.

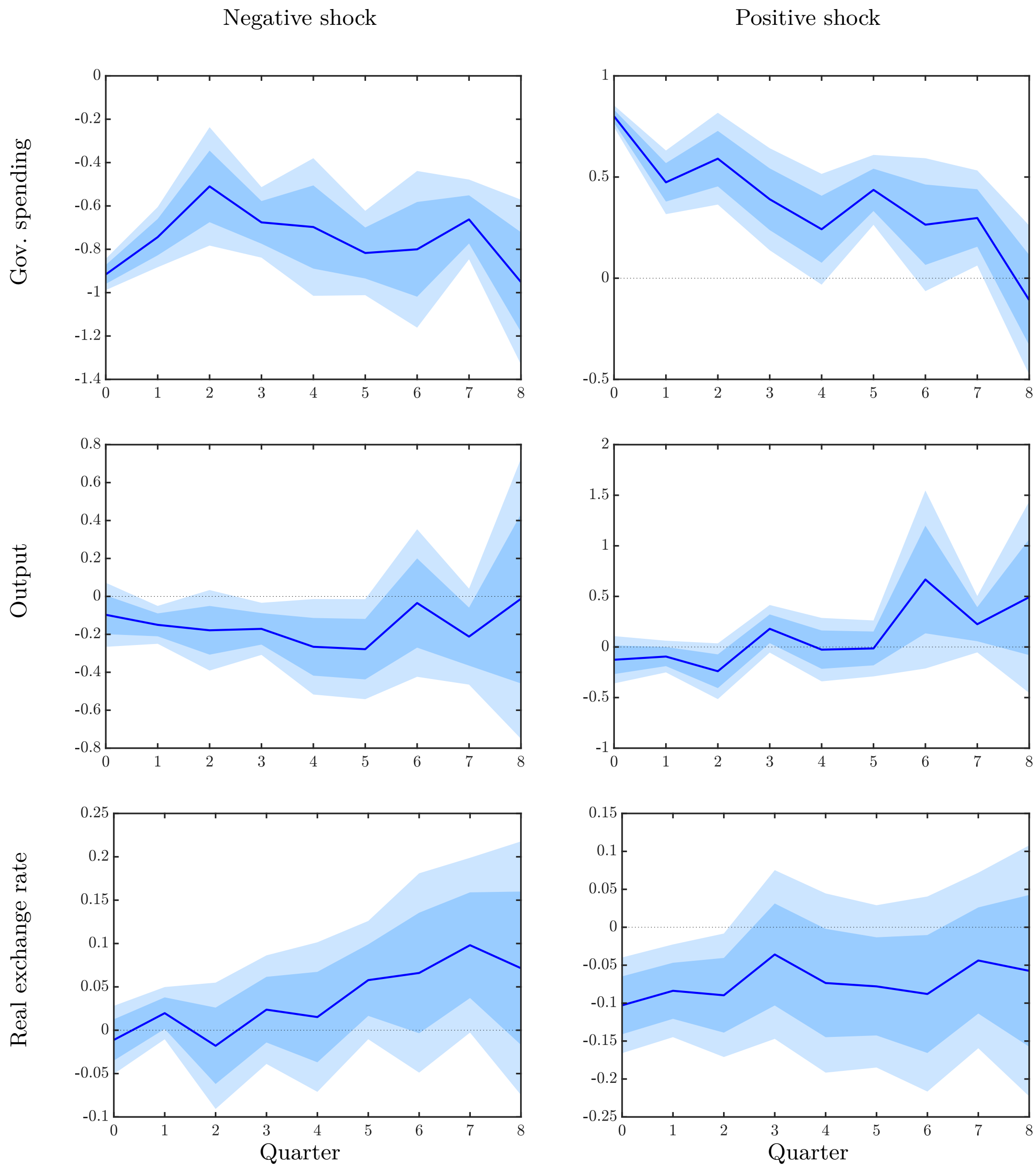
D Additional impulse response functions

Figure D.1: Adjustment to government spending shocks – Blanchard and Perotti



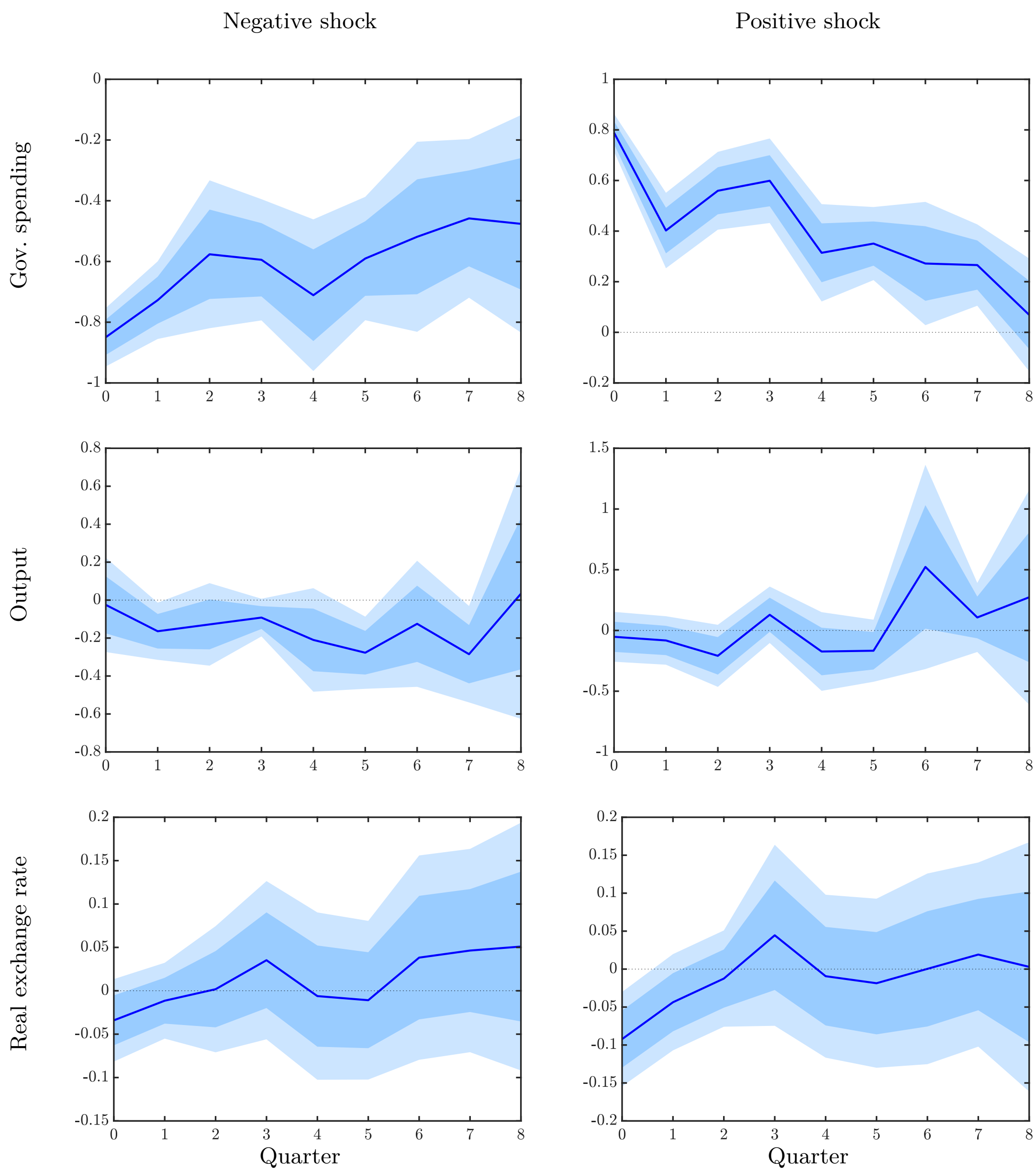
Notes: Estimates for panel of EA countries based on Blanchard and Perotti (2002) identification. Solid lines represent point estimates, light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from the pre-shock trend/level in percent.

Figure D.2: IRFs – EA excluding big countries



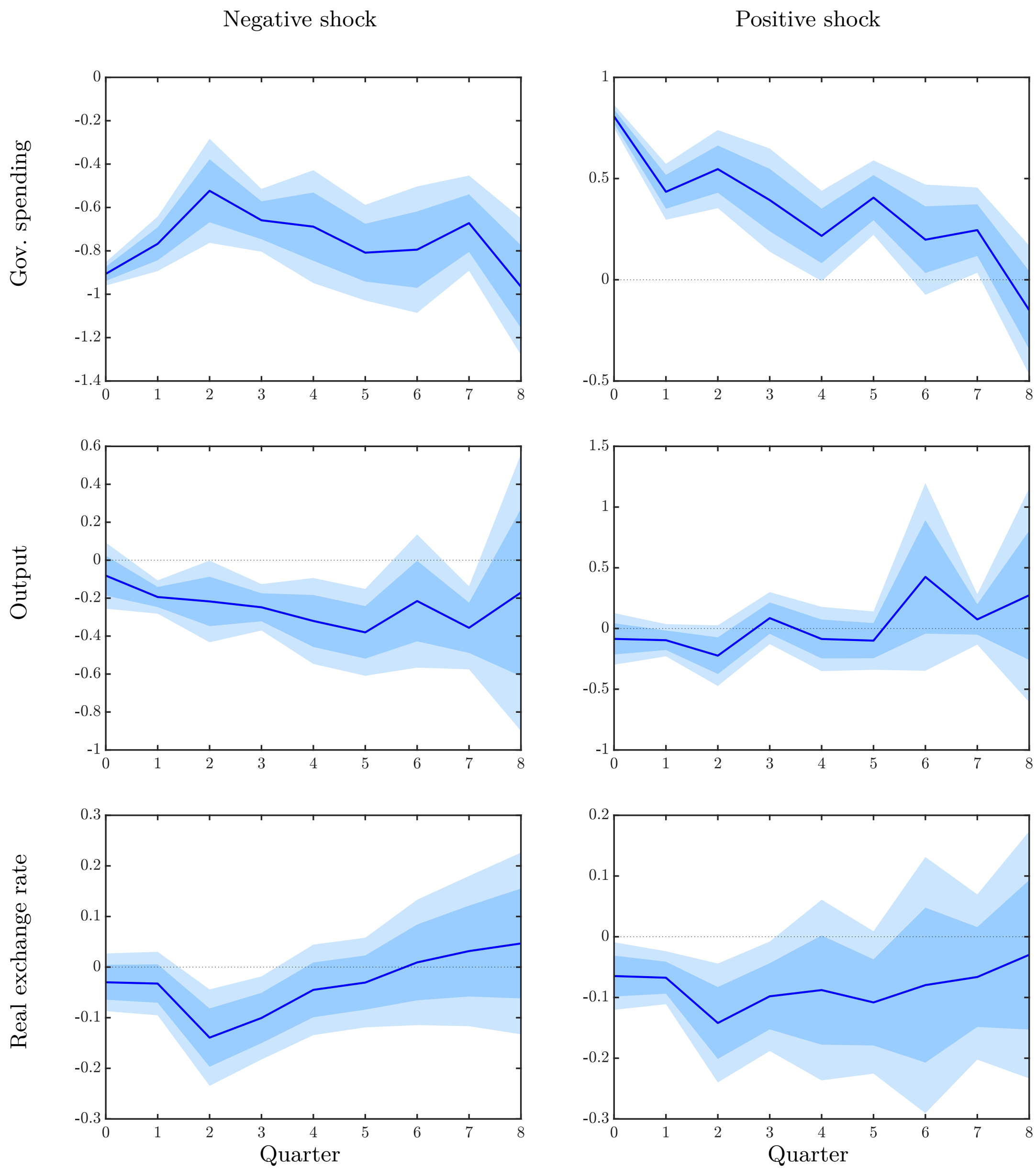
Notes: Estimates for panel of EA countries, where France, Germany, and Italy have been excluded. Solid lines represent point estimates, light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from the pre-shock trend/level in percent.

Figure D.3: IRFs – ea excluding Greece



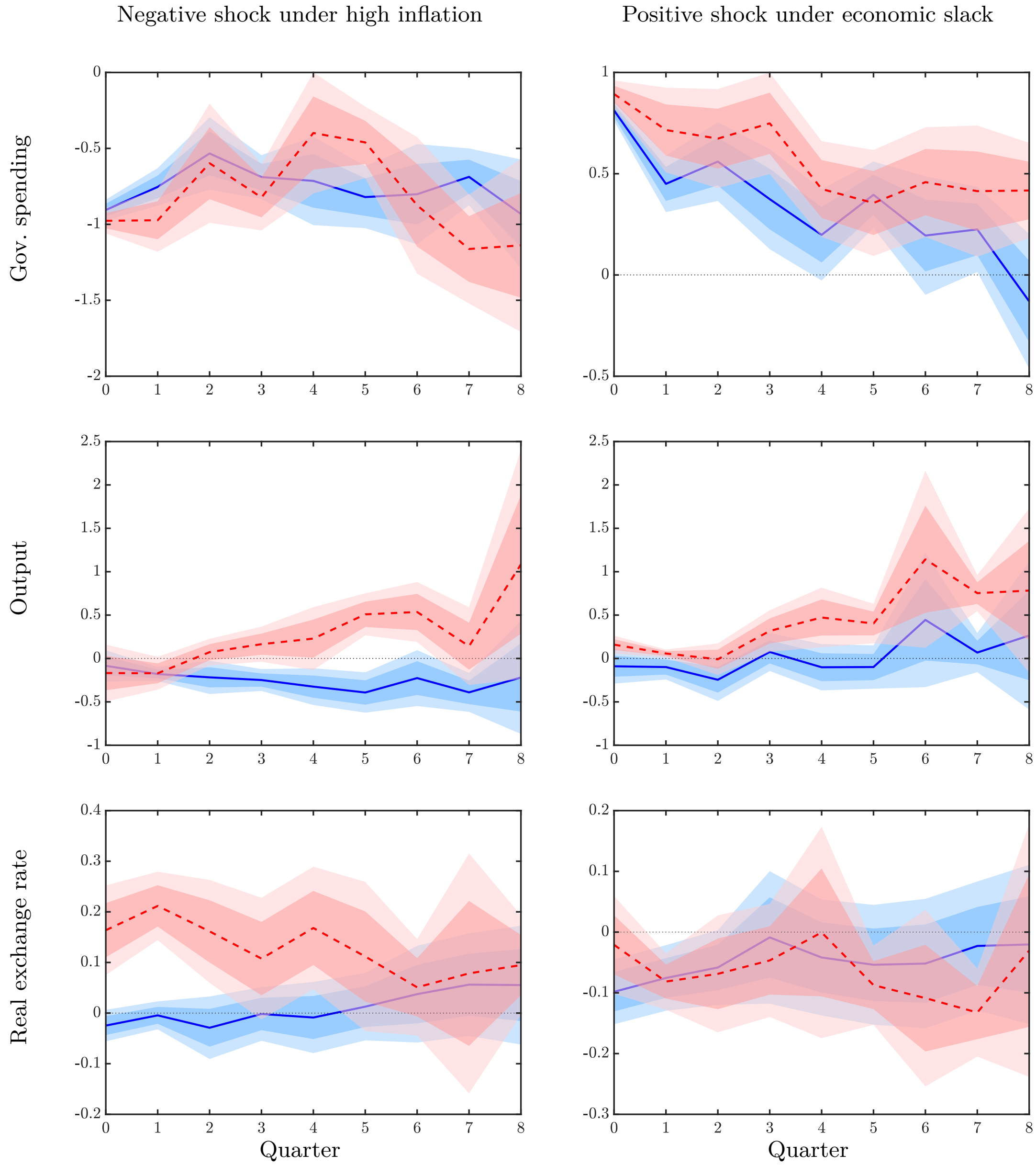
Notes: Estimates for panel of EA countries, where Greece has been excluded. Solid lines represent point estimates, light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from the pre-shock trend/level in percent.

Figure D.4: IRFs – EA with broad real effective exchange rate



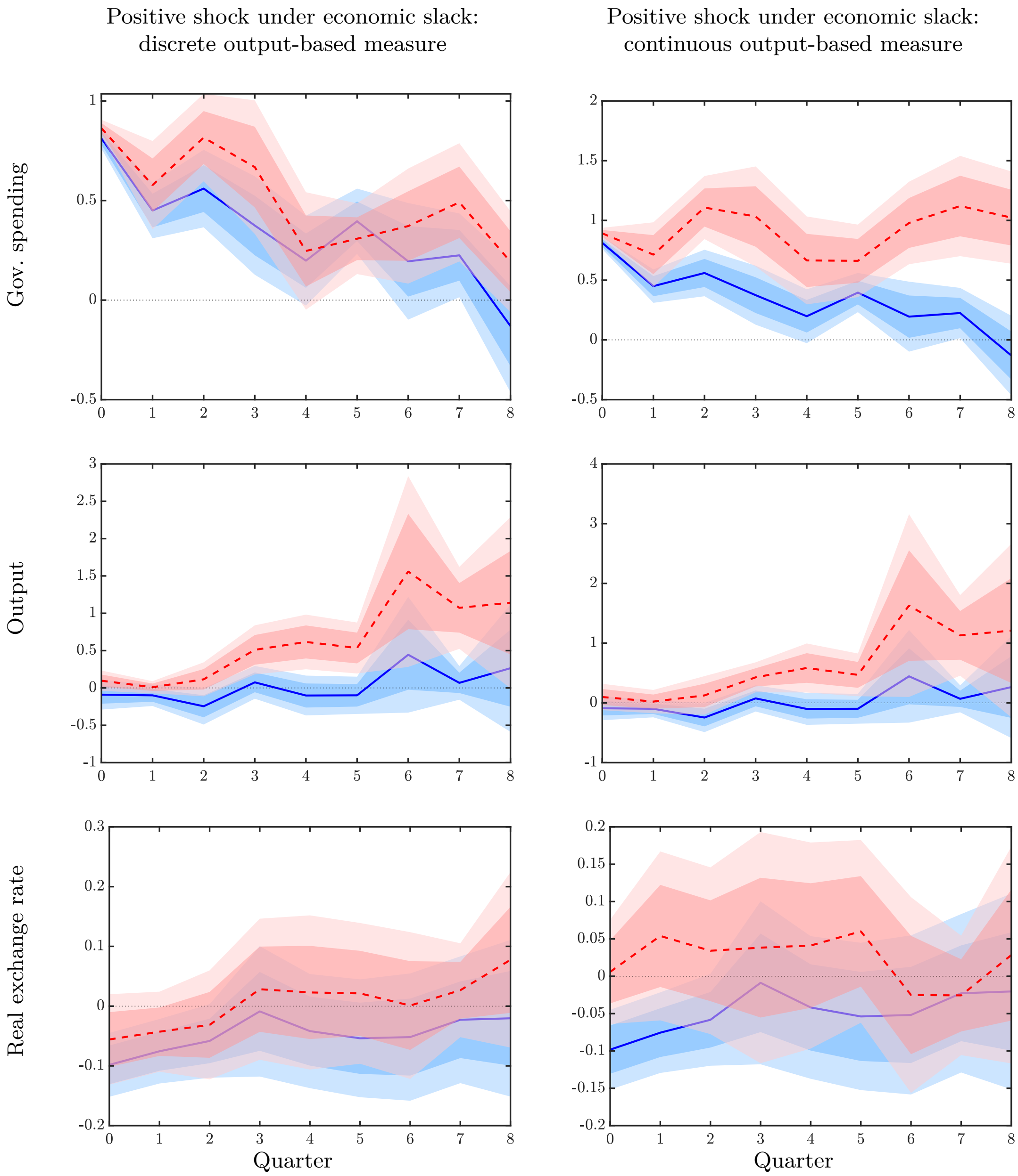
Notes: Estimates for panel of EA countries, using a broad real effective exchange rate index compiled by the Bank for International Settlements (BIS). Solid lines represent point estimates, light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from the pre-shock trend/level in percent.

Figure D.5: IRFs – Inflation and slack v baseline



Notes: Estimates for panel of EA countries. Blue/solid: baseline (reproduced from Figure 3.A); red/dashed (left column): inflation only (inflation rate above 3 percent); red/dashed (right column): slack only (unemployment rate above a country's median). Light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Figure D.6: IRFs – Slack v baseline (for alternative slack measures)



Notes: Estimates for panel of EA countries. Blue/solid: baseline (reproduced from Figure 3.A); red/dashed: slack episodes based on GDP-cycle indicator of Bachmann and Sims (2012). To construct the indicator, we let $z_{i,t}$ denote the z-score normalized seven-quarter backward-looking moving average of real GDP growth in country i and define $f(z_{i,t}) = \frac{e^{-\gamma z_{i,t}}}{1+e^{-\gamma z_{i,t}}}$, with $\gamma = 1.5$. $f(z_{i,t})$ can be interpreted as the probability of a time-country observation being characterized by slack. Left column shows results based on a dummy variable, constructed on the basis of $f(z_{i,t})$: We set the cutoff to select approximately as many slack episodes as with the baseline unemployment indicator ($\approx$ 40 percent); Right column shows results for when $f(z_{i,t})$ is directly interacted with shock measures in the spirit of a smooth-transition model (Auerbach and Gorodnichenko, 2012; Bachmann and Sims, 2012). Light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

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