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Abstract

In economies with fixed exchange rates, the adjustment to government spending shocks is asymmetric. A fiscal expansion appreciates the real exchange rate but does not stimulate output. A fiscal contraction does not alter the exchange rate, but lowers output. We develop these insights in a two-sector model of a small open economy with downward nominal wage rigidity. We establish new empirical evidence that supports the predictions of the model along several dimensions: not only does the exchange rate regime shape the fiscal transmission mechanism as predicted by the model – in doing so it also interacts with economic slack and inflation.

JEL code: E62, F41, F44

Keywords: Downward nominal wage rigidity, government spending shocks, exchange-rate peg, real exchange rate, nonlinear effects, 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 of 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, thus crowding out the demand for domestic goods. Likewise, a cut in government spending depreciates the real exchange rate, but it affects output very little.

In this paper, we attempt to reconcile the Keynesian and the 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 this 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 a large data set covering up to 38 countries and quarterly observations since the early 1990s. We use two alternative strategies to identify positive and negative government spending shocks, and we estimate their effect on output and the real exchange rate.

The main result of our analysis—both in terms of theory and evidence—is that the effects of positive and negative government spending shocks are indeed asymmetric under an exchange-rate peg. In response to a negative government spending shock, the real exchange rate does not adjust in the short run. In line with the Keynesian view, downward nominal wage rigidity prevents the adjustment, output and employment fall sharply. 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 for 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] We plead guilty to the charge that what we label "Keynesian view" is perhaps not giving full justice to Keynes' original ideas. Still, our language follows a long tradition in macroeconomics going back to Hicks (1937). Galí (2013) offers a contemporary account based on a more rigorous reading of Keynes. Classic (or neoclassic) treatments of fiscal policy in a closed economy include Barro (1989) and Baxter and King (1993). Corsetti and Müller (2006) offer a detailed discussion of the role of international relative prices for fiscal policy transmission in the classic open-economy framework of Backus et al. (1994). Similarly, Sinn (2014) stresses the implications of fiscal adjustments for competitiveness.

[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 nontraded goods. To finance its purchases, the government levies lump-sum taxes so that its budget is balanced at all times. 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 and the case of flexible exchange rates. 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 nontraded goods. This, in turn, crowds out private demand for nontraded goods. In contrast, a cut to government spending lowers the relative price of nontraded 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 induce the real exchange rate to appreciate. Yet, in response to a cut, the real exchange rate cannot adjust because of DNWR. The output of nontraded goods as well as employment fall. We stress an important qualification of this result: it obtains only if the economy operates near full capacity. If there is slack, the effects of government spending shocks are symmetric under a peg. However, they are still distinct from the float because the adjustment operates through output and not through prices, and this is the case whether government spending is cut or raised. We establish these results in closed form for a simplified version of the model, and we illustrate that they are quantitatively relevant through model simulations.

As a second contribution, we provide evidence for the asymmetric effects of government spending shocks. For our empirical analysis, we extend and update a fairly rich data set, originally assembled in Born et al. (2020). It contains quarterly time-series data for government spending shocks for a panel of 38 countries, including both advanced and emerging market economies. The data run from the early 1990s to the end of 2018. Importantly, we rely on two distinct measures of fiscal shocks. First, as in Ramey (2011), we identify government spending shocks as the difference between actual government spending and the forecast of professional forecasters. Second, as in Blanchard and Perotti (2002), government spending shocks are obtained as forecast errors within a vector autoregression (VAR) model.

We estimate the response of government spending, the real exchange rate, and output to both shock measures using local projections (Jordà, 2005). This approach is particularly suited for our purpose, since it allows 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 they operate a fixed-exchange-rate regime. In line with the predictions of the theoretical model, we find that the adjustment differs for positive and negative shocks. Negative shocks induce a contraction of output, but they leave the real exchange rate unchanged. Positive shocks, instead, induce an appreciation of the real exchange rate, but they leave output basically unaffected. These results hold for both intra-EA and broader effective exchange rate measures.

Informed by our model analysis, we further probe into the transmission mechanism and condition the effects of fiscal shocks on economic slack, defined as a value for the unemployment rate above a country's median value. Just as the model predicts, we find that the adjustment to positive shocks is different in the presence of slack: the exchange rate hardly appreciates; instead, output increases. Thus, the adjustment in the presence of slack is symmetric because the adjustment to negative shocks remains basically unchanged. Next, we condition estimates on high inflation periods because in that case DNWR should be less of a constraint. We find that the economy responds much more symmetrically to government spending shocks. What changes relative to the baseline is the effect of negative spending shocks: if inflation is high, they depreciate the exchange rate and affect output less, thereby mirroring the adjustment pattern in response to a positive spending shock. Our results for EA countries are robust across several alternative specifications, and they also hold up once we extend the sample to other countries with fixed exchange rates. In a last specification, we compare the transmission of government spending shocks for pegs and floats.

The response of the real exchange rate to government spending shocks has puzzled researchers for some time. Several studies have shown that government spending shocks depreciate the real exchange rate, based on alternative identification schemes and without distinguishing between positive and negative shocks (e.g., Enders et al., 2011; Kim and Roubini, 2008; Monacelli and Perotti, 2010). Their results are normalized to represent the effect of a positive government spending shock, for which standard open economy models, just like ours, predict an appreciation (Kim, 2015). Several mechanisms have been put forward to rationalize the depreciation result (e.g., Corsetti et al., 2012a; Ravn et al., 2012). Other studies have looked into alternative samples and identified country groups and/or specifications for which government spending shocks appreciate the exchange rate (e.g., Ferrara et al., 2021; Ilzetzki et al., 2013; Miyamoto et al., 2019).

Against this background, we run a simple Monte Carlo experiment using our model as the data-generating process. First, we simulate time-series data, and we verify that we indeed can recover the impulse responses to positive and negative shocks based on our empirical specification. In a second step, we repeat the experiment but restrict the empirical estimates to be symmetric. In that case, the estimated exchange rate response exhibits a "depreciation bias". If we restrict responses to be symmetric, the estimator cannot distinguish between the responses to the two shocks. The estimated response to a spending cut will be too strong, the estimated response to a spending increase will be too weak. In each instance, the exchange rate response remains depreciated relative to the true response. We obtain the same pattern once we estimate the symmetric specification on our sample of EA countries. We conclude that distinguishing between positive and negative government spending shocks goes some way towards understanding the depreciation result obtained by earlier studies.

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. (2021) 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 fictions and DNWR.[3] Other recent closed-economy models also assume DNWR in order to generate asymmetries in fiscal transmission (Burgert et al., 2019; Jo and Zubairy, 2021; Shen and Yang, 2018).

Our analysis differs from these studies in two ways. First, in terms of empirical analysis because we use a large cross-country data set rather than time series for the US only. This is is essential for our analysis, because, second, our focus is on the real exchange-rate response to government spending shocks and, in particular, its interaction with the exchange-rate regime. Our analysis thereby assigns a key role to monetary policy for the fiscal transmission mechanism. This is in line with 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. In the following section, we derive closed-form results for a bare-bones version of the model, but we also show the impulse responses computed for the full model. Section 4 introduces our empirical framework, our identification strategy, and our data set. Section 5 presents estimation results for both the EA sample and the larger sample. In Section 6, we restate the case for asymmetry based on a Monte Carlo experiment. Section 7 concludes.

2 A small open economy model with DNWR

The model features a small open economy with two types of goods. One type is produced by a representative firm with labor as the only production factor, and it is not traded internationally. The other type is an endowment good that is traded internationally by a representative household. Wages are downwardly rigid. The model is an extension of SGU, and we keep the exposition short. Our only innovation is to allow for government consumption, assumed to be determined exogenously, financed through lump-sum taxes, and falling exclusively on nontraded goods. This assumption gives us a lot of tractability, and it is not overly restrictive (Corsetti and Müller, 2006).

[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. (2020) study optimal fiscal policy in the presence of sovereign risk, while Liu (2018) focuses on sudden stops.

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 over private and public consumption are given by:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{c_t^{1-\sigma} - 1}{1-\sigma} + \psi_g \frac{(g_t^N)^{1-\varsigma} - 1}{1-\varsigma} \right] , \tag{2.1}$$

where $\mathbb{E}_t$ is the expectation operator, c_t denotes private consumption in period t, g_t^N denotes government consumption of nontraded goods, $\beta \in (0,1)$ is the discount factor, and σ, ς, and ψ_g are positive constants with $1/\sigma$ being the intertemporal elasticity of substitution. Consumption, in turn, is an aggregate of traded goods, c_t^T, and nontraded goods, c_t^N:

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

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

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

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

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 and spends its income on traded and nontraded 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, defined below, and τ_t denotes lump-sum taxes levied by the government. The world interest rate r_t and the endowment of traded output y_t^T are assumed to be exogenous and stochastic.

We assume that the law of one price holds for traded goods, that is, $P_t^T = \mathcal{E}_t P_t^{T*}$, and normalize the foreign-currency price of traded goods to unity: $P_t^{T*} = 1$. As a result, the price of traded goods is equal to the exchange rate, $P_t^T = \mathcal{E}_t$. In addition, we assume $P_t^*/P_t^{T*} = 1$, that is, we normalize the foreign relative price of consumption to unity. This assumption of exogeneity is reasonable in the context of our analysis, for we study a small open economy.

Through its choice of c_t^T, c_t^N, and d_{t+1}, the representative household maximizes (2.1), subject to (2.4) and a no-Ponzi scheme constraint:

$$d_{t+1} \leq \bar{d} \ , \tag{2.5}$$

where $\bar{d}$ is a positive constant. Defining the relative price of nontraded goods, $p_t^N \equiv \frac{P_t^N}{P_t^T}$, the optimality conditions of the household are the budget constraint and

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

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

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

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

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), and (2.9) is the complementary slackness condition.

2.2 The firm

Nontraded output y_t^N is produced by a representative competitive firm. It operates a production technology with labor only:

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

where $\alpha \in (0, 1]$. The firm chooses the amount of 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 understand the mechanics of the model. To maintain full employment, a drop in the demand for nontraded goods requires their relative price to fall. This, in turn, requires a decline in the firm's marginal costs to stabilize the demand for labor. A key factor that determines the firm's real marginal costs is the wage in terms of traded goods. For marginal costs to fall, either nominal wages, W_t, must decline, or the exchange rate must devalue (an increase of $\mathcal{E}_t$).

2.3 The labor market

The household faces no disutility from working, and it meets the labor demand to the extent that it does not exceed the total endowment of labor:[4]

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

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. This is captured by the following complementary slackness condition that must hold in equilibrium for all dates and states:

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

This implies that in periods of unemployment, that is, whenever $h_t < \bar{h}$, the downward nominal wage rigidity constraint is binding. 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 denote 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.

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:

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

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

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 nontraded goods in the following way:

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

2.5 Government spending

The government consumes only nontraded goods g_t^N and it finances its expenditure through a lump-sum tax:

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

Government spending g_t^N is assumed to follow an exogenous process.

2.6 Market clearing

Market clearing in the nontraded-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 (2.13)–(2.15). Appendix A lists the full set of equilibrium conditions, and it provides a definition of the equilibrium for a given exchange rate policy $\{\epsilon_t\}_{t=0}^{\infty}$. This is specified next.

2.7 Exchange rate policy

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

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

This expression is obtained by combining the demand and supply schedules of nontraded 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.

In what follows, we pick from this class of full-employment exchange rate policies the one that minimizes movements in the nominal exchange rate. It is given by:

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

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.

In addition to the scenario of "fully" flexible exchange rates, we also study a scenario of fixed exchange rates and intermediate cases. Formally, we specify the following exchange rate rule (as in Liu, 2018) to capture alternative exchange rate arrangements:

$$\epsilon_t = \max\left\{\gamma \frac{w_{t-1}}{w_t^f}, 1\right\}^{\phi_\epsilon} , \tag{2.26}$$

with $\phi_\epsilon \in [0, 1]$. $\phi_\epsilon = 0$ corresponds to a peg, whereas $\phi_\epsilon = 1$ implements a full-employment stabilizing float ("float"). In general, the smaller the ϕ_ϵ, the less flexible the exchange rate.

3 The fiscal transmission mechanism

In this section, we solve the model and establish several results. First, and most importantly, unless the exchange rate is flexible, the real exchange rate and nontraded output respond asymmetrically to negative and positive government spending shocks. Second, the adjustment to shocks is state-dependent: it differs depending on whether the shock happens when the economy is operating at full capacity or in a state of slack. To show this, we first consider a special case of the model for which we can derive results in closed form. Here we once more mimic the strategy of SGU. However, while they study the prudential nature of optimal capital controls, our focus is on government spending. Afterwards we present results based on simulations of the full model.

3.1 A bare-bones version of the model

Using a simplified version, we illustrate the mechanism that operates at the heart of the model. For this purpose, we assume perfect foresight: a fully unanticipated government spending shock materializes in period $t = 0$ and everybody understands that there will be no further shocks. Specifically, government spending is initially at the steady state level $g < 1$, and it will either be permanently reduced or raised. Formally, we assume:

$$g_t^N = \begin{cases} 0 < \underline{g} < g & \text{in case of negative shock} \\ g < \bar{g} < 1 & \text{in case of positive shock} \end{cases} \quad \text{for all } t \geq 0. \tag{3.1}$$

Moreover, we assume that $U(c_t) = \ln(c_t)$ and $c_t = c_t^T c_t^N$. In this case, the intertemporal consumption choice is decoupled from the intratemporal choice so that we may solve for the equilibrium in the market for nontraded goods while taking as given the level of consumption of traded goods.[5] Regarding the production function, we assume that $\alpha = 1$, so that the marginal product of labor is constant. We also assume that the world interest rate, r, and the endowment of traded goods are constant over time, and we normalize $y^T = 1$. We set $\gamma = 1$ such that wages are perfectly downwardly rigid. Furthermore, we fix $\bar{h} = 1$ and $\beta(1 + r) = 1$ and abstract from the borrowing constraint, but we continue to rule out Ponzi schemes. Lastly, we assume that initially there is no outstanding debt, $d_0 = 0$, and that the economy is in steady state.

The equilibrium conditions of this version of the model are listed in Appendix B.1. In what follows, we focus on the optimality conditions that characterize the market for nontraded goods:

$$p_t^N = \frac{c_t^T}{y_t^N - g_t^N} \tag{3.2}$$

$$p_t^N = w_t \ . \tag{3.3}$$

Recall that p_t^N is the (relative) price of nontraded goods. Given our assumptions on preferences, it is inversely linked to the real exchange rate: $RER_t = 1/p_t^N$. The real exchange rate appreciates (declines) whenever p_t^N increases. Equation (3.2) represents the demand for nontraded goods. It is "downward sloping" in nontraded output: $y_t^N = c_t^N + g_t^N$. Equation (3.3) represents the supply of nontraded goods. It is "horizontal", that is, independent of nontraded output, because, in the simplified model, marginal costs are independent of the quantity produced. Combining the two equations results in the condition:

$$w_t = \frac{c_t^T}{y_t^N - g_t^N} \ . \tag{3.4}$$

In what follows, we obtain several results for this bare-bones version of the model. Note that it features degenerate dynamics. In response to the (permanent) shock, the economy immediately jumps to the new equilibrium and does not adjust further. This gives us a lot of tractability. We omit formal expressions altogether and relegate proofs to Appendix B.

For the first results, we maintain the assumption that, before the shock, the economy resides in a full-employment steady state.

[5] In this case $\lambda = 1/c_t^T$ replaces condition (2.7): marginal utility of traded consumption goods does not depend on c_t^N. Because this preference structure is not linearly homogeneous, it is not nested by the specification in Section 2.

Proposition 1. *(Negative spending shock) Under a float, a negative government spending shock depreciates the real exchange rate, and it does not alter the level of nontraded output; full employment is maintained. In contrast, under a peg, the real exchange rate remains steady, but nontraded output declines, and employment falls below its efficient level.*

Intuitively, because nominal wages cannot fall to restore full employment, it is the nominal exchange rate that adjusts under a float and brings about a decline of real wages. This, in turn, lowers real marginal costs and the price of nontraded goods. As a consequence, the demand for labor and nontraded output is stabilized. In contrast, under a peg, real wages and the price of nontraded goods do not adjust: output and employment fall in sync with government spending. Results are different for a positive government spending shock.

Proposition 2. *(Positive spending shock) Regardless of the exchange-rate regime, a positive government spending shock does not alter the level of nontraded output and employment. It appreciates the real exchange rate.*

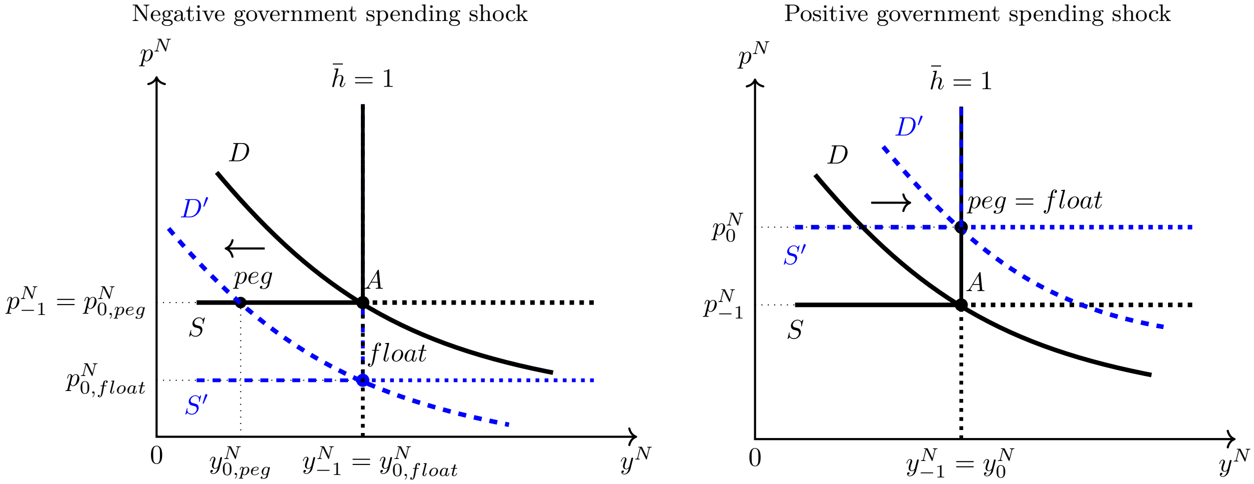
Intuitively, as the economy initially is at full employment, raising government spending cannot induce a further increase of employment. Instead, the real exchange adjusts to absorb the shock. Private expenditure is completely crowded out. The exchange-rate regime is irrelevant for this adjustment, because nominal wages are perfectly flexible to adjust *upwards*. As they increase, the real appreciation is the same under the peg and the float.

Comparing Proposition 1 and Proposition 2, we see that under a peg the responses of the real exchange rate and nontraded output to a government spending shock are asymmetric. The exchange rate appreciates in response to a positive shock, but it does not depreciate in response to a negative shock. By contrast, output does not respond to a positive shock, but it declines in response to a negative shock. In the case of a float, the output response is zero and therefore symmetric. With respect to the exchange rate response, we can formally establish an additional result.

Proposition 3. *Under a float, the response of the real exchange rate to positive and negative government spending shocks of the same size is perfectly symmetric.*

Figure 1 illustrates our results. Both panels show the market for nontraded goods. In the left panel, we show the effect of a negative government spending shock and in the right panel the effect of a positive shock. The level of production of nontraded goods is measured along the horizontal axis. The vertical axis measures the price of nontraded goods in terms of traded goods. Recall that an increase in the price of nontraded goods corresponds to an appreciation (a decline) of the real exchange rate. In both panels, the initial equilibrium is given by point A, the intersection of the supply curve (3.3) and the downward-sloping demand curve (3.2). Note that the effective supply of nontraded goods, which takes into account the capacity constraint, is kinked. This feature of the model drives our results. Once the economy operates at full capacity, the output of nontraded goods cannot be raised any further. But it may decline, which in turn depends on how the price of nontraded goods (or, equivalently, the real exchange rate) responds to the shock.

Figure 1: Theoretical response to fiscal shocks – peg v float (full employment)



Notes: Figure displays the market for nontraded goods, starting from full employment. The horizontal axis measures the level of production of nontraded output. The vertical axis measures the price of nontraded goods (the inverse of the real exchange rate). The downward-sloping curves represent the demand for nontraded goods prior to the shock (D) and after the shock (D'). The kinked lines represent the effective supply of nontraded goods prior to the shock (S) and after the shock (S').

Consider a negative government spending shock (left panel). For a given price of nontraded goods, the demand for nontraded goods declines: this is visualized by the shift from curve D (solid line) to D' (dashed line). Under a peg with downward nominal wage rigidity, 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 nontraded output and the presence of involuntary unemployment. 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 nontraded-goods sector remains unaffected by the shock. Regardless of the exchange-rate regime, there is no further adjustment after impact. Under the peg, the economy never recovers in this version of the model, because wages are perfectly downwardly rigid and the exchange-rate peg is permanent, too. Instead, under the float, the new equilibrium features a permanently depreciated real exchange rate.

Consider now a positive government spending shock, displayed in the right panel of Figure 1. 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 nontraded goods. This happens independently of whether the exchange rate is pegged or floating. In fact, given our assumptions regarding the exchange rate policy, the increase in the price of nontraded goods is based purely on an increase in nominal wages, under both a peg and a float. For both exchange-rate regimes, private consumption of nontraded goods is completely crowded out. In the new equilibrium, the production of nontraded goods and the employment level are unchanged, while the relative price of nontraded goods is higher—that is, there is a real appreciation. Put differently, the fiscal multiplier on nontraded output and employment is zero.

Comparing the adjustment across the two panels of Figure 1, we stress that adjustment is symmetric under the float but asymmetric under the peg. We also compute impulse response functions for the simple model to illustrate the adjustment dynamics. The results are shown in Figure B.1 in the appendix.

Before moving on, we highlight an interesting aspect of the model that becomes pertinent in case—contrary to our assumption above—the positive shock is not permanent. In response to such a shock, the economy would first, as before, settle on point "peg" in the right panel of Figure 1. Now assume that after a while the demand curve shifts back to S because the shock levels off. Because nominal wages cannot fall, the supply curve cannot shift back under the peg. Hence, the economy would settle at a new equilibrium with permanent unemployment. Of course, if wages are permitted to decline over time, that is, if $\gamma < 1$, the economy will gradually converge back to point A. Still, the economy would undergo a recession once the initial fiscal stimulus is turned off. We discuss the case of temporary shocks in more detail in Appendix B.8.

The asymmetric effects of government spending shocks under a peg hinge on an important assumption: that the economy is at full employment when the shock takes place. In what follows, we relax this assumption and obtain a new result for the case of an exchange-rate peg. With such a peg, the effects of spending shocks are symmetric, provided there is sufficient slack in the economy. To induce some slack, we assume that in period 0 the endowment of traded goods, y_t^T, permanently contracts from 1 to some $y_0^T < 1$. Again, this path of y_t^T is perfectly known at time 0, allowing us to establish the following intermediate result.

Lemma. *A drop in the endowment reduces demand for traded and nontraded consumption goods. If the exchange rate is pegged, the downward nominal wage constraint binds, and both the production of nontraded goods and employment decline. The economy operates below potential.*

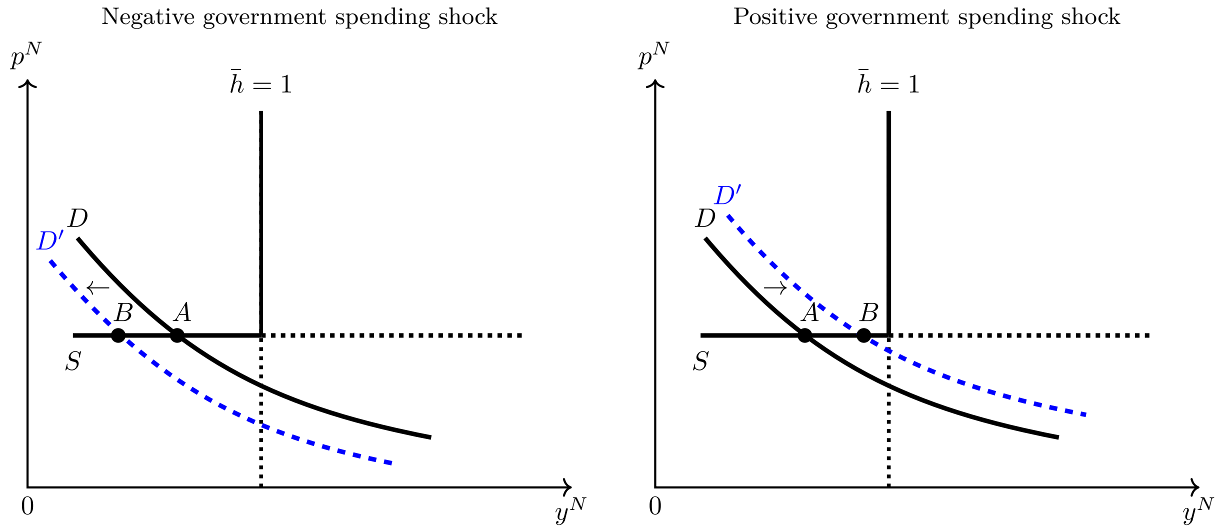
Intuitively, in response to the negative income shock, the household lowers its demand for traded and nontraded consumption. The drop in the traded-goods endowment, therefore, spills over into the market for nontraded goods. To maintain full employment, the reduced demand for nontraded goods would require the relative price of nontraded goods to fall. As this is not possible under the peg if $\gamma = 1$, the endowment shock induces a drop in nontraded output and employment. Eventually, we are interested in how a government spending shock plays out in such a situation (as opposed to full employment). The next proposition establishes our result formally.

Proposition 4. *Consider an exchange-rate peg. The response of the real exchange rate to positive and negative government spending shocks of the same size is zero and therefore symmetric, provided:*

1. *there is slack in the economy to begin with*
2. *and the increase in government consumption is not sufficient to restore full employment.*

Under these conditions, the output multiplier of government spending is also fully symmetric and equal to 1.

Figure 2: Theoretical response to fiscal shocks – peg (slack)



Notes: Figure displays the market for nontraded goods under a peg in times of slack. The horizontal axis measures the level of production of nontraded output. The vertical axis measures the price of nontraded goods (the inverse of the real exchange rate). The downward-sloping curves represent the demand for nontraded goods prior to the shock (D) and after the shock (D'). The kinked line represents the effective supply of nontraded goods.

Figure 2 illustrates this result. As before, the left panel shows the case of a government spending cut, while the right panel shows a spending increase. In contrast to Figure 1, there is now unemployment in the initial equilibrium represented by point A. As before, a reduction of government spending under a peg shifts the demand curve from D to D', but it does not alter the relative price of nontraded goods. However, since the economy is operating below potential, an increase in government spending now raises employment instead of pushing up nominal and real wages (right panel). Either way, the economy moves horizontally along the supply curve in response to changes in government spending, provided they do not make the capacity constraint binding. Put differently, the effects of government spending shocks are symmetric in times of slack.[6]

A corollary of Proposition 4 is that, while the effects of government spending are symmetric for small shocks in times of slack, the response is still asymmetric for large enough shocks. If government spending increases demand beyond the point of full employment, the additional adjustment will work through prices rather than quantities, that is, the exchange rate will appreciate. In contrast, the adjustment to spending cuts will always work through output and employment and not through prices. We also compute the impulse responses to government spending shocks in times of slack. The results are in Figure B.2 in the appendix.

[6]In the full model, the response to government spending shocks is not exactly symmetric under a peg even if there is slack because the supply curve is nonlinear for $\alpha < 1$.

3.2 Simulating the full quantitative model

Once we relax the simplifying assumptions made above, the model features richer adjustment dynamics, but it requires numerical solution techniques to assess the extent to which the asymmetry established in the theoretical model is quantitatively relevant. We employ a quarterly quantitative model tailored to Greece. Nominal wages are allowed to fall by roughly 3% per year.[7]

Figure 3 displays the model impulse responses (IRF) to positive and negative government spending shocks of ±2.2 percentage points of steady-state nontraded output (a one-standard-deviation shock).[8] In the figure, the solid lines represent the dynamics from a spending increase, while the dashed lines correspond to a spending cut. We report the responses for the first 8 quarters after a shock.

In the left column, we show results based on 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%.[9] We also compute impulse responses for an intermediate exchange-rate regime with $\phi_e = 0.33$. We find, perhaps unsurprisingly, that they are in between those obtained for the peg and the pure float (see Figure C.2 in the appendix).

The panels in the top row of Figure 3 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 nontraded output, y^N, and the real exchange rate, RER, respectively.[10] As before, a decline of RER represents a real appreciation.

Overall, we find that the qualitative results established above turn out to be quantitatively important. Several points are particularly noteworthy. First, as established in Proposition 1, a cut in government spending (dashed lines) depreciates the real exchange rate under a float (left column), and nontraded output is fully stabilized. In contrast, under a peg (middle and right columns), the response of the real exchange rate is much weaker. Now, and in contrast to the analytical findings, because we no longer restrict wages to be completely downwardly rigid, the exchange rate does adjust over time. However, its response is still very much muted compared to the float. Therefore, nontraded output declines strongly and persistently in response to the spending cut.

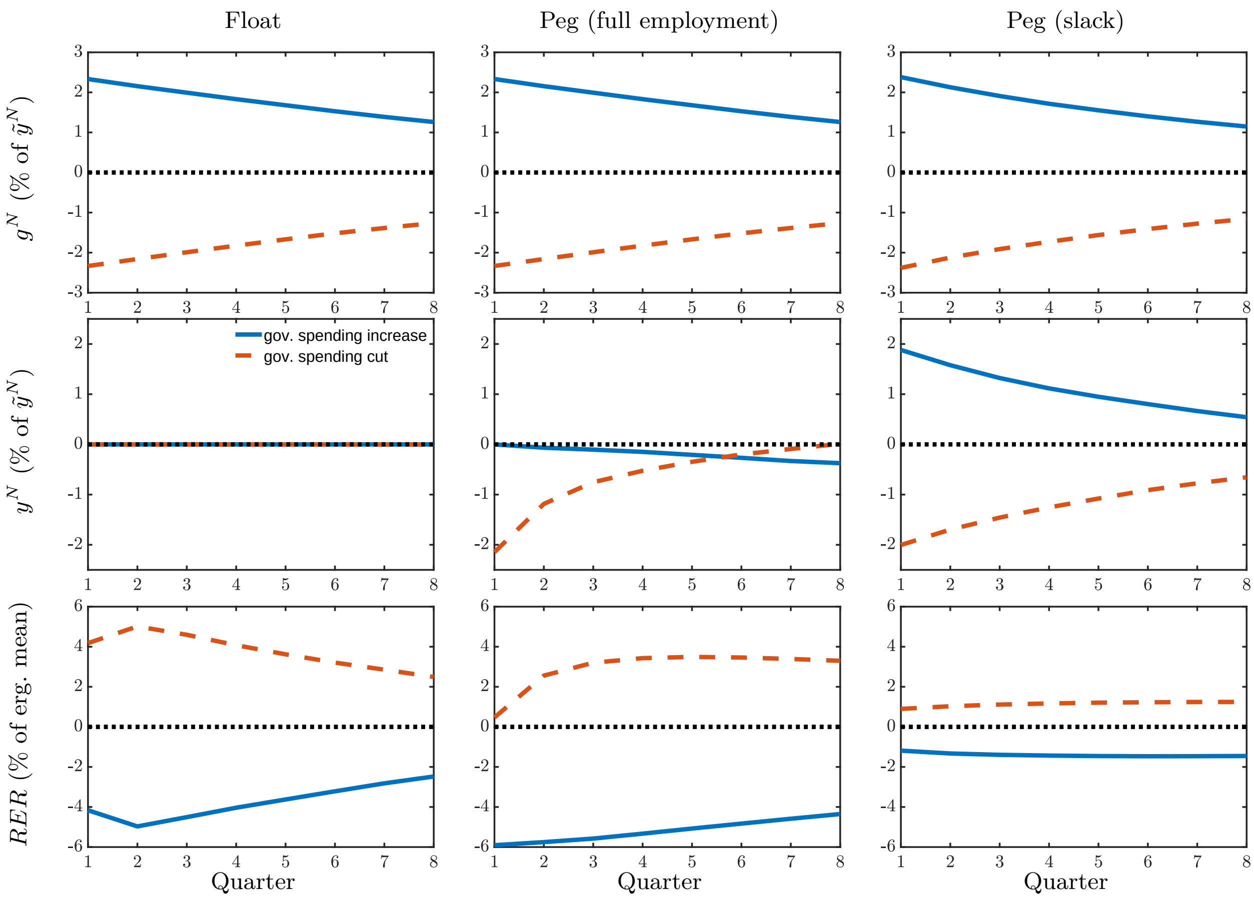
[7] Appendices C.1 to C.3 present the details of the model calibration and the solution method.

[8] 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.

[9] Using different initial conditions for the scenarios 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 draw from the ergodic distribution by first simulating the model for a burn-in period of 300 quarters. Appendix C.4 provides summary statistics of the ergodic distribution.

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

Figure 3: Quantitative model irf



Notes: Generalized impulse responses to one-standard-deviation government spending shocks in the quantitative model. Solid line: spending increase, dashed line: spending cut. Left column: flexible exchange rate. Middle column: exchange-rate peg and full employment. Right column: peg and economic slack. Top panels: government spending; middle panels: nontraded output; bottom panels: real exchange rate. Vertical axis: effect of shocks in percent of full employment nontraded output $\tilde{y}^N$ and of the ergodic mean of the RER, respectively.

Second, turning to positive spending shocks (solid lines), we obtain dynamics in line with Proposition 2. On impact, the adjustment is independent of the exchange-rate regime, provided there is full employment. Output does not fall, and the exchange rate depreciates for reasons discussed above. However, as we simulate the full model, we now observe richer adjustment dynamics. While initially unaffected, output under the peg declines somewhat over time under the peg because the shock process reverts to the mean rather than being permanent. Put differently, we find that under a peg (with full employment) the impact multiplier of positive government spending shocks on output is zero. It is negative in the short run. As government spending reverts to its pre-shock level, real wages and the real exchange rate must decline in order to maintain full employment. This is what happens under the float (left column). It also happens under the peg (middle panel) but more slowly because of the downward nominal wage rigidity.[11]

[11] See also Figure B.3 in the appendix.

Third, we find that the response of the real exchange rate response is symmetric under a float, as established in Proposition 3. It is asymmetric under a peg with full employment. Positive shocks appreciate the real exchange rate, whereas negative shocks induce some depreciation in the full model because wages are not fully downwardly rigid and the supply curve is upward sloping. Yet, the exchange rate response to spending cuts is one order of magnitude weaker than the response to spending increases. Just like the response of the real exchange rate, the asymmetry is quite strong for nontraded output, too.

Fourth, we find that the adjustment under a peg is symmetric if there is slack, consistent with Proposition 4. This holds both for the exchange rate and for output. In contrast to what we established for the simplified model, we now observe that the real exchange rate actually moves in response to positive shocks, because the supply curve is not perfectly horizontal ($\alpha < 1$), and nominal wages are allowed to fall somewhat ($\gamma < 1$). But the exchange-rate response is considerably weaker compared to the case of full employment.

4 Empirical strategy

Informed by the model-based analysis, we ask whether positive and negative government spending shocks affect the real exchange rate asymmetrically. At the same time, we look at the response of output because theory suggests that asymmetry in the response of the exchange rate to fiscal shocks is tied to that of output.

In our empirical analysis, we consider two identification schemes, and because the data requirements differ across these schemes, we rely on somewhat different samples for each instance. Both identification schemes are centered around forecast errors, and they build on earlier work by Ramey (2011) and Blanchard and Perotti (2002), respectively. In both cases, the idea is to measure the surprise component of government spending. The first case is based on professional forecasts. The second case uses an estimated vector autoregressive (VAR) model. Either way, the surprises represent fiscal shocks under the assumption that they do not reflect an endogenous response of fiscal policy to other innovations in the economy. We then rely on local projections (Jordà, 2005) to estimate the impulse responses of government spending, output, and the real exchange rate to fiscal shocks.

4.1 Estimation equation

Conceptually, it is convenient to distinguish two steps in our analysis. In the first step, we compute fiscal shocks or exogenous variation in government spending, denoted by $\varepsilon^g_{i,t}$. Here, indices i and t refer to country i and period t, respectively. The computation of $\varepsilon^g_{i,t}$ varies across identification schemes and we provide more details below.

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 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, $\varepsilon_{i,t}^{g-}$. Letting $x_{i,t+h}$ denote the variable of interest in period $t+h$, we estimate how it responds to fiscal shocks in period t on the basis of the following specification:

$$x_{i,t+h} = \alpha_{i,h} + \eta_{t,h} + \psi_h^+ \varepsilon_{i,t}^{g+} + \psi_h^- \varepsilon_{i,t}^{g-} + \gamma Z_{i,t} + u_{i,t+h} \; . \tag{4.1}$$

Here, the coefficients ψ_h^+ and ψ_h^- provide a direct estimate of the impulse response at horizon h to a positive and negative shock, respectively. $Z_{i,t}$ is a vector of control variables. 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-fixed 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).

4.2 Identification

As stressed above, we obtain results for two identification schemes. For both, we provide a detailed discussion in Born et al. (2020). What follows is a summary of the essential aspects. While distinct, the two strategies are centered around the notion of forecast errors. One strategy has been introduced by Ramey (2011). The idea is simply to purge actual government spending growth of what professional forecasters project spending growth to be. Formally, we have

$$\varepsilon_{i,t}^{g} = \Delta g_{i,t} - \mathbb{E}_{t-1} \Delta g_{i,t} \; ,$$

where $\Delta g_{i,t}$ is the realized growth of government consumption and $\mathbb{E}_{t-1}\Delta g_{i,t}$ is its previous-period forecast.

The second strategy uses a panel VAR model to compute spending surprises. Let $X_{i,t}$ denote a vector of endogenous variables, which include government spending and output. We estimate the following model:

$$X_{i,t} = \alpha_i + \eta_t + A(L) X_{i,t-1} + \nu_{i,t}, \tag{4.2}$$

where $A(L)$ is a lag polynomial, and $\nu_{i,t}$ is a vector of reduced-form disturbances with covariance matrix $E(\nu_{i,t}\nu_{i,t}') = \Omega$. In our analysis, we allow for four lags since the model is estimated on quarterly data. Assuming i) a lower Cholesky factorization L of Ω, and ii) that government consumption growth is ordered on top in the vector $X_{i,t}$, the structural shock $\varepsilon_{i,t}^{g}$ equals the (scaled) first element of the reduced-form disturbance vector $\nu_{i,t}$, that is, $\varepsilon_{i,t}^{g} = L^{-1}\nu_{i,t}$.[12]

Our identifying assumption, dating back to Blanchard and Perotti (2002), is that the forecast error of government spending growth is not caused by contemporaneous innovations, so that it represents a genuine fiscal shock. We make the same assumption with regard to both measures of fiscal surprises, those obtained in the VAR setting and those based on the professional forecasts. It is also implicit in Ramey (2011), as she considers a measure of fiscal shocks based on professional forecasts. For identification to go through, her (implicit) assumption is that surprise innovations

[12]The estimated shocks $\hat{\varepsilon}_{i,t}^{g}$ enter the second-stage equation (4.1) 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 is zero. See also Coibion and Gorodnichenko (2015), footnote 18, on this point.

do not represent an endogenous response to other shocks. As discussed by Blanchard and Perotti (2002), the rationale for this assumption is that government consumption can be adjusted only subject to decision lags. Since we impose this assumption on quarterly time-series data, it seems not overly restrictive. Also, there is no automatic response, since government consumption does not include transfers or other cyclical items.

Lastly, we note that the VAR model (4.2) is linear. It does not distinguish between the effects of positive and negative government spending shocks. However, this is immaterial for their identification, which we verify by means of a Monte Carlo exercise in Section 6. Using the (nonlinear) model introduced in the previous section as the data-generating process, we show that our empirical strategy allows us to recover the effects of positive and negative government spending shocks correctly.

4.3 Data

Our data sets differ across shock measures because of differences in data coverage. We can compute the VAR-based forecast errors for 38 countries using quarterly observations starting in the early 1990s and ending in 2018. However, the professional forecasts are available only for a subset of 23 countries. In the latter case, we rely on proprietary data on quarter-on-quarter growth rate projections provided by *Oxford Economics*.[13] We focus on growth *rates* rather than *levels* 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. *Oxford Economics* provides 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 $E_t \Delta g_{i,t+1}$. We compute the forecast error $\varepsilon^g_{i,t}$ by professional forecasters as the difference between actual spending growth and the forecast.[14]

Table 1 provides summary statistics for the two shock measures, including the number of countries, the number of observations and the mean forecast error in each instance. The left panel reports statistics for the full sample, the right panel for a subset of EA countries. The latter group is of particular interest because, in our analysis, we establish several results for this group of countries. It is also informative to compare the two measures in terms of their root mean squared error (RMSE). We observe that *Oxford Economics* produces forecasts with a somewhat higher RMSE than the VAR. Compared to the full sample, RMSEs for the EA sample are lower for both shock measures. This is probably because the full sample contains more volatile emerging economies. In the last row of Table 1, we report a measure of the predictive power of the shocks for actual government spending growth in the form of an F-statistic along the lines of the tests conducted in Ramey (2011) and Ramey and Zubairy (2018).[15] We find that both shock measures pass the

[13] *Oxford Economics* is a large forecasting firm serving a wide range of clients, including large corporations and institutions.

[14] For this purpose we rely on the latest data vintage, rather than on the historical real-time series that we used in earlier work (Born et al., 2020). As a result, the forecast errors are more powerful in predicting actual government spending (for which we also use the latest vintage).

[15] Technically, given our panel structure with potentially non-i.i.d. errors, we follow the suggestion in Baum et al.

Table 1: Fiscal shock measures – descriptive statistics

	Full sample		EA sample	
	Prof. forecasts	VAR	Prof. forecasts	VAR
Countries	23	38	11	15
Observations	1713	2944	757	979
Mean	-0.23	0.00	0.12	0.00
RMSE	2.52	1.95	1.24	0.99
Wald F-statistic	306.50	840.43	237.47	357.25

Notes: Forecast errors and RMSE are measured in percentage points. Kleibergen and Paap (2006) rk-Wald F-statistic computed using Stata's xtivreg2 in a first-stage regression of government consumption growth on the respective forecast error. Robust covariance estimator clustered at country and quarter level. Professional forecasts are based on Oxford Economics. Left panel: full sample of countries. Right panel: sample restricted to euro area observations.

rule-of-thumb threshold of 10 proposed by Staiger and Stock (1997) with flying colors.[16]

We report details on the country coverage in Table D.3 in the appendix, and we show the time series for the shock measures in Figures D.1 to D.4 on a country-by-country basis.[17] The two shock series display a high degree of correlation in all countries, and they are generally more volatile in emerging economies. We also observe some larger shocks around crisis events like the global financial crisis, the euro debt crisis, the Mexican Peso crisis, and the Asian financial crisis. But these instances are limited to a few countries, and the shocks do not appear unusually large or persistent in the context of the longer time series. In the baseline, we pool observations across countries as we estimate the VAR model—while allowing for country-fixed effects—because the time series for individual countries are sometimes short. In a robustness check, we estimate the first-stage VAR on a country-by-country basis. In addition, we re-estimate the VAR-based shocks on the EA sample only. We compare the resulting shock series and find that they are very similar to the baseline, see Figures D.5 to D.7 in the appendix.

For the EA sample, we also compute the cross-country correlation of shocks. This is of particular interest because, during the sovereign debt crisis in the euro area, there were some considerable shifts in fiscal policy, possibly correlated across countries. We find, however, that most cross-country correlations are moderate and similar across the two shock measures, see Table D.4 in the appendix.

For the dependent variables, we rely on conventional data sources. Our measure of the real exchange rate is the broad real effective exchange rate index compiled by the Bank for International Settlements (BIS), complemented by data for Ecuador, El Salvador, and Uruguay, based on the data for 38 trading partners compiled by Darvas (2012). We obtain quarterly values as the average of the

(2007) and check the predictive power of our identified shocks using the Kleibergen and Paap (2006) rk Wald F-statistic. It is computed in a "first-stage" panel fixed effects regression of the growth of government consumption on the respective shock measure. Computing "naïve" F-statistics in our pooled sample yields very similar values.

[16]The Montiel Olea and Pflueger (2013)-threshold for the 5 percent critical value for testing the null hypothesis that the 2SLS bias exceeds 10 percent of the OLS bias in our context is 23.1.

[17]To ensure the comparability of the two shock measures, we remove time-fixed effects from the shock measure based on professional forecasters because the VAR model features time-fixed effects.

monthly index values. An increase in the index indicates a depreciation of the economy's currency against a broad basket of currencies. Our measures of real GDP and government consumption are based on national accounts. For the EA sample, we rely on the CPI-based intra-EA real effective exchange rate provided by Eurostat.

The vector of controls in the local projection (4.1) features four lags of log real government consumption, log real output, and the log real effective exchange rate. In addition, we include the sovereign default premium, measured as the spread between foreign currency debt and a riskless benchmark interest rate (Born et al., 2020). We remove country-specific log-linear time trends for output and government spending.[18]

5 Empirical evidence

We now present estimates based on equation (4.1). Throughout, we distinguish the effects of positive and negative government spending shocks. As established formally in Section 3, the distinction between positive and negative shocks is important for understanding the effect of fiscal shocks in open economies, provided that additional conditions are met. Most important of all, the exchange-rate regime is key. The model predicts the effects of positive and negative spending shocks to differ only for exchange-rate pegs, but to be symmetric under a float. 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 again. Finally, while not explicitly included in our formal model analysis, whether the response is asymmetric should also depend on the level of inflation. After all, 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.

In our empirical analysis we account for these complications progressively. 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. They cannot resort to monetary policy to bring about a nominal exchange-rate adjustment in response to country-specific (fiscal) shocks—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.[19] While this proviso is certainly not exactly met for each country in the EA, focusing on the EA provides us with a fairly homogeneous and large data set that allows us to condition the results on the state of the business cycle and the level of inflation as well. That being said, we will also present results for exchange-rate pegs in general, as well as for floating exchange rates.

[18]Doing so for the real exchange rate does not alter our results.

[19]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 D.3 for the detailed sample coverage.

5.1 Results for euro area countries

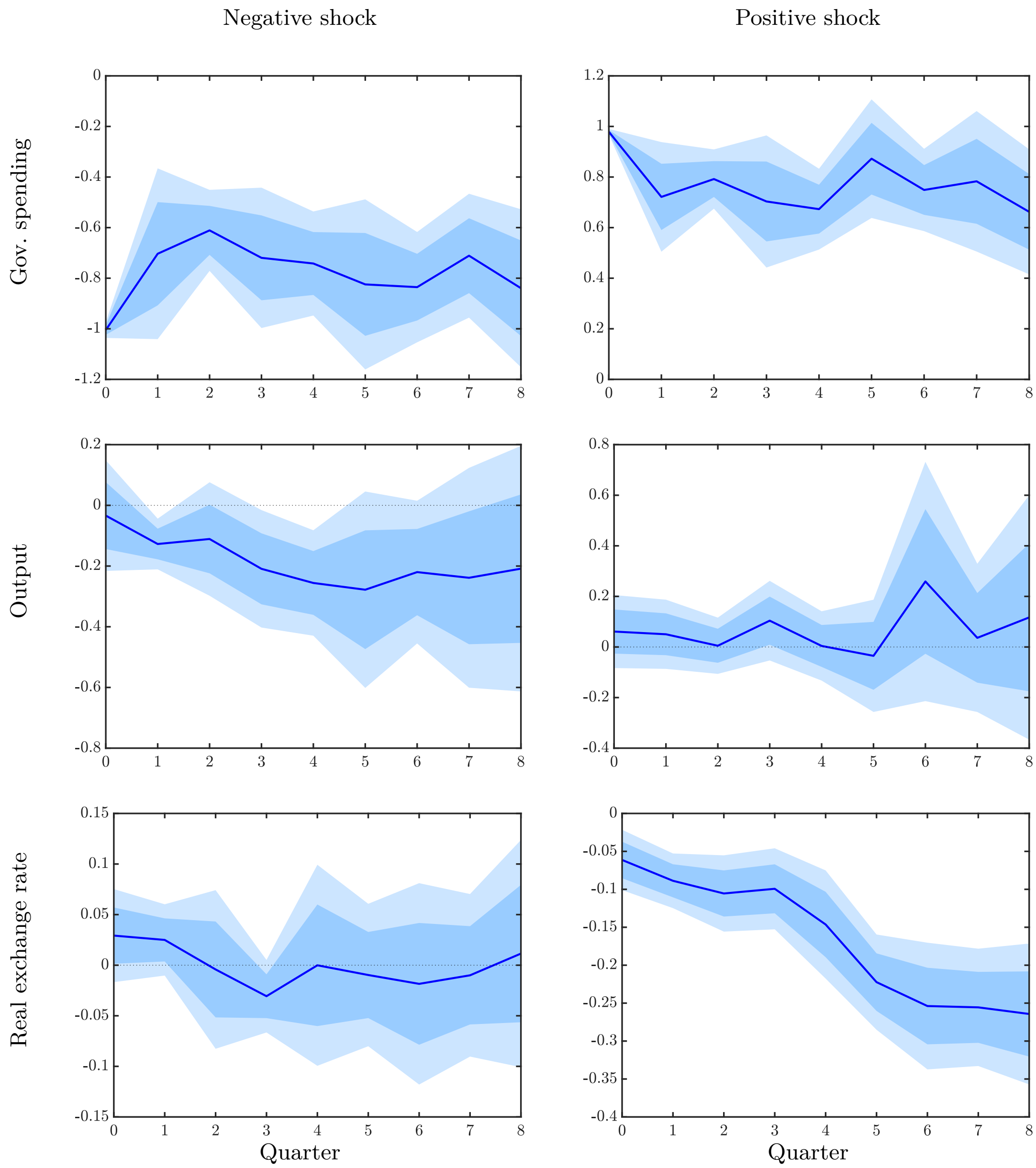
Our focus is on how government spending shocks affect the exchange rate. In this section, we present results based on a sample of EA countries. This requires us to address several concerns regarding our sample upfront. First, the nominal exchange rate of each EA member is fixed as far as the other EA countries are concerned. At the same time, the euro is floating against many non-euro currencies, and since EA countries are very open to trade, this matters for our analysis. 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, it is important to include time-fixed effects in equation (4.1). As a result, identification is not driven by EA-wide developments but by country-specific fluctuations relative to the common component. Still, and this is a third complication, a fiscal shock that occurs in a big EA country such as Germany, France, or Italy may still have a non-negligible impact on EA-wide aggregates.[20] This, in turn, may induce an adjustment of monetary policy that is ruled out in our stylized model of an exchange-rate peg. In our sensitivity analysis in Section 5.2, therefore, we verify that our results are not driven by specific countries in the sample. Last, we recognize that fiscal policy underwent some sharp adjustments during the sovereign debt crisis in the EA. Therefore it is important to control for sovereign risk as we estimate the effect of government spending shocks. We do so by including the sovereign default premium in our set of control variables in equation (4.1).

In what follows, we report results based on both shock measures introduced in Section 4.2. Consider first the results for the VAR-based forecast error computed on the EA sample, shown in Figure 4: the left column displays the impulse responses to a negative government spending shock, the right column displays the responses to a positive shock. Here and in what follows, solid lines represent the point estimate, while the dark (and light) shaded areas indicate 68 (and 90) percent confidence intervals, respectively. We measure the time after impact along the horizontal axis in quarters and the effect of the shock along the vertical axis in percentage deviation from the pre-shock trend (or pre-shock level in case of the exchange rate). The response of government spending, shown in the top row, is fairly persistent in both cases. While the initial shock amounts to one percent of government spending, spending is still deviating from its pre-shock trend by about 0.8 percent after 8 quarters. Importantly, the response of government spending to positive and negative shocks is fairly symmetric.

We show the response of output in the middle panels and the response of the real exchange rate in the bottom panels of the figure. We find that the predictions of the model are fully borne out by the evidence: output drops in response to a spending cut, but it is virtually unchanged if government spending is raised. The exchange rate, instead, does not respond to a spending cut, but it appreciates (declines) in response to a spending increase. Put differently, a negative shock is absorbed by economic activity, while a positive shock is absorbed by relative prices. Mr. Keynes meets the Classics: the adjustment to a negative shock is Keynesian, but the adjustment to a

[20]The same may be said for a small country such as Greece during the EA crisis, if there is fear of contagion.

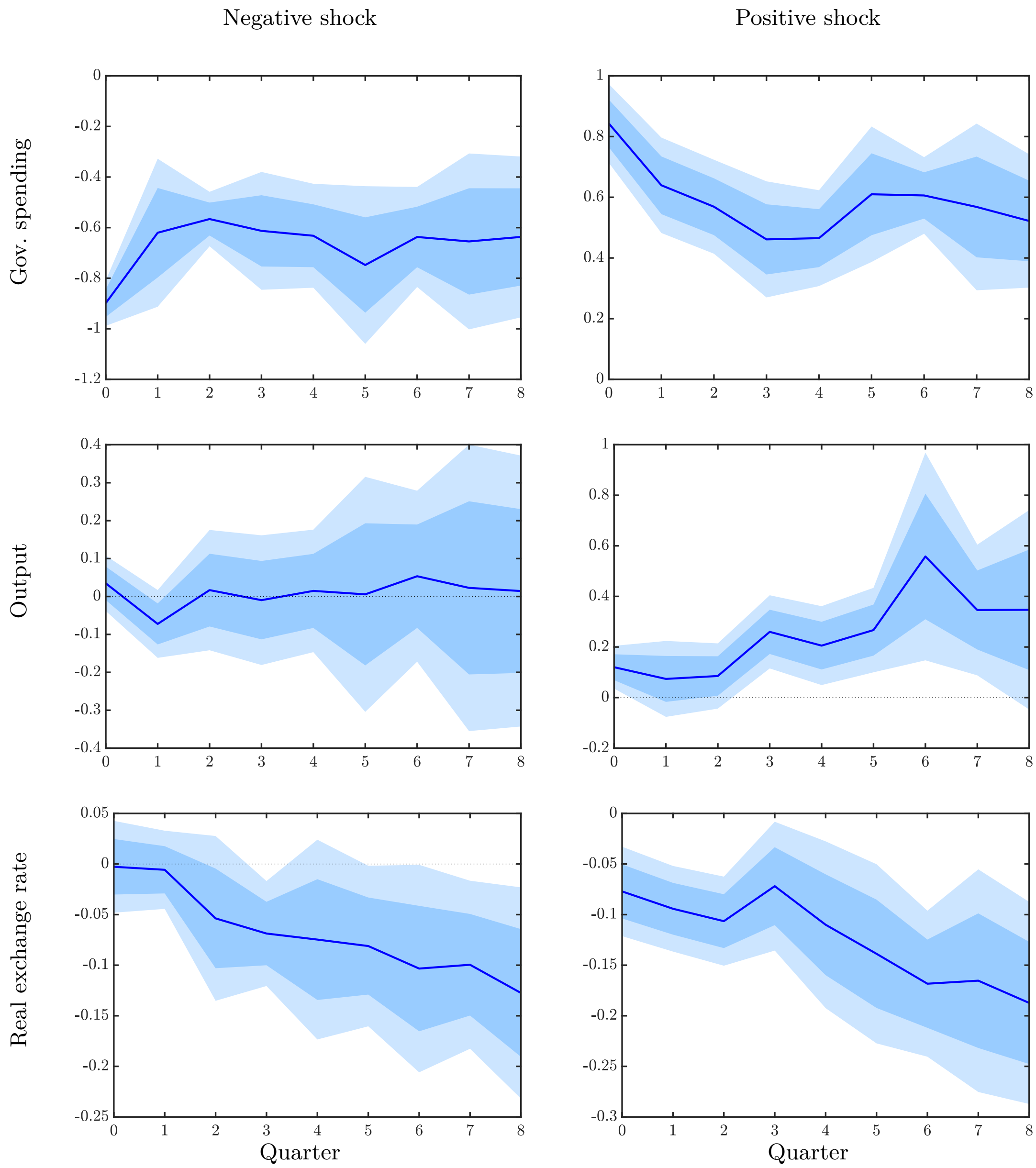
Figure 4: IRFs – VAR forecasts EA



Notes: Adjustment to negative and positive government spending shocks, identified using *VAR forecasts*. Sample: EA countries. Solid lines represent point estimates, light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

positive shock is Classical. It is also worth commenting briefly on the fiscal multiplier entailed in our estimates. For positive spending shocks the (impact and peak) multiplier is essentially zero. This is perhaps surprising, but not unheard of (Corsetti et al., 2012b). 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 15 percent of GDP on average, our finding that a change in government spending of one

Figure 5: IRFs – professional forecasts EA



Notes: Adjustment to negative and positive government spending shocks, identified using *professional forecasts*. Sample: EA countries. Solid lines represent point estimates, light (dark) shaded areas represent 90 (68) percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

percent affects output by about 0.2 percent, implies a multiplier of about 1.33.[21]

Not only do our results align well with theory, but they are also robust across shock measures. To see this, consider Figure 5. It shows the results for the shock measure based on professional forecasts. The figure is organized in the same way as Figure 4, and we find that the results are very similar. The response of government spending to negative spending shocks (left column) and to

[21]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.

positive spending shocks (right column) is again shown in the top row. It exhibits similar, roughly symmetric dynamics. The responses of output and the real exchange rate are shown in the middle and bottom rows of the figure. As before, we observe an adjustment of the exchange rate on impact only in response to positive spending shocks. It is fairly flat in response to negative spending shocks, at least initially. While this pattern accords fully with the predictions of the model, the response of output is less aligned. It increases somewhat in response to a positive spending shock—in contrast to what we documented in Figure 4 for the VAR-based shock measure.

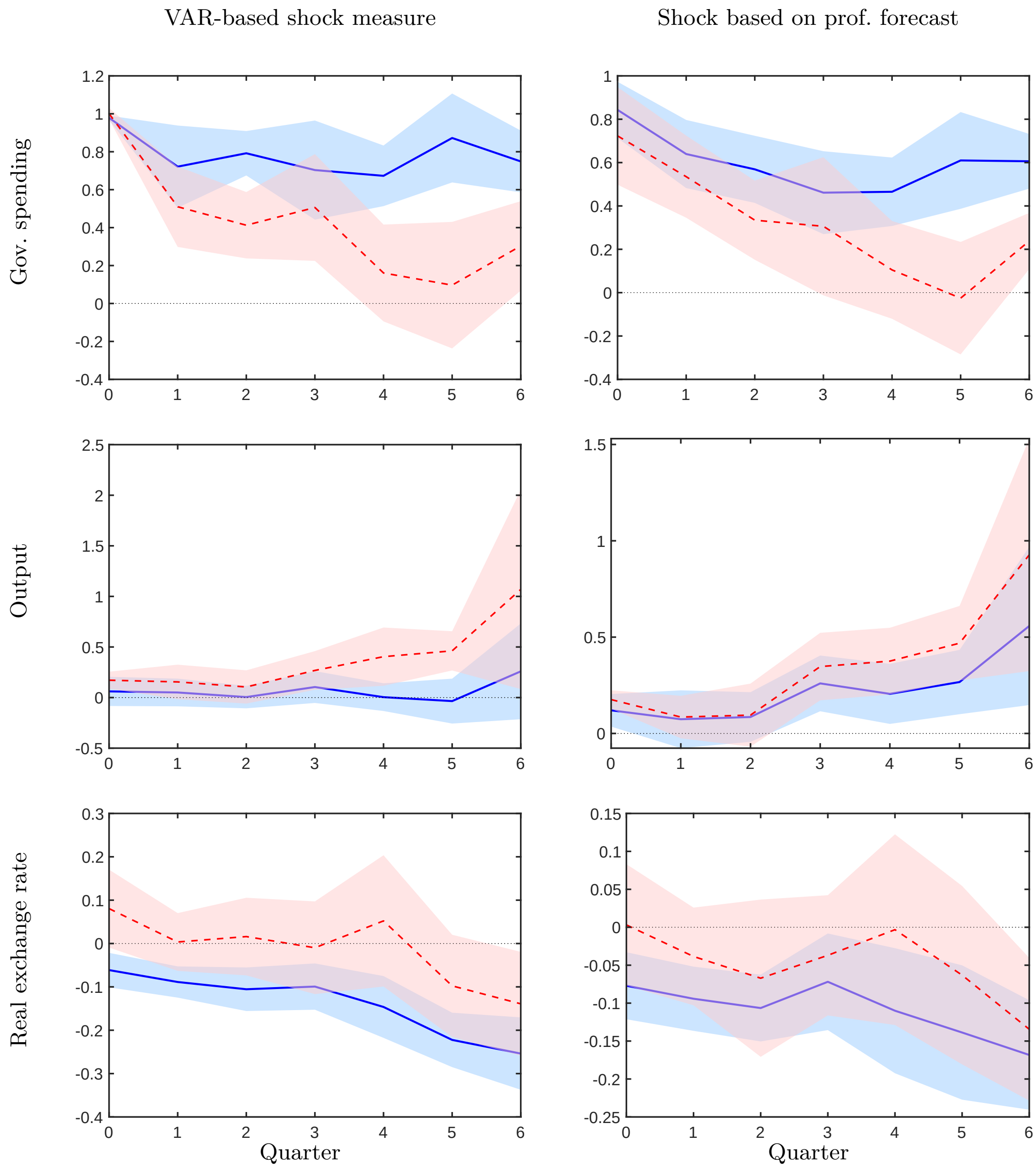
To rationalize this finding, we turn to another key prediction of the model. The response to positive spending shocks does not depend only on the exchange-rate regime, but also on whether there is economic slack. In the case of sufficient slack, a positive government shock should affect output rather than the exchange rate. Put differently, for slack, the responses should be symmetric even as countries have their exchange rates pegged. Earlier work has focused on the role of slack in the transmission of fiscal shocks and obtained partly conflicting results. Influential studies by Auerbach and Gorodnichenko (2012, 2013) show that the effects of fiscal policy are stronger in a recession than in a boom. Ramey and Zubairy (2018), on the other hand, find that multipliers generally do not depend on the extent of slack in the economy. Our stylized model with DNWR suggests a refinement based on the distinction of positive and negative spending shocks. It predicts that economic slack alters the effects of government spending shocks, but only those of positive shocks: raising government spending in times of slack should affect output rather than the exchange rate, as opposed to when the economy is operating at full capacity.[22] Instead, the effect of negative spending shocks should be independent of whether there is slack.

To assess this prediction empirically, we use the unemployment rate to measure the extent of slack and limit our sample to observations for which it is above a country's median unemployment rate, as in Barro and Redlick (2011).[23] Then we re-estimate equation (4.1) on this sample and show results in Figure 6 for positive spending shocks, both for the VAR-based shock measure (left column) and for the shock measure based on professional forecasts (right column). We restrict the maximum horizon in the estimation to six quarters, as conditioning on slack shrinks the sample considerably. The red dashed lines show the impulse responses for slack episodes while the blue solid line reproduces the result for the baseline. Shaded areas indicate 90 percent confidence intervals. The result is clear-cut and independent of the shock measure. Slack alters the response to a positive spending shock. Just as the model predicts, output rises in times of slack, while the exchange-rate response is muted and insignificant. Also consistent with the theory, the response to negative spending shocks does not change much relative to baseline. See Figure E.1 in the appendix. Hence, in times of slack, the response to a positive or negative shock is symmetric. These findings, as we show in Section 5.2, are robust once we vary the definition of slack and point to an explanation for why the output responses to a positive spending shock in Figures 4 and 5 differ. After all,

[22]This prediction obtains under the assumption that monetary policy pursues an exchange-rate target. However, the predictions of the model may apply more generally provided that monetary policy does not perfectly stabilize economic activity even if unconstrained by an exchange-rate target.

[23]Here we use unemployment as a percentage of the active population from the EU-LFS main indicators.

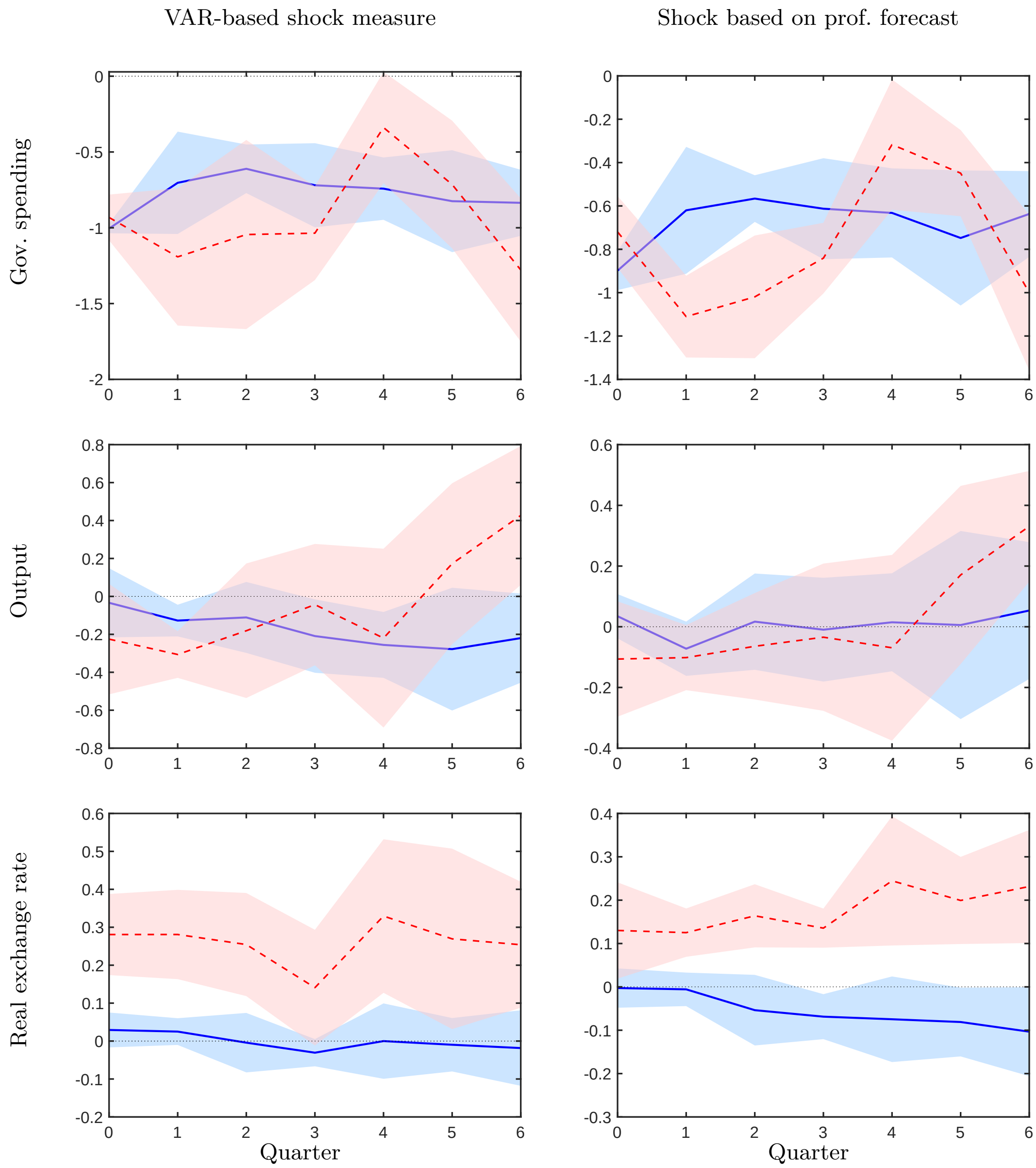
Figure 6: IRFs to positive shocks – slack only v baseline



Notes: Adjustment to positive government spending shocks, identified using *VAR forecasts* (left) and *professional forecasts* (right). Blue/solid: baseline (reproduced from Figures 4 and 5); red/dashed: slack only (unemployment rate above a country's median). Sample: EA countries. Lines represent point estimates; shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

the estimates reported in those figures are based not only on different shock measures, but also on somewhat different samples for reasons of data availability. It is thus possible that differences in the output response to positive spending shocks may reflect differences in the cyclical conditions of the underlying sample.

Figure 7: IRFs to negative shocks – high inflation only v baseline



Notes: Adjustment to negative government spending shocks, identified using *VAR forecasts* (left) and *professional forecasts* (right). Blue/solid: baseline (reproduced from Figures 4 and 5); red/dashed: high inflation periods only (above 3 percent). Sample: EA countries. Lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Finally, we condition the effect of government spending shocks on high inflation periods. We conjecture that inflation affects fiscal transmission for the following reason. In our stylized model, the asymmetric response to government spending shocks under a peg is caused by DNWR. It prevents real wages from declining in response to a spending cut, but it does not constrain their rise in response to a positive spending shock. Yet, in times of high inflation DNWR should have less of a bearing on the adjustment because, in that case, wages are adjusting in real terms, even if they are nominally rigid.[24] To test this conjecture, we re-estimate our empirical specification on a sample limited to high inflation periods. For this purpose, we specify a threshold for year-on-year inflation of 3 percent (measured by the GDP deflator). According to this definition, 25 percent of the observations qualify as episodes of high inflation in our sample.

Figure 7 displays the results, focusing on the effects of a negative spending shock. Each column shows results for one of the two shock measures and contrasts the result for high inflation periods (red) and those for the baseline (blue), the latter reproduced from Figures 4 and 5. Again, we find considerable support for the theoretical predictions that are robust across shock measures. The exchange-rate response to a spending cut is much stronger if inflation is high. It depreciates considerably. At the same time, there is no longer a significant contraction of output. It is important to note that the response of the exchange rate to government spending shocks under a peg turns out to be symmetric, provided that inflation is (relatively) high. Whether inflation is high or not turns out to be largely inconsequential for the adjustment to spending hikes. Just as in the baseline, the adjustment takes place mostly through the exchange rate. See Figure E.2 in the appendix. In the next section, we verify that our results are robust once we consider alternative thresholds for inflation.

Overall, we find that the evidence for the effects of government spending shocks aligns quite well with the predictions of the model. This holds for our main result, namely that under fixed exchange rates the real exchange rate responds asymmetrically to positive and negative shocks. But it also holds for the theoretical predictions regarding the specific roles of inflation and economic slack.

5.2 Sensitivity analysis

In what follows, we consider several alternative specifications, and we show that the results for our baseline are robust along several dimensions. The figures for these alternative specifications are in the appendix. The results are based on the VAR-shocks because in this case, our sample is larger. Since our results in the previous section are very similar for both shock measures, we do not consider this a serious limitation.

In the first set of regressions, we rule out that our results are driven by any of the big three economies in the EA: France, Germany, and Italy. Figure E.3 shows the results when we drop these countries from the sample, contrasting them to those for the baseline. They are very similar. 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.[25] Results are shown in Figure E.4, again together with those for the baseline. Once more the results are quite similar, notably as far as the exchange-rate adjustment is concerned.

Next, we also look into an alternative measure for the real exchange rate, since it is the focus of our analysis. Recall that so far we have used the intra-EA real effective exchange rate because of

[24] The argument that positive inflation greases the wheels of the labor market by facilitating real wage cuts dates back to Tobin (1972). Addison et al. (2017) present recent evidence from Portugal that DNWR matters less in periods of high inflation.

[25] Note that any default episodes like the Greek ones (2012Q1–2012Q2, 2012Q4) are not contained in the sample.

concerns that while the exchange rate of each EA member country is fixed vis-à-via the other EA countries, the euro exchange rate and therefore member countries' real exchange rate may fluctuate relative to other currencies. We now assess whether using the real effective exchange rate (rather than the intra-EA real effective exchange rate) makes a difference for our results. The results in Figure E.5 suggest that it does not.

Figure 6 shows that economic slack strongly affects the impact of positive government spending shocks strongly. These results are based on a definition that slack is present in case the unemployment rate exceeds the median value in a country. We check that results are robust as we vary the definition of slack. Using the 60th and 70th percentiles as the threshold for slack, we also find that slack induces a spending hike to be more expansionary, while it dampens the exchange-rate response, as shown in Figure E.6 in the appendix.

Figure 7 illustrates that the level of inflation also affects whether the effects of spending shocks are asymmetric, using a threshold value of 3 percent. We verify that results are robust across alternative threshold values for high inflation. Specifically, when we use, in turn, 2 percent and 4 percent (rather than 3 percent) as critical values, we obtain very similar results (Figure E.7).

5.3 Pegs and floats

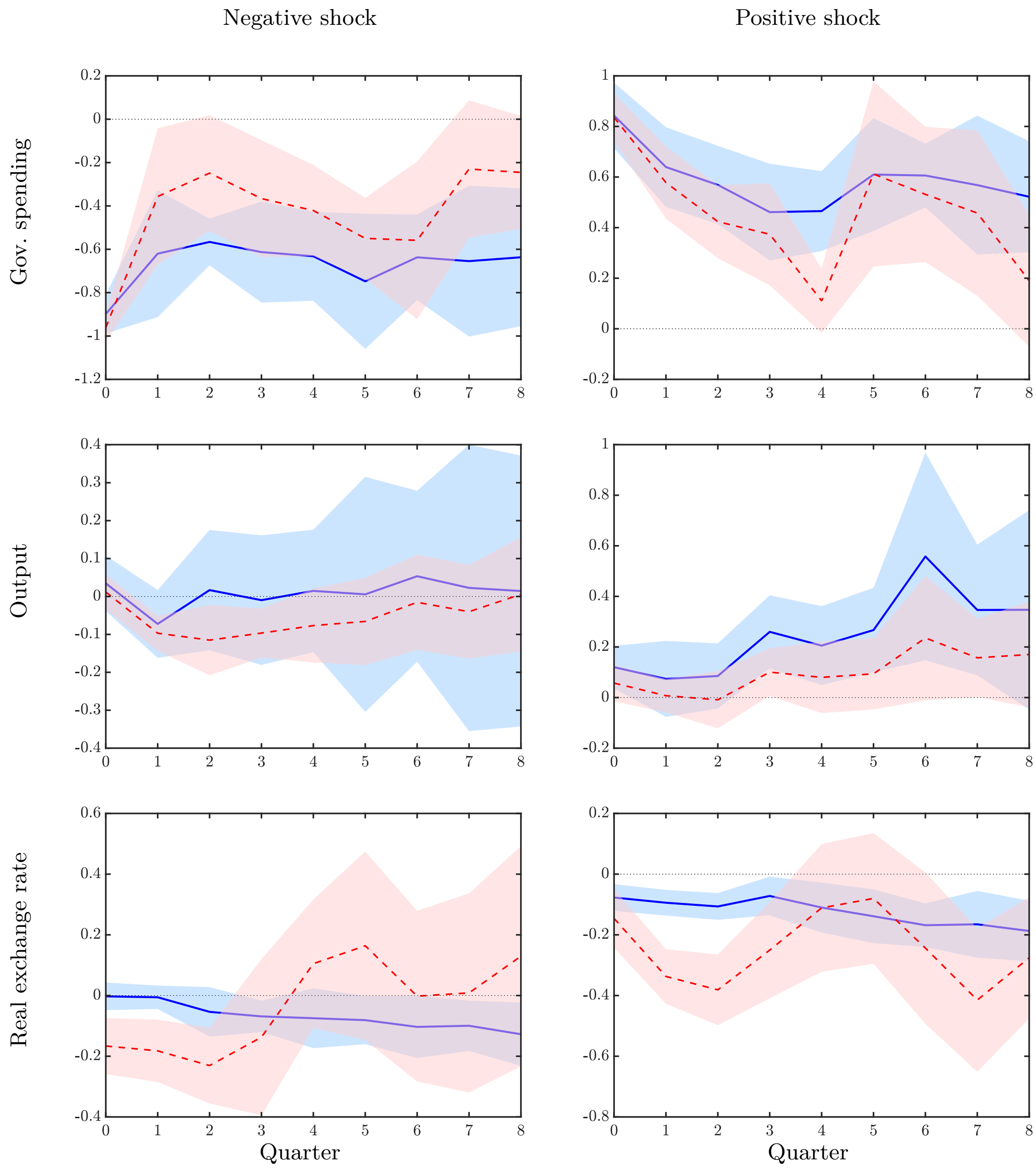
In our analysis thus far, we have relied on a sample of EA countries. We now explore the extent to which our results hold up once we extend the sample to also include conventional exchange-rate pegs. For this purpose, we classify the country-time observations as pegs whenever a country operates a peg or a crawling peg according to Ilzetzki et al. (2019).[26] We then re-estimate equation (4.1) on the larger sample. The results for the spending shocks identified using professional forecasts are shown in Figure 8. To highlight the effect of extending the sample, we reproduce in blue (with solid lines) the results for the EA sample from Figure 5.

We find that including pegs outside of the EA does not change our main result, and the same is true if we contrast the results for the EA sample with a sample only featuring pegs outside of the EA (see Figure E.8 in the appendix). The exchange-rate response in the bottom panels of the figure exhibits no depreciation in response to a negative spending shock but a significant appreciation in response to a positive shock. Estimates, however, are less precise once we include countries from outside the EA in our sample.[27] The output response, shown in the middle panels, is estimated more tightly and conforms well with the predictions derived from the stylized model. Output declines significantly in response to a negative shock, but it fails to increase in response to a positive spending shock. These results are based on the fiscal shock identified using professional forecasts. In the appendix, we also show the results for fiscal shocks identified using the VAR forecasts. Figure E.9 contrasts results for the baseline (EA countries) with the ones obtained for the full sample of pegs, while Figure E.10 contrasts them to the sample of pegs without the EA.

[26] Specifically, this includes country-time observations with a code 1 or 2 in their coarse classification scheme. The classification of Ilzetzki et al. (2019) ends in 2016M12. We extended their classification to the end of the sample.

[27] For the EA-only sample we consider intra-EA exchange rates; for the larger samples, we use the broader measure of the effective real exchange rate.

Figure 8: IRFs – all pegs v baseline

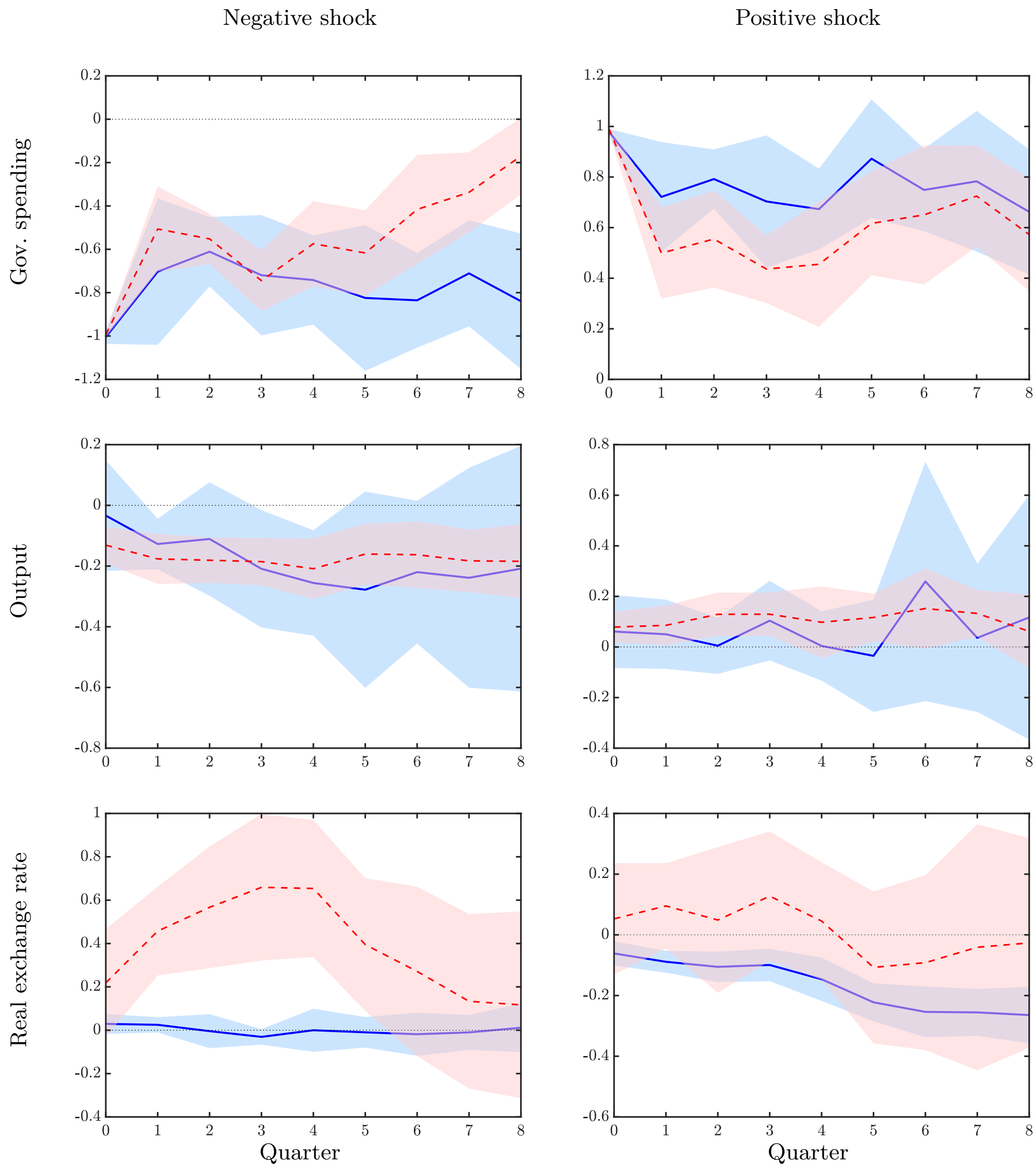


Notes: Adjustment to negative and positive government spending shocks, identified using *professional forecasts*. Blue/solid: EA sample; red/dashed: all pegs. Lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Also, in this case, we find that including pegs from outside the EA does not change our main results as far as the exchange rate is concerned. We observe, though, that positive spending shocks have a positive impact on output, an effect that is absent for the EA sample.

Last, we re-estimate equation (4.1) for observations featuring a floating exchange rate, defined by category 3 or higher in the coarse classification scheme of Ilzetzki et al. (2019). We limit this analysis to government spending shocks identified using VAR forecasts because the data coverage for floaters is much larger in this case as professional forecasts are mostly available for pegs. Figure

Figure 9: IRFs – float only v baseline



Notes: Adjustment to negative and positive government spending shocks, identified using *VAR forecasts*. Blue/solid: EA sample; red/dashed: countries with floating exchange rate. Lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

9 shows the results in red (with dashed lines), contrasted with the results for the EA baseline (in blue with solid lines) from Figure 4. In contrast to the EA sample where the exchange rate is flat in response to a spending cut, we now find that it depreciates sharply, exactly as our stylized model predicts. However, this depreciation is not sufficient to insulate output fully. GDP declines in response to spending cuts for floaters just as for pegs. Yet after 3 or 4 quarters, the decline is somewhat weaker than under a float. This suggests that the exchange-rate depreciation contributes to output stabilization in a J-curve-type fashion with some delay.

In response to a positive spending shock, the exchange rate under a float no longer appreciates (right-bottom panel). At the same time, the output response is stronger than in the EA baseline. This pattern of adjustment partially conflicts with the predictions of our model. Recall that the model assumes a very specific behavior of monetary policy under a float. It adjusts the exchange rate to fully insulate economic activity from the shock—see equation (2.26). However, there are many ways to float, a point recently stressed by Corsetti et al. (2021). Under a float, monetary policy is free to accommodate certain shocks and constrain the impact of others. The pattern in the right column of Figure 9 is consistent with the notion that monetary policy provides some accommodation in the face of positive government spending shocks. This prevents an appreciation of the exchange rate, and it allows economic activity to expand.

6 The case for asymmetry

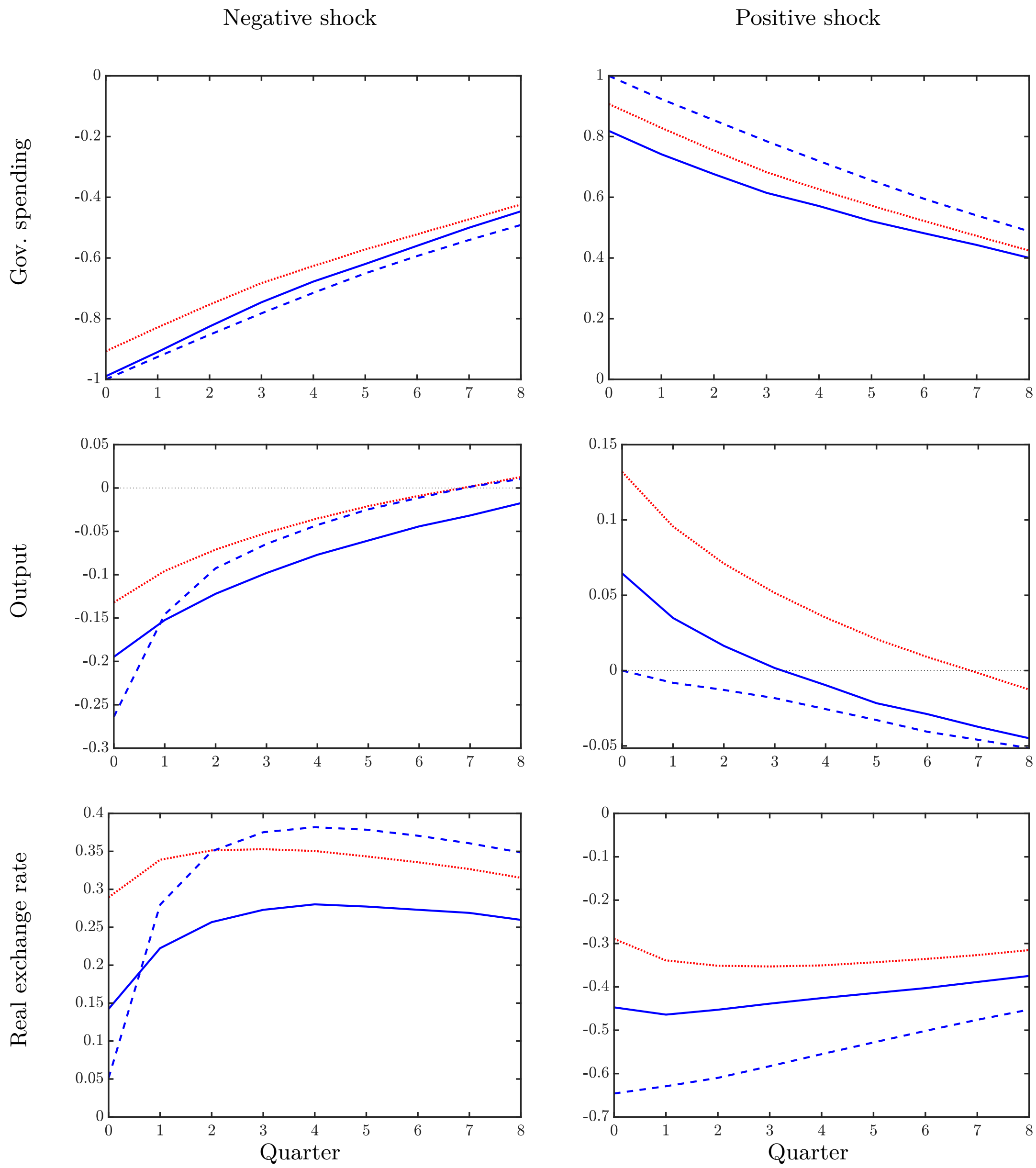
The evidence so far supports the predictions of the stylized open economy model put forward in Section 2 along several important dimensions. In what follows, we complete our analysis by bringing the model and empirical analysis closer together still. We first set up a simple Monte Carlo experiment for which we rely on the model as the data generating process. We apply our econometric approach to the simulated data and show that it allows us to correctly identify the dynamic effects of fiscal shocks. At the same time, we find that an empirical specification that constrains the effects of positive and negative government spending shocks to be symmetric gives rise to a depreciation bias. The estimated exchange-rate response implies too much depreciation after a fiscal shock. In a second step, we estimate the symmetric specification on our EA sample. And indeed, we obtain an estimate for the exchange-rate response showing considerably more depreciation in response to the fiscal shocks compared to the baseline estimate that allows for asymmetric effects.

6.1 Monte Carlo evidence

For our Monte Carlo experiment, we use the nonlinear quantitative model specified in Section 3.2 as the data-generating process. Since our focus is on the asymmetric effects of positive and negative government spending shocks, we assume an exchange-rate peg throughout, and we simulate the model for one million periods. To measure fiscal shocks, we regress government spending on its own lag as well as on lagged output. In this way we mimic the first equation of the VAR model (4.2), which is sufficient to recover fiscal shocks under our identification strategy (see Section 4.2).[28] Next, we sort shocks into positive and negative realizations, just like we do with the actual data. Last, we estimate the response of the logged variables of interest to positive and negative government spending shocks using the local projection (4.1). In doing so, we restrict the estimation to observations where unemployment is low because theory predicts asymmetric

[28]We do not attempt to identify fiscal shocks based on professional forecasts since there is no well-defined counterpart in the model.

FIGURE 10: MONTE CARLO IRF – FULL EMPLOYMENT



Notes: Adjustment to negative and positive government spending shocks identified using *VAR forecasts*. Sample: 1 million observations 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. Blue dashed lines: generalized impulse responses of the model under a peg with full employment (scaled to a 1% government spending shock). Red dotted line: empirical two-stage estimate restricted to symmetric effects. Vertical axis measures deviations from pre-shock level in percent.

adjustment dynamics only in the absence of slack—see again the middle column of Figure 3.[29]

Figure 10 displays the results. The left column shows the responses to a negative government spending shock, the right column to a positive shock. The blue solid line represents the impulse

[29]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.

response that we obtain once we estimate our empirical specification on simulated data. To assess the performance of the estimator, we contrast it to the model response, indicated by the blue dashed line. It is computed as the generalized impulse response function (GIRF) of the model under full employment, rescaled so that the size of the shock corresponds to a 1 percent change of government spending. Observe that the blue solid line is fairly close to the dashed line. Hence, we conclude that our two-stage approach is indeed successful in recovering the responses to positive and negative government spending shocks.[30]

6.2 The depreciation bias

A robust result of our analysis is that positive and negative government spending shocks have asymmetric effects, notably on the exchange rate. We now investigate what happens if one restricts estimates to be symmetric. For this purpose, we repeat the Monte Carlo exercise but without distinguishing between positive and negative shocks in the local projections. By doing so, we take the perspective of earlier work which ignored the possibility of asymmetry in the effects of government spending shocks. The results are shown by the red dotted line in Figure 10. Note that the estimated responses now differ considerably from the true responses, particularly on impact. By construction, the estimator cannot recover the asymmetry in the response to spending shocks of output and the real exchange rate. Instead, in the symmetric specification, the estimated responses are a weighted average of the true responses to positive and negative shocks.

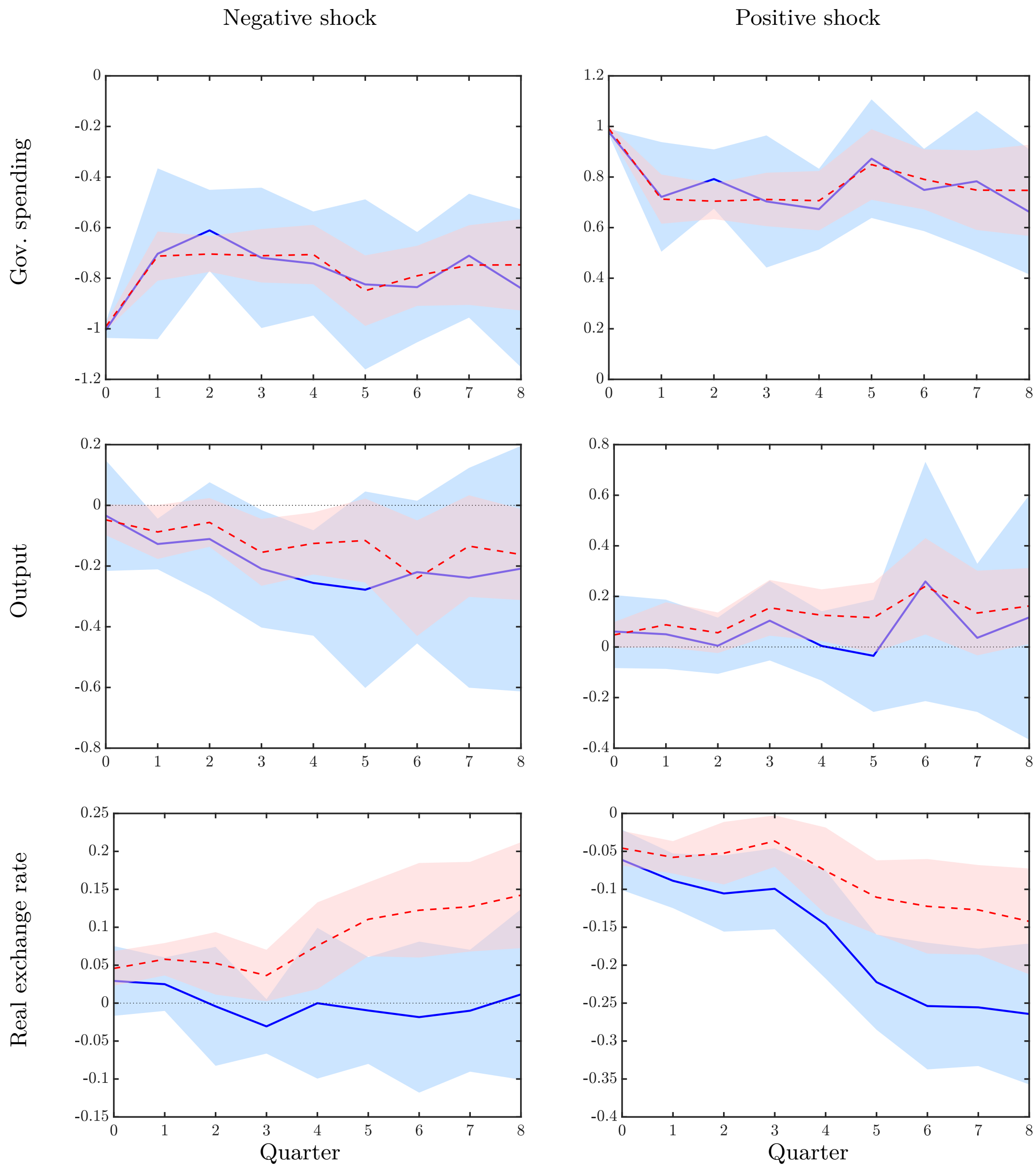
We find that imposing symmetry in the linear projection induces a noticeable upward bias in the estimated exchange rate response (as well as for output). In response to both negative and positive government spending shocks, there is too much depreciation. The symmetric specification overestimates the extent of depreciation in response to a spending cut (left panel), and it underestimates the extent of appreciation in response to a spending hike (right panel). Intuitively, while negative spending shocks induce very little depreciation, spending increases lead to a sizeable appreciation. The symmetric specification does not distinguish between the responses to the two kinds of shocks: it delivers an estimate for the response to a spending cut that is too strong and an estimate for the response to a spending increase that is too weak.

This upward (or depreciation) bias in the exchange rate response goes some way to account for the puzzling finding that positive government spending shocks tend to depreciate the real exchange rate. This finding has received considerable attention in the literature, as discussed in the introduction. Still, the results shown in Figure 10 do not indicate a reversal in the sign of the exchange rate response after constraining the effects of spending shocks to be symmetric. They merely indicate a sizeable depreciation bias. Hence, our account does not offer a full substitute for prior explanations of the exchange rate response to fiscal shocks.[31] Last, we note that earlier

[30] Figure E.11 in the appendix corroborates this finding. It compares the local projection IRFs when not conditioning on unemployment to the ergodic GIRFs estimated when integrating over 1 million replications of government spending shocks after a burn-in of 1000 periods.

[31] These explanations are based on model modifications rather than on a possible misspecification of the econometric model. Ravn et al. (2012) focus on deep habits, and Corsetti et al. (2012a) focus on spending reversals. Instead,

Figure 11: IRFs – symmetric model v baseline



Notes: Adjustment to negative and positive government spending shocks, identified using *VAR forecasts*. Blue/solid: baseline, reproduced from Figure 4; red/dashed: estimate based on symmetric specification. Sample: EA countries. Lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

research has documented exchange rate depreciation in response to fiscal shocks for the US and other countries with floating exchange rates, while our model predicts an asymmetric response to government spending shocks only under a peg. That said, we conjecture that in a more general model in which monetary policy does not fully insulate employment from government spending shocks, the real exchange rate dynamics under a float are likely closer to that under a peg.

Forni and Gambetti (2016) find that whether government spending depreciates the exchange rate depends on whether shocks are anticipated. According to their estimates, the exchange rate does not depreciate in response to news shocks, but only in response to surprise shocks.

In a final step, we verify that the depreciation bias is also present when we work with actual time-series data. For this purpose we estimate a symmetric specification on our EA sample, and we compare the estimated impulse responses to our baseline estimates. Figure 11 shows the results. The blue solid responses reproduce the baseline estimate, while the red dashed responses show the estimates based on the symmetric specification. The pattern is quite similar to that shown in Figure 10. In particular, the estimated exchange rate response displays a considerable depreciation bias. While (positive) government spending shocks still appreciate the exchange rate, we find that the effect is considerably weaker than under the baseline specification.

7 Conclusion

In economies with fixed exchange rates, the adjustment to government spending shocks is asymmetric. Assuming full employment, an increase in government spending appreciates the real exchange rate, but it does not affect output and employment. In contrast, a reduction of government spending lowers output and employment but it does not impact the exchange rate very much. We derive these results in a stylized model of a small open economy featuring downward nominal wage rigidity, and we establish new evidence based on a large cross-country data set. That evidence supports the predictions of the model regarding the asymmetric adjustment to government spending shocks along several dimensions: the exchange rate regime, the state of the business cycle, and the level of inflation.

Our results reconcile Keynesian and Classical views on the short-run effects of government spending. 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. Based on our analysis, both views appear to be (somewhat) correct—it is just a matter of the sign of the fiscal impulse. Our analysis is limited to government spending shocks, but the mechanism at the heart of our analysis 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, in conclusion, 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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Appendix

A Full set of equilibrium conditions (baseline model)

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*

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

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

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

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

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

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

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

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

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* $\{\epsilon_t\}_{t=0}^{\infty}$*.*

B Analytical model

B.1 Full set of equilibrium conditions (simplified model)

Given the preferences and the functional forms assumed in Section 3, we obtain the following equilibrium conditions:

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

$$y_t^N = h_t = c_t^N + g_t^N \tag{B.2}$$

$$\frac{1}{c_t^T} = \frac{1}{c_{t+1}^T} \tag{B.3}$$

$$p_t^N = \frac{c_t^T}{h_t - g_t^N} \tag{B.4}$$

$$p_t^N = w_t \tag{B.5}$$

$$RER_t = \frac{1}{p_t^N} \tag{B.6}$$

$$w_t \geq \frac{w_{t-1}}{\epsilon_t} \wedge h_t \leq 1 \text{ with } 0 = (1 - h_t)\left(w_t - \frac{w_{t-1}}{\epsilon_t}\right) \tag{B.7}$$

$$w_t^f = \frac{c_t^T}{1 - g_t^N} \tag{B.8}$$

$$\epsilon_t = \max\left\{\frac{w_{t-1}}{w_t^f}, 1\right\}^{\phi_\epsilon} \tag{B.9}$$

$$0 = \lim_{j \to \infty} \left(\frac{1}{1+r}\right)^j d_{t+j}\ . \tag{B.10}$$

Consequently, the initial steady state is given by $d_{-1} = 0, c_{-1}^T = y^T = 1, c_{-1}^N = 1 - g$, where g denotes the steady-state value of government consumption, $p_{-1}^N = w_{-1} = \frac{1}{1-g}$, and $RER_{-1} = 1 - g$. Note that while we abstract from the borrowing constraint (2.5), we still rule out Ponzi schemes.

B.2 Proof of Proposition 1

The Euler equation (B.3) implies that traded consumption is constant at its new value, i.e., $c_t^T = c_{t+1}^T$ for all $t \geq 0$. The resource constraint (B.1) then implies $\frac{d_{t+1}}{1+r} - d_t = \frac{d_{t+2}}{1+r} - d_{t+1}$ for all $t \geq 0$. Thus, if there is any increase in debt in one period, debt will keep increasing. This is a reflection of the well-known random walk property of consumption in this type of setup. Any increase in additional traded consumption financed by debt persists in future periods and, given a constant endowment y^T, needs to be financed by further additional debt issuance. Because this continuing debt accumulation would violate the transversality condition (B.10), debt needs to be constant at its initial value of 0, i.e., $d_t = 0$ and $c_t^T = y^T = 1$ for all $t \geq 0$.[32] In period 0, the

[32] A different way to see this is to notice that this equation is a homogeneous second-order difference equation with roots $(1 + r)$ and 1. Given d_0 and the transversality condition, the unstable root can be ruled out.

nontraded goods resource constraint (B.2) implies $c_0^N = y_0^N - \underline{g}$, while equations (B.4) and (B.5) imply that the real wage is given by $w_0 = \frac{1}{h_0 - \underline{g}}$. Thus, we need to solve for nontraded output y_0^N and hours worked h_0, which both depend on the exchange-rate regime.

Peg ($\phi_\epsilon = 0$): Conjecture that the economy is in a situation of unemployment with $h_0 < 1$. In this case, the wage constraint (B.7) must be binding: $w_0 = \frac{w_{-1}}{\epsilon_0}$. Under the peg, the gross nominal exchange rate devaluation is given by $\epsilon_0 = 1$. Consequently, the real wage is given by $w_0 = \frac{1}{h_0 - \underline{g}} = \frac{1}{1-g} = w_{-1}$, which implies $1 - g = h_0 - \underline{g} < 1 - \underline{g}$. This, in turn, requires $g > \underline{g}$, which is true by assumption (3.1). This proves that $h_0 < 1$ indeed is the equilibrium employment level, which is associated with the output level $y_0^N = h_0 = \frac{1}{w_{-1}} + \underline{g} = 1 - (g - \underline{g})$.

Float ($\phi_\epsilon = 1$): Again conjecture that the economy is in a situation of unemployment with $h_0 < 1$. The gross nominal exchange-rate devaluation follows from (B.9) as $\epsilon_0 = \max\left\{\frac{1-\underline{g}}{1-g}, 1\right\} = \frac{1-\underline{g}}{1-g}$. This implies $h_0 - \underline{g} = 1 - \underline{g}$. The assumption that $h_0 < 1$ therefore leads to a contradiction: $1 - \underline{g} = h_0 - \underline{g} < 1 - \underline{g}$. Consequently, it must be that $y_0^N = h_0 = 1$ and the economy is at its full-employment equilibrium.

From (B.4) then follows that $p_{0,peg}^N = \frac{1}{h_0 - \underline{g}} = \frac{1}{1-g} > \frac{1}{1-\underline{g}} = p_{0,float}^N$. Hence, a negative government spending shock causes a fall in p^N and a corresponding increase in RER—i.e., real exchange-rate depreciation— under a float, but not under a peg. □

B.3 Proof of Proposition 2

Conjecture that the shock does not cause unemployment, that is, $h_0 = 1$. Then it must be that the wage constraint is not binding, so that

$$w_0 = \frac{1}{1-\bar{g}} > \frac{1}{(1-g)\epsilon_0} = \frac{w_{-1}}{\epsilon_0}\,. \tag{B.11}$$

Peg ($\phi_\epsilon = 0$): With a gross nominal exchange-rate devaluation rate equal to $\epsilon_0 = 1$, equation (B.11) implies that $1 - g > 1 - \bar{g}$. This is true by assumption (3.1).

Float ($\phi_\epsilon = 1$): Equations (B.8) and (B.9) imply a gross nominal exchange-rate devaluation rate of $\epsilon_0 = \max\left\{\frac{1-\bar{g}}{1-g}, 1\right\}^{\phi_\epsilon} = 1$. The same logic as in the peg case then requires that $h_0 = 1$.

Thus, full employment $h_0 = 1$ is the equilibrium, regardless of the exchange-rate regime. From (B.4) then follows that the price of nontraded goods increases and therefore the real exchange rate appreciates by the same amount: $p_{0,peg}^N = p_{0,float}^N = \frac{1}{1-\bar{g}} > \frac{1}{1-g} = p_{-1}^N$. □

B.4 Proof of Proposition 3

For a negative and a positive shock of the same magnitude, we have $\bar{g} - g = g - \underline{g}$. From equation (B.6) and Propositions 1 and 2 then follows that in response to a negative shock

$$\Delta RER^{-} = \frac{1}{p^N_{0,float}} - \frac{1}{p^N_{-1}} = (1-\underline{g}) - (1-g) = g - \underline{g} = (\bar{g} - g)\,, \tag{B.12}$$

while for a positive shock

$$\Delta RER^{+} = (1-\bar{g}) - (1-g) = -(\bar{g} - g). \tag{B.13}$$

□

B.5 Proof Lemma

The resource constraint in (B.1) becomes

$$c^T_t = y^T_t - d_t + \frac{d_{t+1}}{1+r}. \tag{B.14}$$

We can solve the nontraded goods block by backward induction. The Euler equation (B.3) implies that traded consumption jumps to a new level and stays there, i.e., $c^T_t = c^T_{t+1}$ for all $t \geq 0$. The resource constraint (B.1) again implies $\frac{d_{t+1}}{1+r} - d_t = \frac{d_{t+2}}{1+r} - d_{t+1}$ for all $t \geq 1$. Thus, if there is any increase in the face value of debt after $t = 1$, debt will keep increasing and will violate the transversality condition (B.10). Therefore, debt needs to be constant at its value at the beginning of period one, d_1. The Euler equation and the resource constraint then imply

$$c^T_0 = y^T_0 + \frac{d_1}{1+r} = 1 - \frac{r}{1+r} d_1 = c^T_1. \tag{B.15}$$

From this follows that the debt choice d_1 is given by

$$d_1 = 1 - y^T_0. \tag{B.16}$$

Thus, the household will smooth traded consumption by borrowing the shortfall from abroad and permanently foregoing the annuity out of this debt in terms of consumption:

$$c^T_0 = 1 - \frac{r}{1+r}(1 - y^T_0). \tag{B.17}$$

Given the drop in traded consumption, equation (B.4) shows that hours worked h_0 must also fall. The latter follows from the binding wage constraint, which pins down the relative price via equation (B.5) as $p^N_0 = w_0 = w_{-1}$. As a consequence, the traded-goods endowment shock causes the economy to contract and unemployment to rise. □

B.6 Proof of Proposition 4

First, consider the case of a government spending cut from g to $\underline{g}$. Given that the relative price of nontraded goods cannot fall under a peg with $\gamma = 1$, equation (B.5) implies an additional one-to-one fall of hours worked and therefore nontraded output in order to keep the denominator constant. The real exchange rate then stays constant as well. Now consider an increase in government spending from g to $\bar{g}$. The response of the real exchange rate depends on the movement in the relative price of nontraded goods, which is in turn a function of the relative demand. It will increase whenever the increase in government demand for the nontraded good is sufficient to more than compensate the reduction in private demand caused by the traded-goods endowment shock. As long as this is not the case, the economy remains in a situation of unemployment, the wage constraint keeps binding, and the relative price is pinned down by $p_0^N = w_0 = w_{-1}$. In this case, the real exchange rate response is symmetric to the one observed under a negative shock, namely nil. Any increase in government spending will increase hours worked and hence output one-for-one.

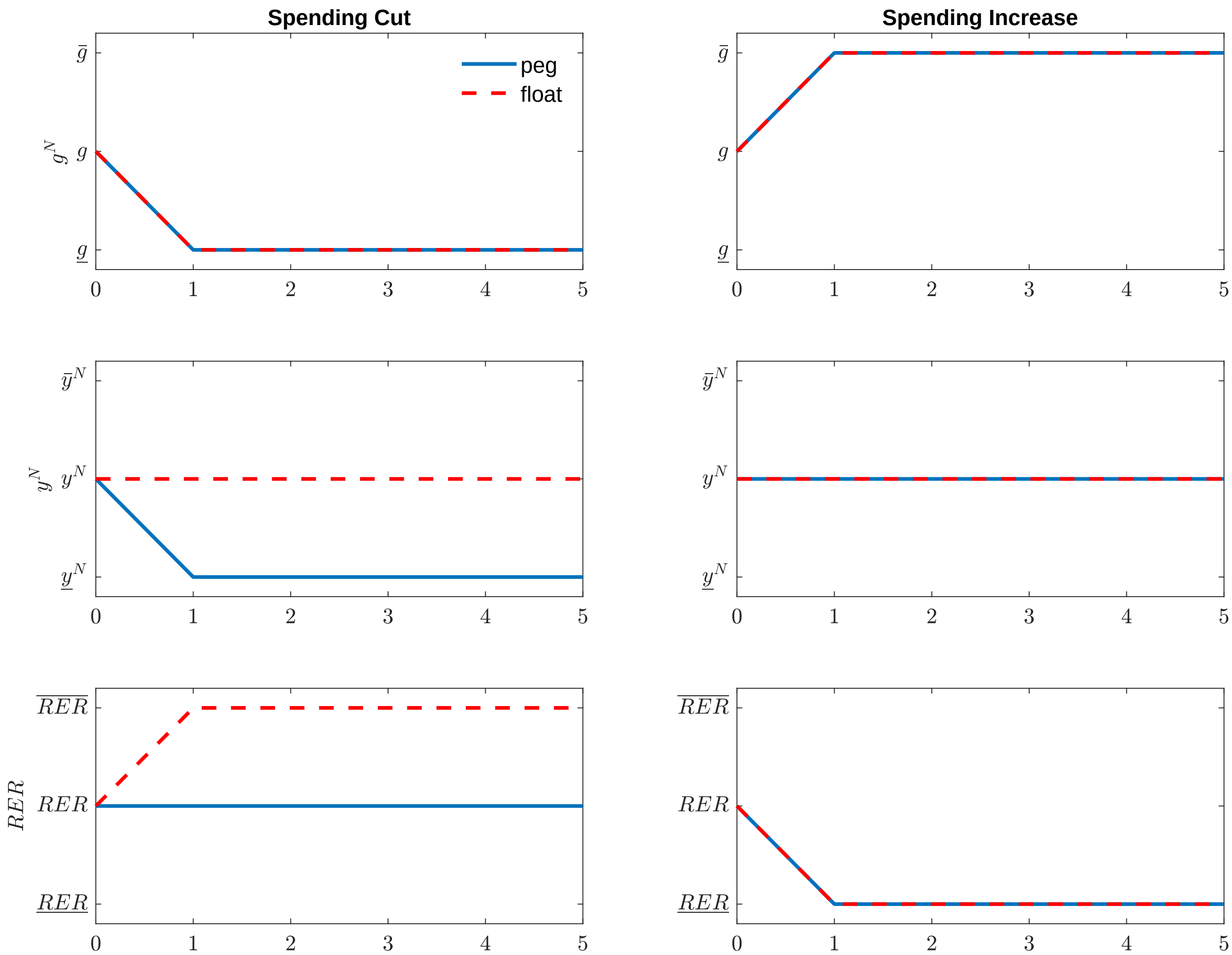
Equation (B.5) allows us to compute the minimum size of $\bar{g}$ after the endowment shock that restores full employment, which is equivalent to the maximum allowable level of $\bar{g}$ for which the exchange rate response is zero. Given

$$p_0^N = \frac{c_0^T}{1-\bar{g}} = \frac{1 - \frac{r}{1+r}\left(1 - y_0^T\right)}{1-\bar{g}} = \frac{1}{1-g} = p_{-1}^N, \tag{B.18}$$

it follows that $1 - \frac{r}{1+r}\left(1 - y_0^T\right) = \frac{1-\bar{g}}{1-g}$. The left-hand side here represents the gross rate of change in traded consumption relative to the baseline level of 1. The right-hand side represents the gross rate of change in the private consumption of nontraded goods. Whenever these rates are equal, government consumption of nontraded goods exactly compensates the private demand shortfall caused by the endowment shock. In this case, the relative price and therefore the real exchange rate do not change. The above equation also makes clear that any increase of government spending above $\bar{g}$ will cause the relative price to increase above its initial level and the real exchange rate to appreciate. □

B.7 IRFs to permanent shocks

Figure B.1: Analytical model IRF to permanent shocks – full employment

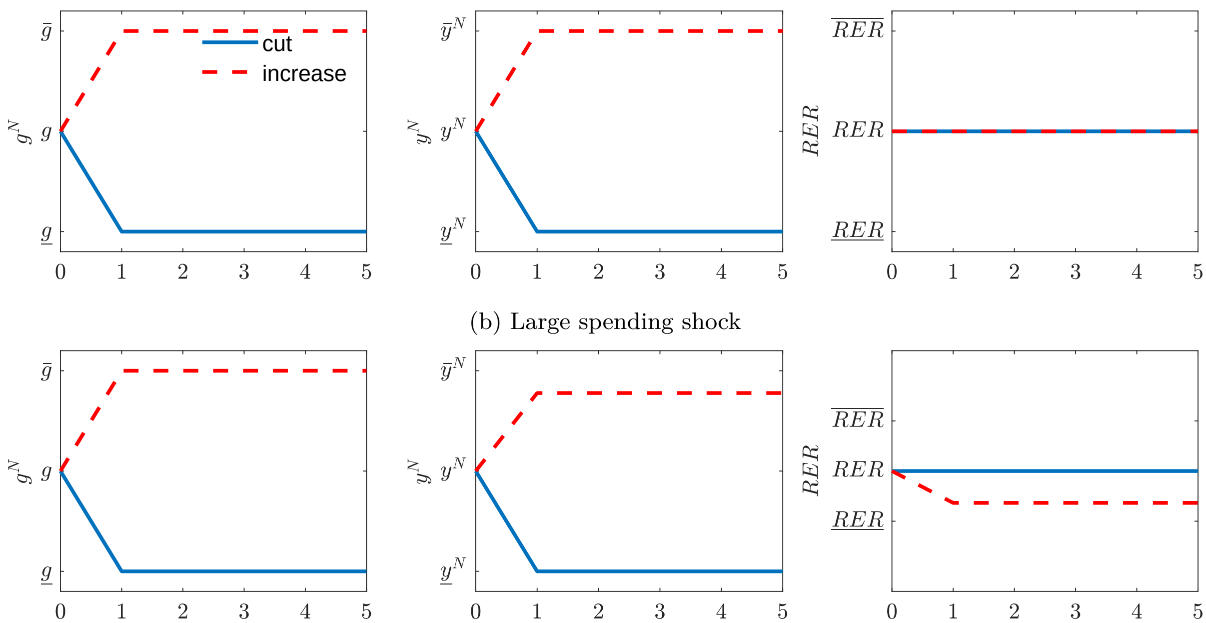


Notes: Impulse responses in the analytical model to a permanent surprise government spending cut (left column) and hike (right column), starting from a full-employment steady state.

Figure B.2: Analytical model irf to permanent shocks – slack

(a) Small spending shock

(b) Large spending shock

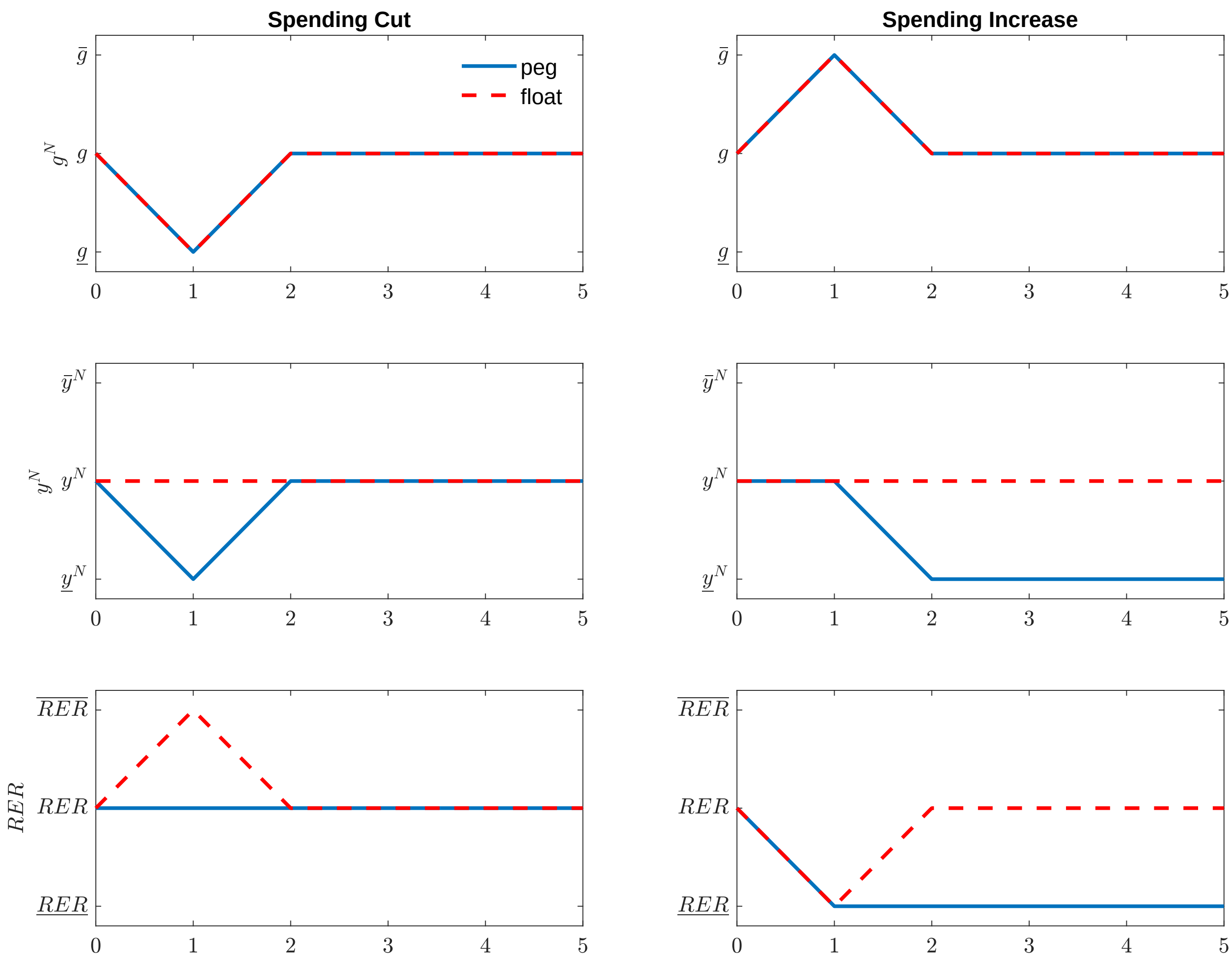


Notes: Impulse responses in the analytical model to a permanent surprise government spending cut (solid line) and hike (dashed line) of the same size, starting from a situation of economic slack. The top panel depicts a small change in government spending insufficient to restore full employment, resulting in a perfectly symmetric response of traded output and no change of the real exchange rate. The bottom panel depicts a large change in spending that is sufficient to restore full employment, resulting in an asymmetric response of both output and the real exchange rate.

B.8 IRFs to temporary shocks

A *temporary* surprise change in government spending can be conceptualized as a surprise permanent shock, followed by an anticipated offsetting permanent shock one period later. Because the intertemporal problem is decoupled from the intratemporal one, anticipation of a future decrease of government spending has no immediate effect per se. Figure B.3 shows the results. A temporary cut in government spending causes a drop in output, followed by a return to full employment when government spending recovers. In contrast, a temporary increase in government spending initially has no effect on output as the real exchange rate appreciates and private activity is crowded out. But once government spending returns to its old, lower level, the real exchange rate cannot adjust and there is no crowding in. The economy enters a permanent state of depression. This is a consequence of our assumption that wages can never fall. It also shows that increases in government spending can be harmful, even if they do not immediately affect output. By increasing the wage, they increase the likelihood that the wage constraint becomes binding in the future, making the economy more prone to recessions when negative shocks hit.

Figure B.3: Analytical model IRF to temporary shocks – full employment.



Notes: Impulse responses in the analytical model to a one-period surprise government spending cut (left column) and hike (right column), starting from a full-employment steady state.

Table C.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	$\omega = 0.37$	Traded-goods share of 0.26

C Quantitative model

In the following we outline how we solve the full model of Section 2. 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 largely follow their calibration—except in those instances where we explicitly account for government spending (since they do not).

C.1 Model calibration and solution

Table C.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 the value of γ 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 nominal wages can 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 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 ω. 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.

C.2 Solution procedure

In order to solve the model, we largely follow SGU. In 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 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 C.3 provides details on the discretization of the state space while Subsection C.4 reports the unconditional moments of the model.

C.3 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 $\underline{w} = 1$ for the peg and $\underline{w} = 0.05$ for the intermediate regime with $\phi_e = 0.33$. The former choice reflects the compression of real wage outcomes in simulations under the float. We set $\bar{w} = 7.5$ for both policy arrangements. 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, 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.

C.4 Unconditional moments and debt distribution

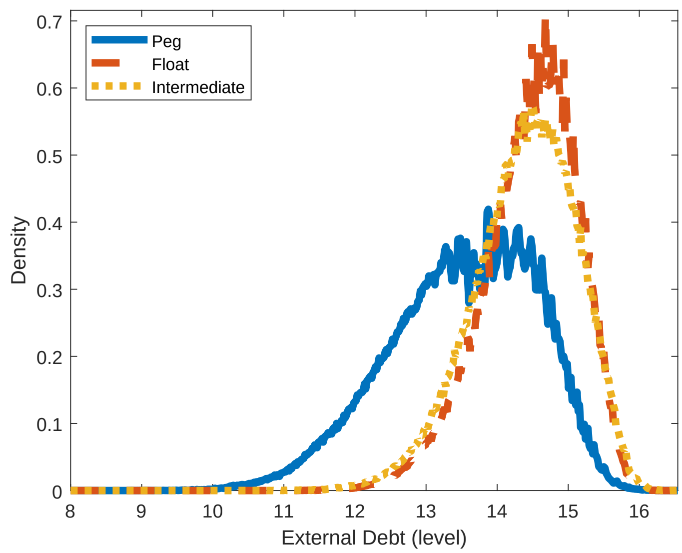
Table C.2 displays unconditional first and second moments of some macro indicators of interest obtained from a simulation of 1 million quarters. These statistics are in line with the predictions of the model. In particular, mean unemployment is shown to decrease from 14% to nil when moving from a peg to a fully stabilizing float. Analogously, mean (nontraded) consumption and nontraded output increase with the degree of exchange-rate flexibility, whereas their respective volatilities are lower. Moreover, the real wage under a peg displays a higher mean but lower standard deviation when compared to the other two regimes, 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 116% and 122% per year under the intermediate regime and the float, respectively. As shown in figure C.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 C.2: First and second moments in the three 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 1000 periods.

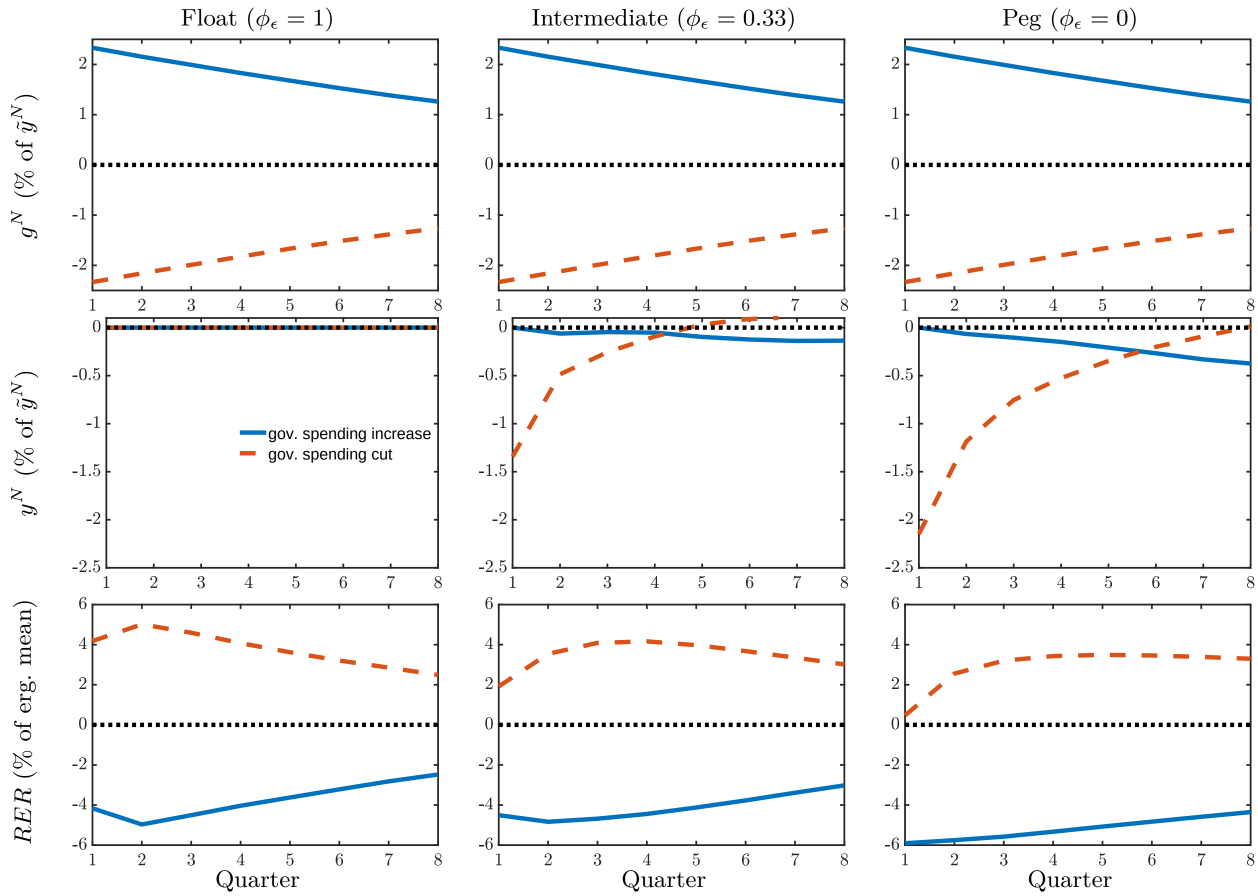
Figure C.1: Quantitative model – ergodic debt distribution



Notes: Distribution of external debt in the three exchange-rate regimes. Blue solid line: peg ($\phi_e = 0$), red dashed line: float ($\phi_e = 1$), orange dotted line: intermediate exchange-rate regime ($\phi_e = 0.33$). Statistics are based on a simulation length of 1 million periods and a burn-in of 1000 periods.

C.5 GIRFs: intermediate exchange rate regime

FIGURE C.2: QUANTITATIVE MODEL IRF INCLUDING INTERMEDIATE CASE – FULL EMPLOYMENT.



Notes: Generalized impulse responses to one-standard-deviation government spending shocks in the quantitative model. GIRFs start from a situation of moderate debt and full employment at the boundary to the unemployment region (see main text for details). Solid blue line: spending increase; dashed red line: spending cut. Top panels: government spending, middle: nontraded output, bottom: real exchange rate. Vertical axis measures effect of shock in percent of full employment nontraded output $\tilde{y}^N$ and of the ergodic mean of the RER, respectively.

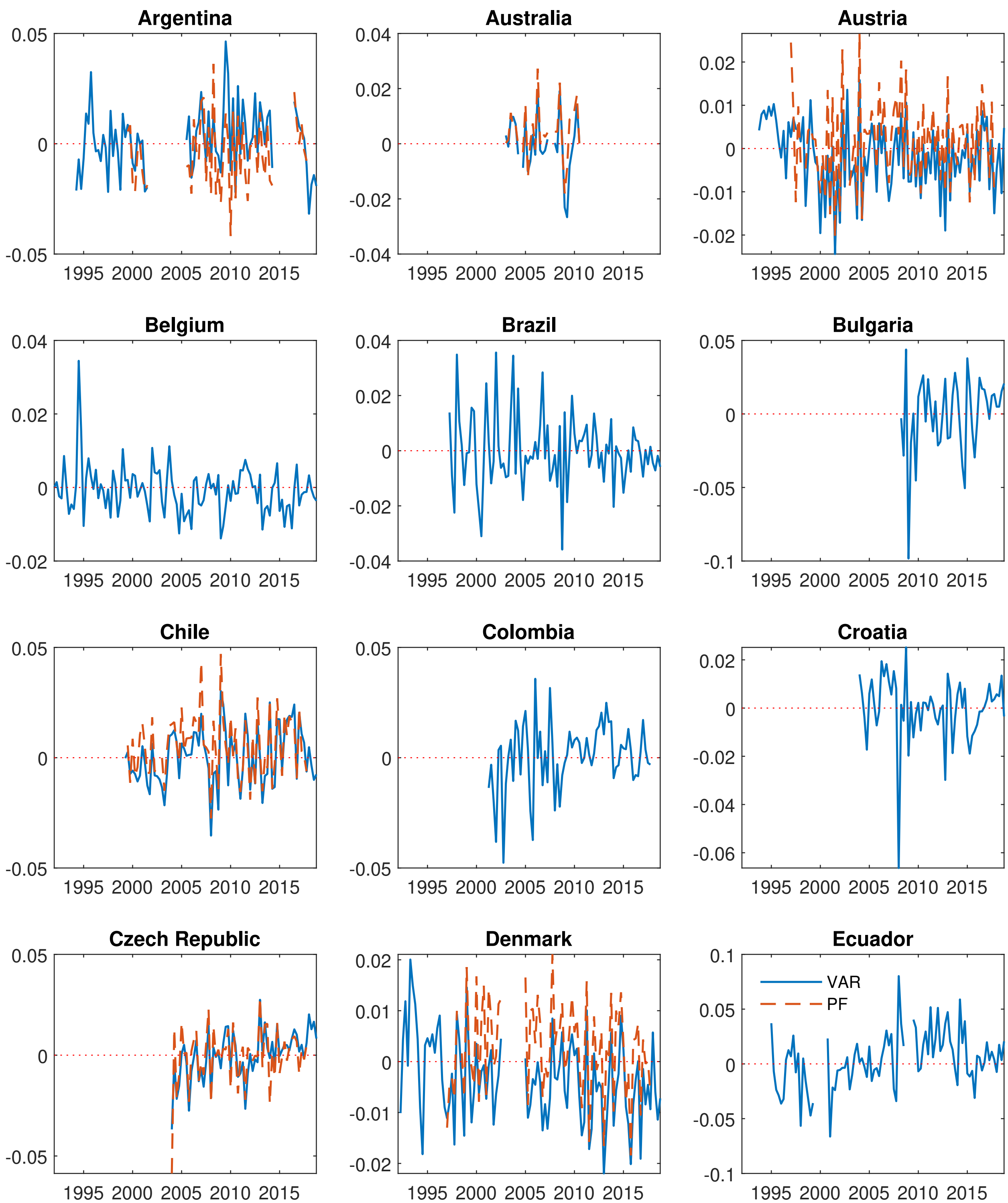
D Empirical evidence: Sample

Table D.3: Sample ranges

	VAR		Oxford Economics		EA	
Country	Range	T	Range	T	Range	T
Argentina	1994Q4-18Q4	66	1999Q3-17Q4	43	-	-
Australia	2004Q1-10Q3	16	2004Q1-10Q3	16	-	-
Austria	1994Q4-18Q4	97	1997Q1-17Q4	80	1999Q1-18Q4	80
Belgium	1992Q4-18Q4	105	-	-	1999Q1-18Q4	80
Brazil	1997Q2-18Q4	87	-	-	-	-
Bulgaria	2008Q2-18Q4	43	-	-	-	-
Chile	2000Q2-18Q4	75	2000Q2-17Q4	69	-	-
Colombia	2001Q2-17Q4	67	-	-	-	-
Croatia	2005Q1-18Q4	56	-	-	-	-
Czech Republic	2005Q1-18Q4	56	2005Q1-17Q4	52	-	-
Denmark	1992Q2-18Q4	94	1997Q1-17Q4	68	-	-
Ecuador	1996Q1-18Q4	76	-	-	-	-
El Salvador	2003Q2-17Q3	58	-	-	-	-
Finland	1993Q2-18Q4	103	1999Q2-17Q4	73	1999Q1-18Q4	80
France	2000Q1-18Q4	76	2000Q1-17Q4	70	2000Q1-18Q4	76
Germany	2005Q1-18Q4	56	2005Q1-17Q4	52	2005Q1-18Q4	56
Greece	1996Q2-18Q4	83	2001Q4-17Q4	55	2000Q3-18Q4	66
Hungary	2000Q1-18Q4	76	2000Q1-17Q4	70	-	-
Ireland	1996Q2-18Q4	91	2004Q1-17Q4	56	1999Q1-18Q4	80
Italy	1992Q2-18Q4	107	1997Q1-17Q4	80	1999Q1-18Q4	80
Latvia	2007Q1-18Q4	48	-	-	2013Q3-18Q4	22
Lithuania	2006Q2-18Q4	51	-	-	2014Q3-18Q4	18
Malaysia	2001Q2-17Q4	67	2001Q1-17Q4	66	-	-
Mexico	1994Q4-18Q4	97	-	-	-	-
Netherlands	2000Q1-18Q4	76	2000Q1-17Q4	70	2000Q1-18Q4	76
Peru	1998Q1-18Q4	79	-	-	-	-
Poland	1996Q2-18Q4	91	-	-	-	-
Portugal	1996Q2-17Q4	87	1998Q4-17Q4	75	1999Q1-17Q4	76
Slovakia	2005Q1-18Q4	56	2005Q2-17Q4	51	2008Q3-18Q4	42
Slovenia	2004Q1-18Q4	60	-	-	2006Q3-18Q4	50
South Africa	1995Q4-17Q4	89	-	-	-	-
Spain	1996Q2-18Q4	91	1997Q1-17Q4	80	1999Q1-18Q4	80
Sweden	1994Q2-18Q4	82	1998Q3-17Q4	60	-	-
Thailand	1998Q2-17Q4	79	1999Q3-17Q4	72	-	-
Turkey	1999Q2-17Q4	75	2000Q1-17Q4	70	-	-
United Kingdom	1996Q2-18Q4	91	1997Q1-17Q4	80	-	-
United States	2008Q4-17Q3	36	2008Q4-17Q3	36	-	-
Uruguay	2002Q2-17Q4	58	-	-	-	-
Total		2801		1444		962

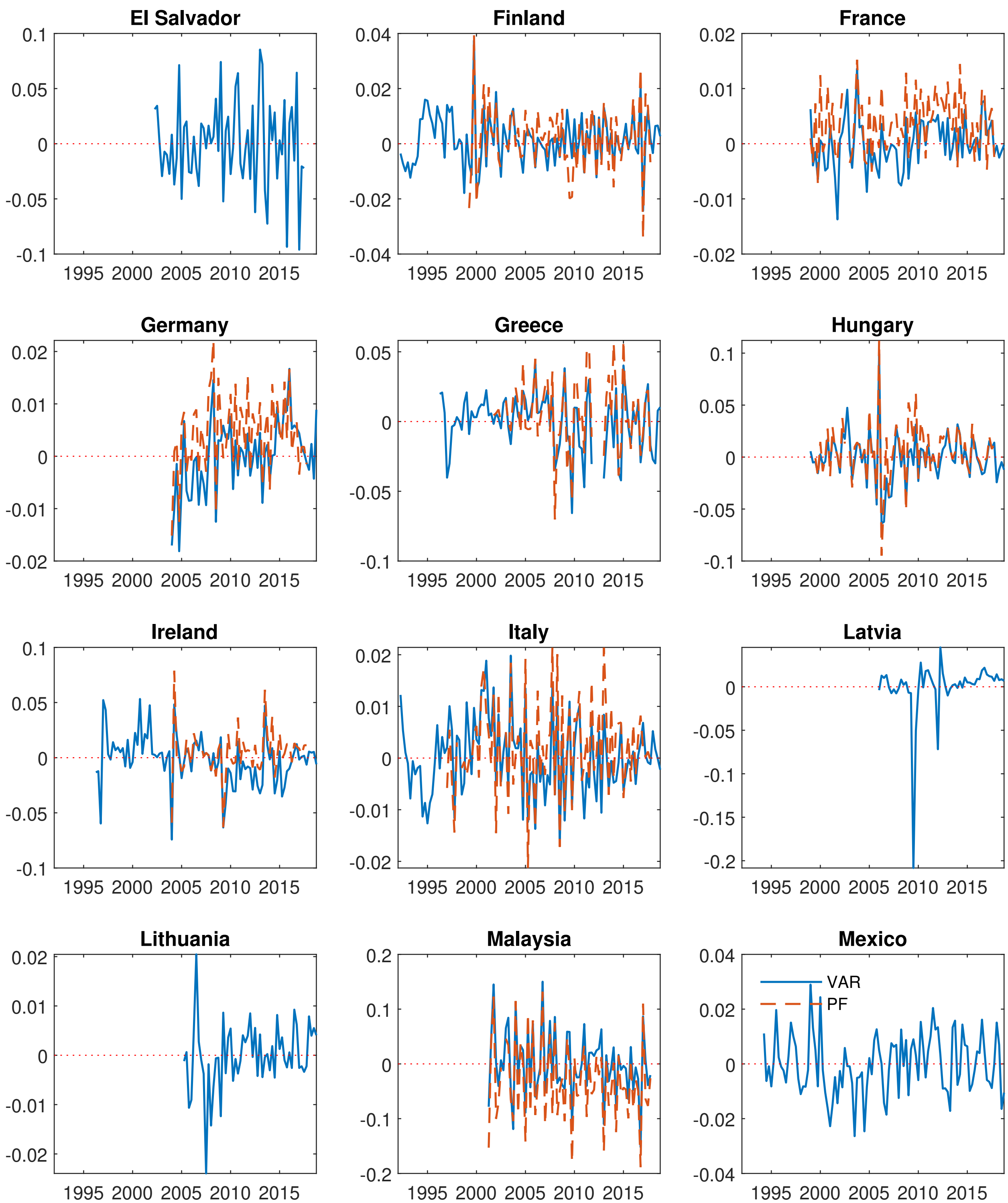
Notes: Range refers to the first and last observation available. Note that the VAR-approach requires 5 observations to construct 4 lags of growth rates. T refers to the number of observations used for the particular country after accounting for missing values and lag construction. See Born et al. (2020) for more details on the data set.

Figure D.1: VAR- vs. professional forecaster-based shocks



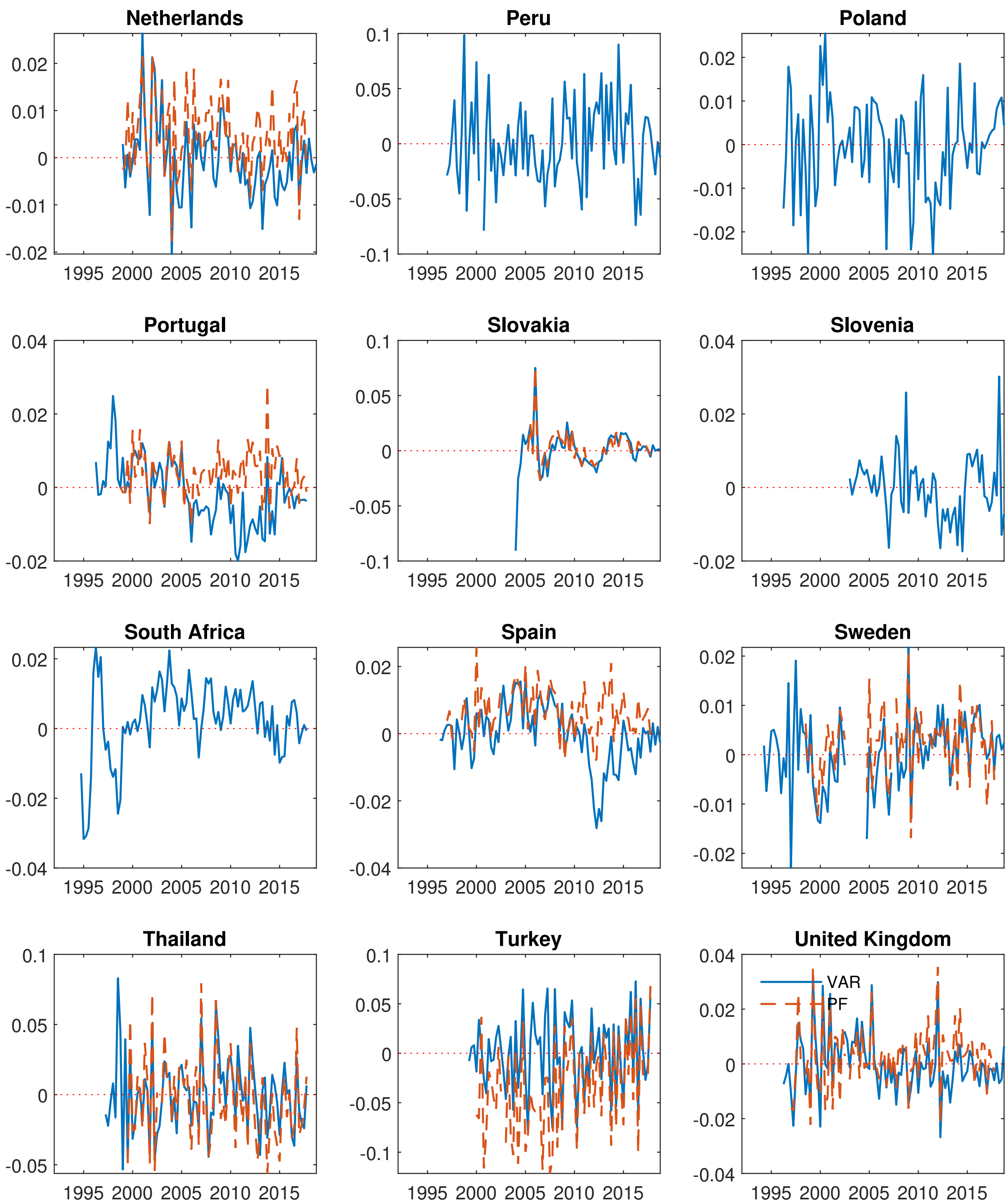
Notes: Blue solid line: forecast errors based on a VAR estimated on the pooled full sample; red dashed line: professional forecaster-based shocks after removal of time-fixed effect.

Figure D.2: Var- vs. professional forecaster-based shocks



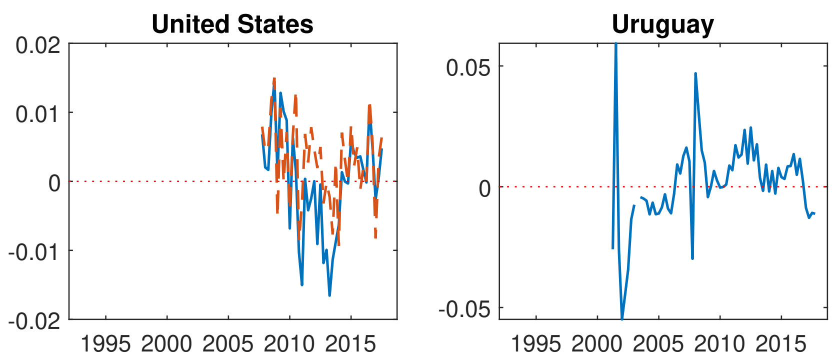
Notes: Blue solid line: forecast errors based on a VAR estimated on the pooled full sample; red dashed line: professional forecaster-based shocks after removal of time-fixed effect.

Figure D.3: Var- vs. professional forecaster-based shocks



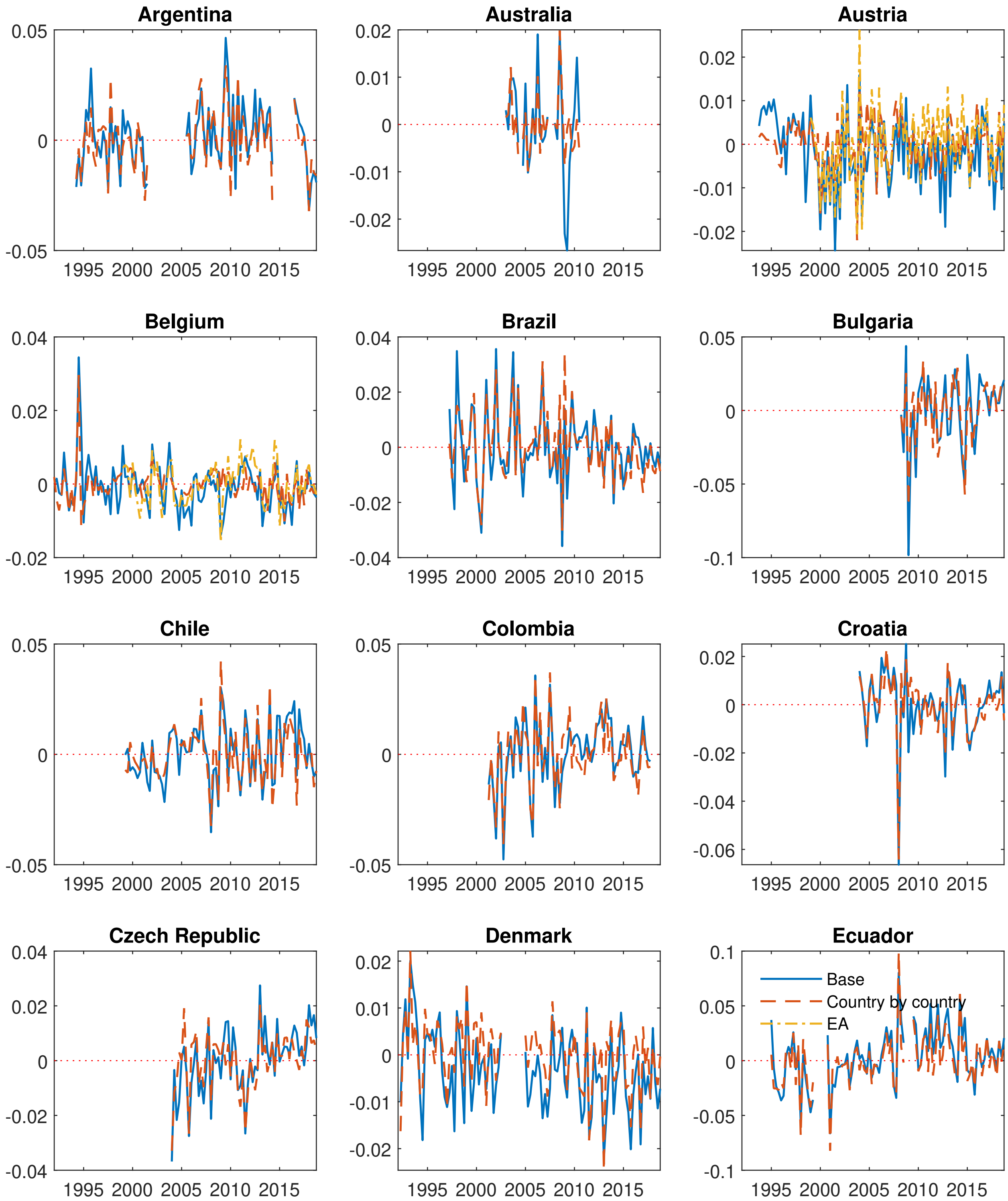
Notes: Blue solid line: forecast errors based on a VAR estimated on the pooled full sample; red dashed line: professional forecaster-based shocks after removal of time-fixed effect.

Figure D.4: Var- vs. professional forecaster-based shocks



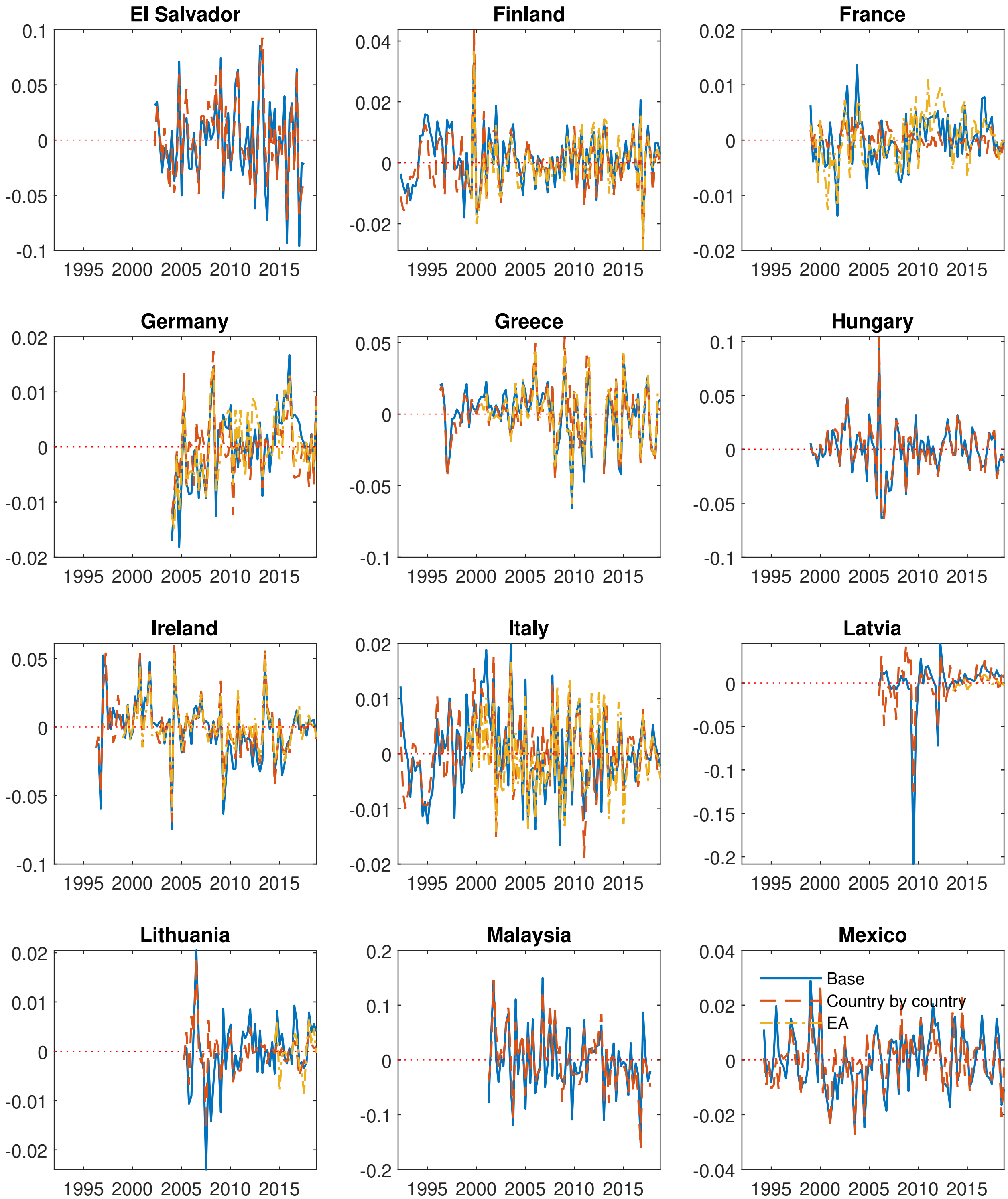
Notes: Blue solid line: forecast errors based on a VAR estimated on the pooled full sample; red dashed line: professional forecaster-based shocks after removal of time-fixed effect.

FIGURE D.5: COMPARISON OF VAR-BASED SHOCKS ACROSS SAMPLES



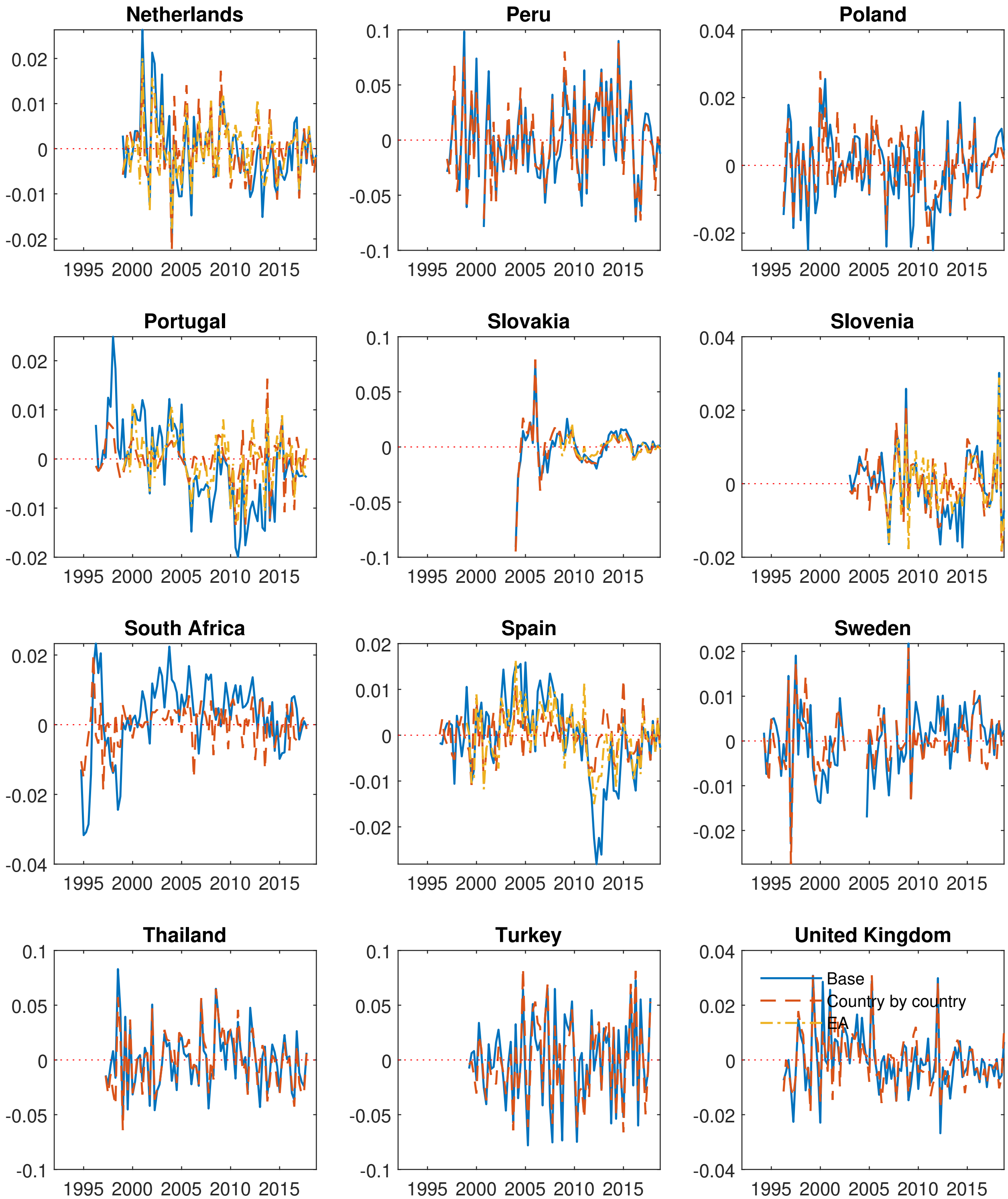
Notes: Blue solid line: pooled full sample; red dashed line: single-country VARs; yellow dash-dotted line: pooled EA sample (if applicable).

Figure D.6: Comparison of var-based shocks across samples



Notes: Blue solid line: pooled full sample; red dashed line: single-country VARs; yellow dash-dotted line: pooled EA sample (if applicable).

Figure D.7: Comparison of var-based shocks across samples



Notes: Blue solid line: pooled full sample; red dashed line: single-country VARs; yellow dash-dotted line: pooled EA sample (if applicable).

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

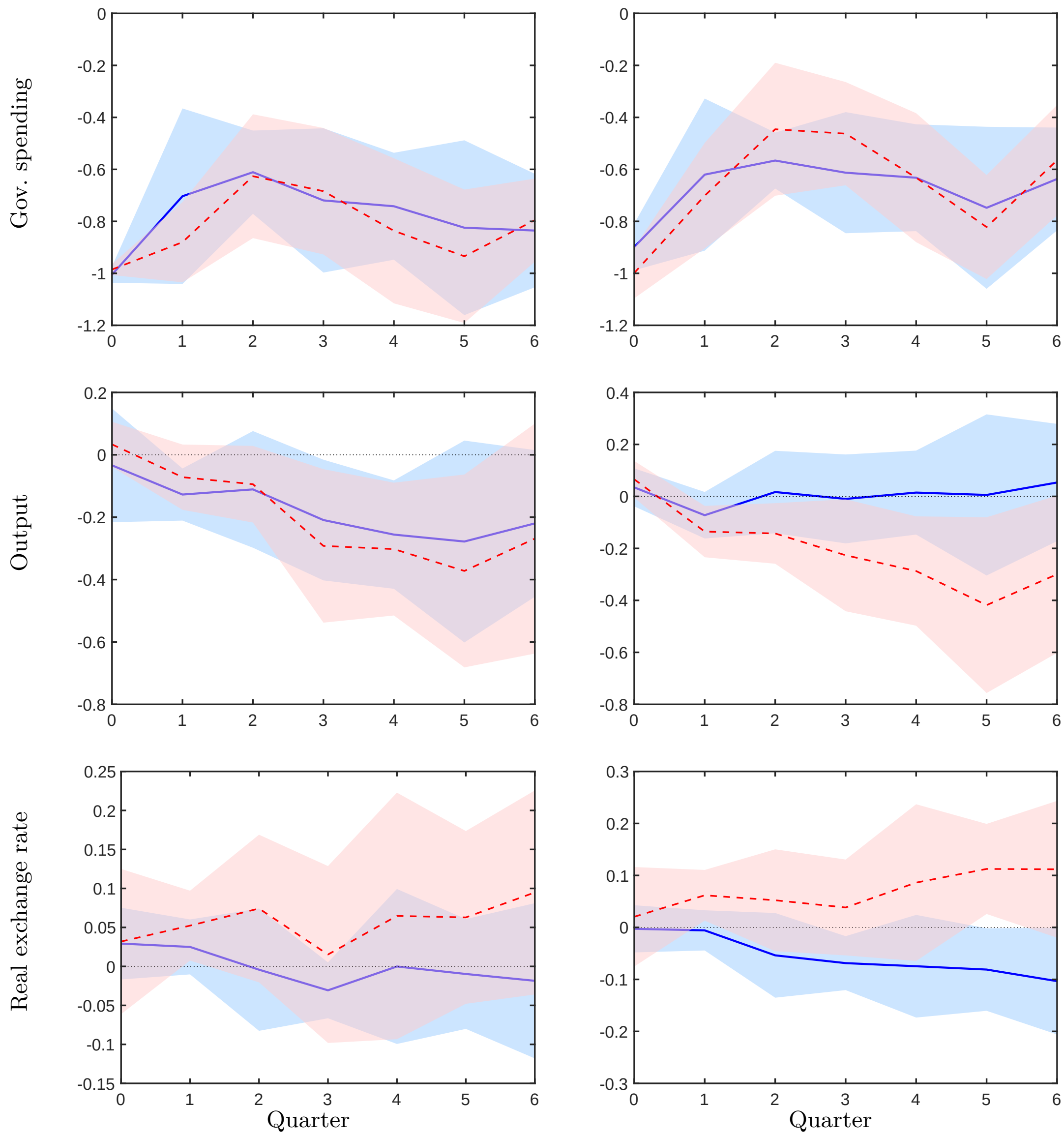
	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Latvia	Lithuania	Netherlands	Portugal	Slovakia	Slovenia	Spain
								VAR							
Austria	1.00	0.14	0.05	0.18	0.28	-0.15	-0.38	0.11	0.21	-0.00	-0.29	-0.31	-0.10	0.20	0.02
Belgium	-	1.00	0.10	0.73	0.24	-0.56	-0.37	0.16	0.56	0.63	0.16	0.09	-0.01	0.16	0.05
Finland	-	-	1.00	0.07	0.25	-0.29	-0.27	0.19	0.01	0.01	-0.01	-0.10	-0.20	0.01	-0.29
France	-	-	-	1.00	0.25	-0.41	-0.50	0.07	0.68	0.34	0.17	0.19	0.02	0.10	0.07
Germany	-	-	-	-	1.00	-0.49	-0.29	0.30	0.09	0.00	0.23	-0.01	0.08	0.21	-0.25
Greece	-	-	-	-	-	1.00	0.08	-0.40	-0.53	-0.67	-0.25	-0.14	-0.32	-0.35	-0.12
Ireland	-	-	-	-	-	-	1.00	-0.31	-0.26	0.00	-0.09	-0.26	-0.15	-0.37	-0.22
Italy	-	-	-	-	-	-	-	1.00	0.60	0.50	-0.06	0.03	-0.03	0.15	-0.01
Latvia	-	-	-	-	-	-	-	-	1.00	0.50	0.35	-0.01	-0.26	-0.05	-0.01
Lithuania	-	-	-	-	-	-	-	-	-	1.00	0.21	0.10	0.19	-0.04	-0.07
Netherlands	-	-	-	-	-	-	-	-	-	-	1.00	0.05	0.06	0.02	-0.11
Portugal	-	-	-	-	-	-	-	-	-	-	-	1.00	0.39	0.05	0.26
Slovakia	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-0.01	0.45
Slovenia	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	0.12
Spain	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00
								Professional forecasts							
Austria	1.00	-	-0.00	0.02	0.00	-0.16	-0.56	0.13	-	-	-0.27	-0.13	0.15	-	0.08
Belgium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Finland	-	-	1.00	-0.10	-0.22	-0.28	-0.18	0.18	-	-	0.05	0.01	-0.26	-	-0.13
France	-	-	-	1.00	0.27	-0.52	-0.41	0.21	-	-	0.23	0.66	0.02	-	0.32
Germany	-	-	-	-	1.00	-0.56	-0.16	0.14	-	-	0.14	0.25	-0.04	-	0.12
Greece	-	-	-	-	-	1.00	0.05	-0.40	-	-	-0.45	-0.46	-0.23	-	-0.44
Ireland	-	-	-	-	-	-	1.00	-0.39	-	-	0.03	-0.31	-0.34	-	-0.23
Italy	-	-	-	-	-	-	-	1.00	-	-	-0.03	0.22	-0.22	-	0.23
Latvia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lithuania	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	1.00	0.24	0.04	-	-0.01
Portugal	-	-	-	-	-	-	-	-	-	-	-	1.00	-0.06	-	0.32
Slovakia	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	0.01
Slovenia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spain	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00

Notes: Top panel: forecast error based on VAR model estimated on EA sample. Bottom panel: forecast error based on professional forecasts after removal of time fixed effect.

E Additional impulse response functions

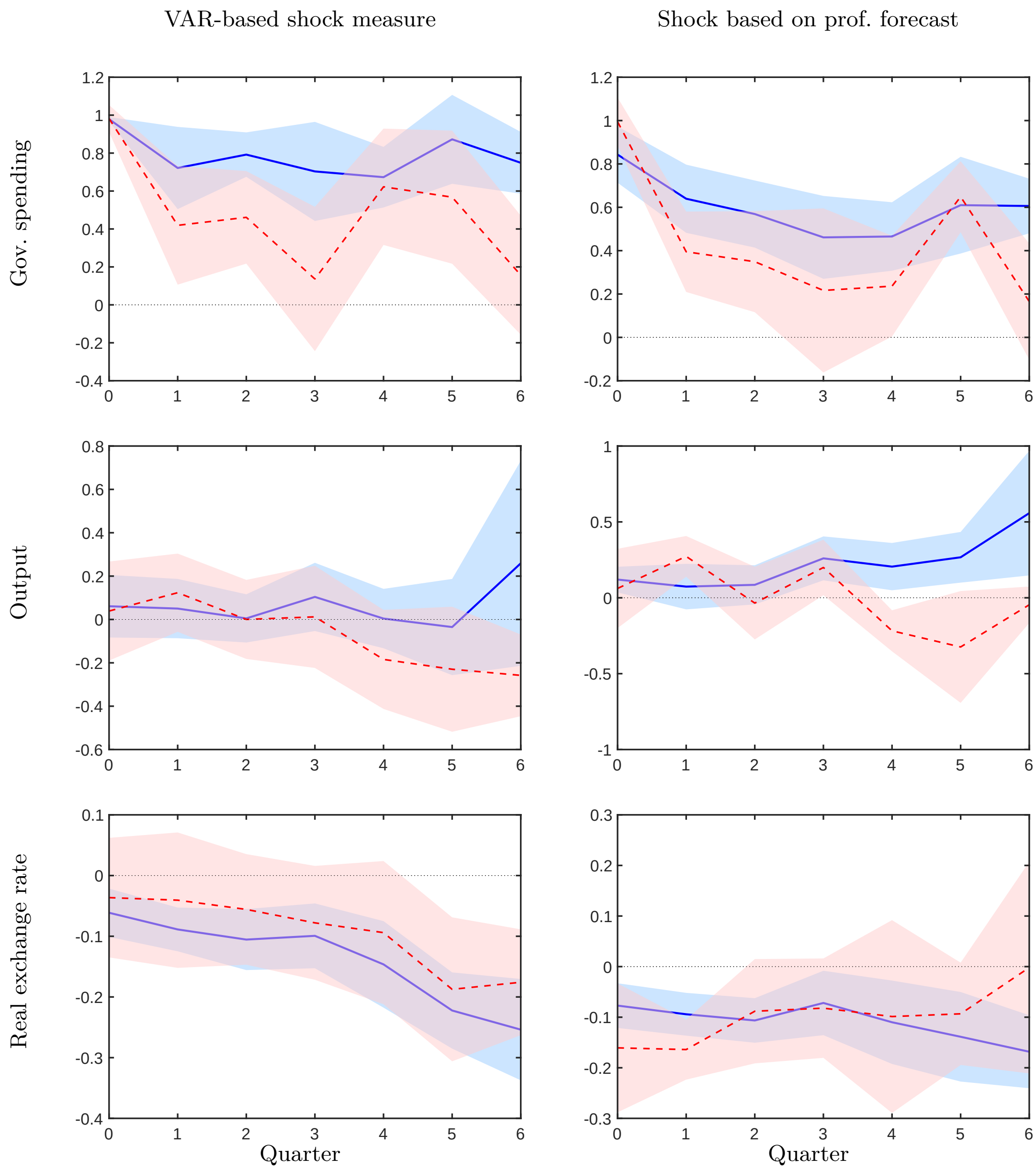
Figure E.1: IRFs to negative shocks – slack only v baseline

VAR-based shock measure | Shock based on prof. forecast



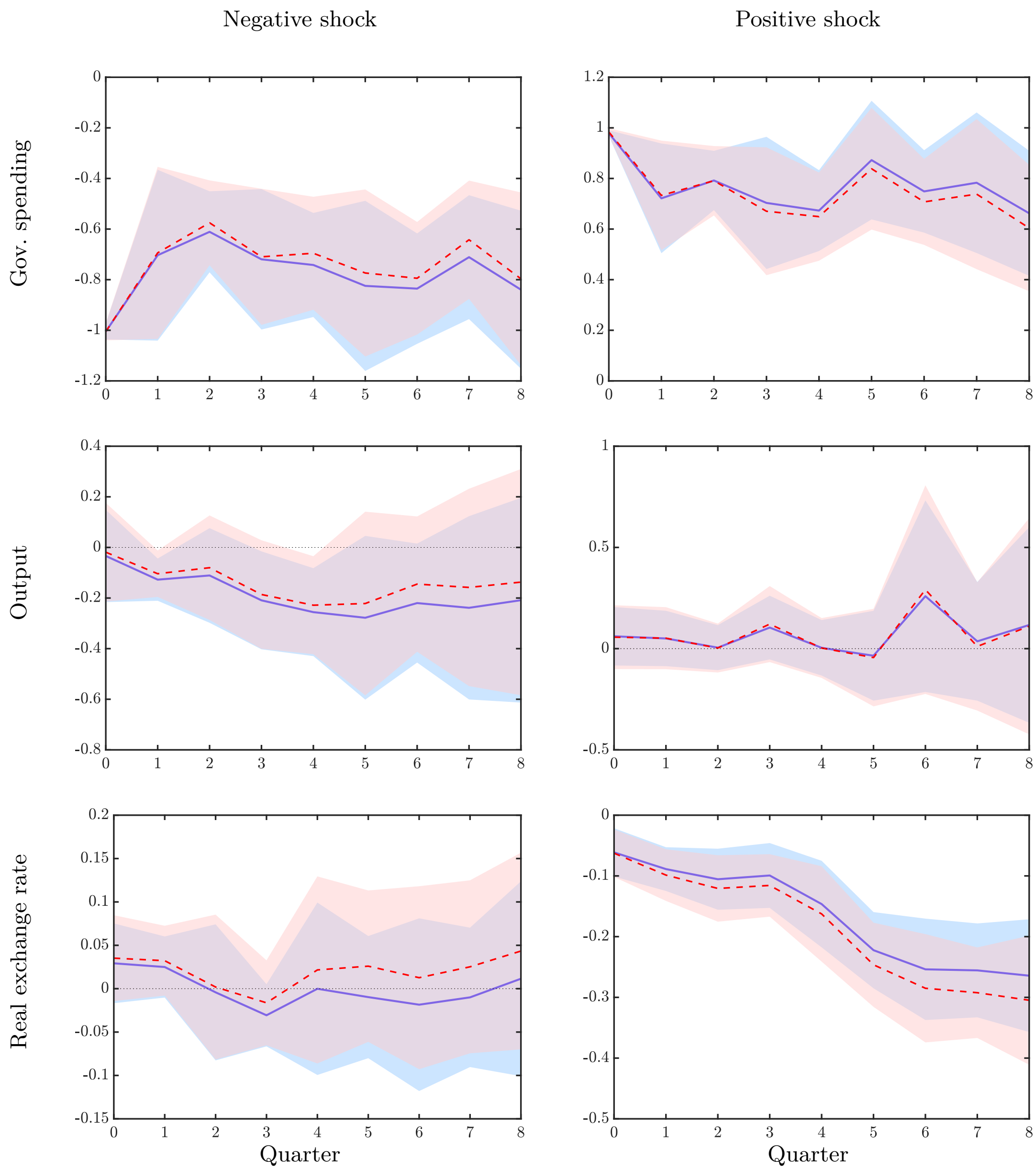
Notes: Adjustment to *negative* government spending shocks, identified using *VAR forecasts* (left) and *professional forecasts* (right). Blue/solid: baseline (reproduced from Figures 4 and 5); red/dashed: slack only (unemployment rate above a country's median). Sample: EA countries. Lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Figure E.2: IRFs to positive shock – high inflation v baseline



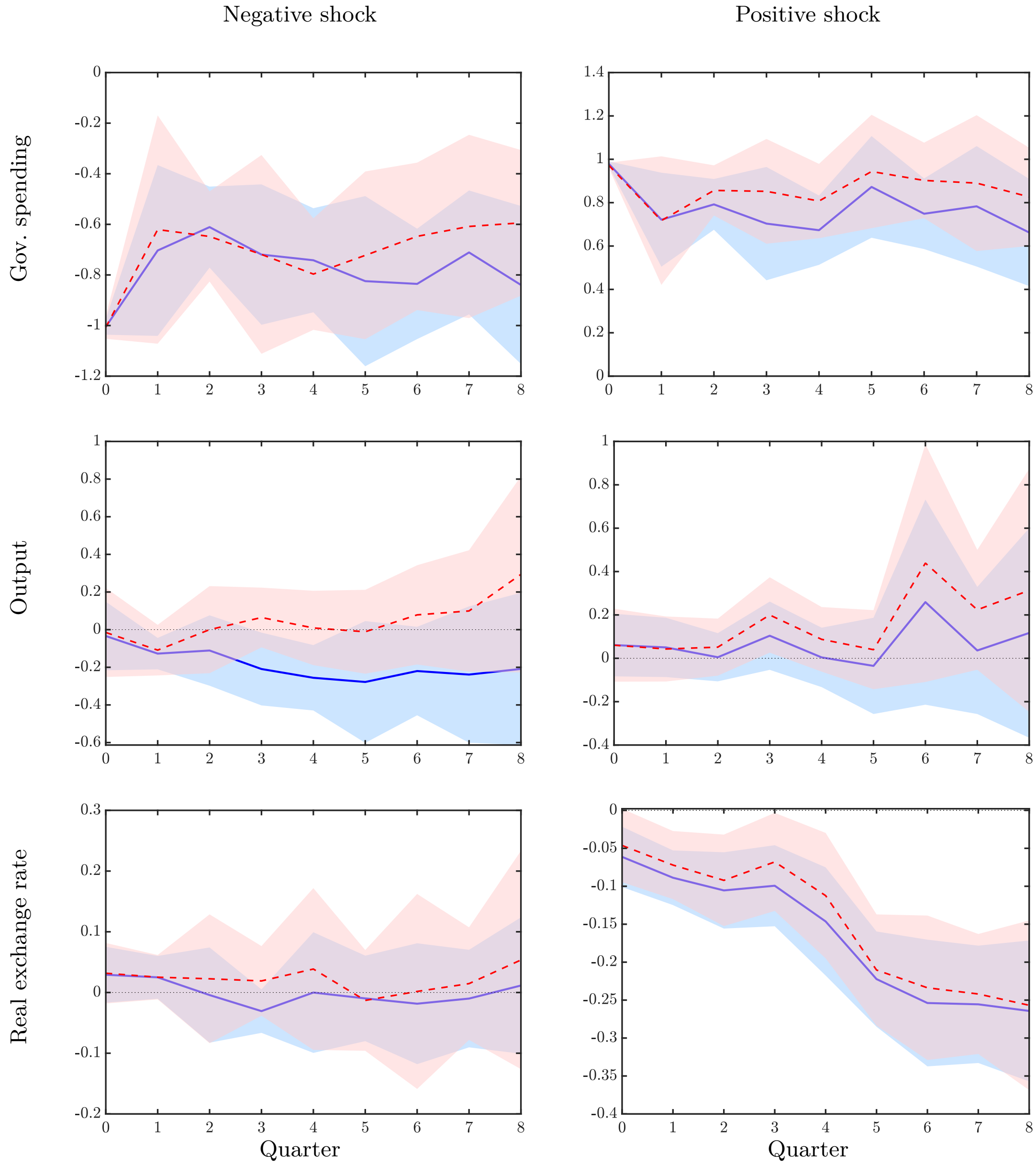
Notes: Adjustment to *positive* government spending shocks, identified using *VAR forecasts* (left) and *professional forecasts* (right). Blue/solid: baseline (reproduced from Figures 4 and 5); red/dashed: high inflation periods only (above 3 percent). Sample: EA countries. Lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Figure E.3: IRFs – EA excluding big countries v baseline



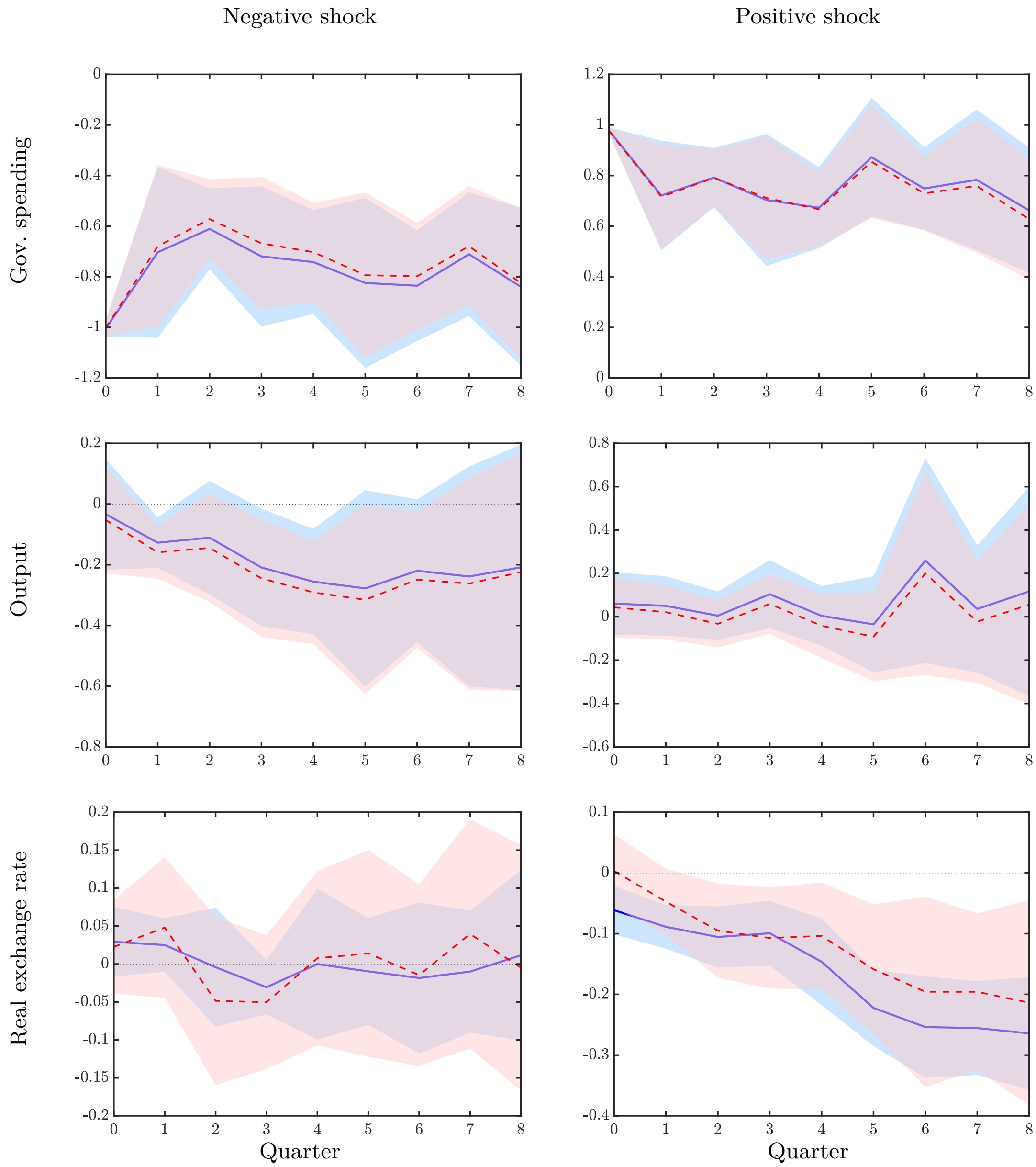
Notes: Adjustment to government spending shocks, identified using *VAR forecasts*. Sample: EA countries except for France, Germany, and Italy (red/dashed) and in the baseline EA sample (blue/solid). Lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Figure E.4: IRFs – ea excluding Greece v baseline



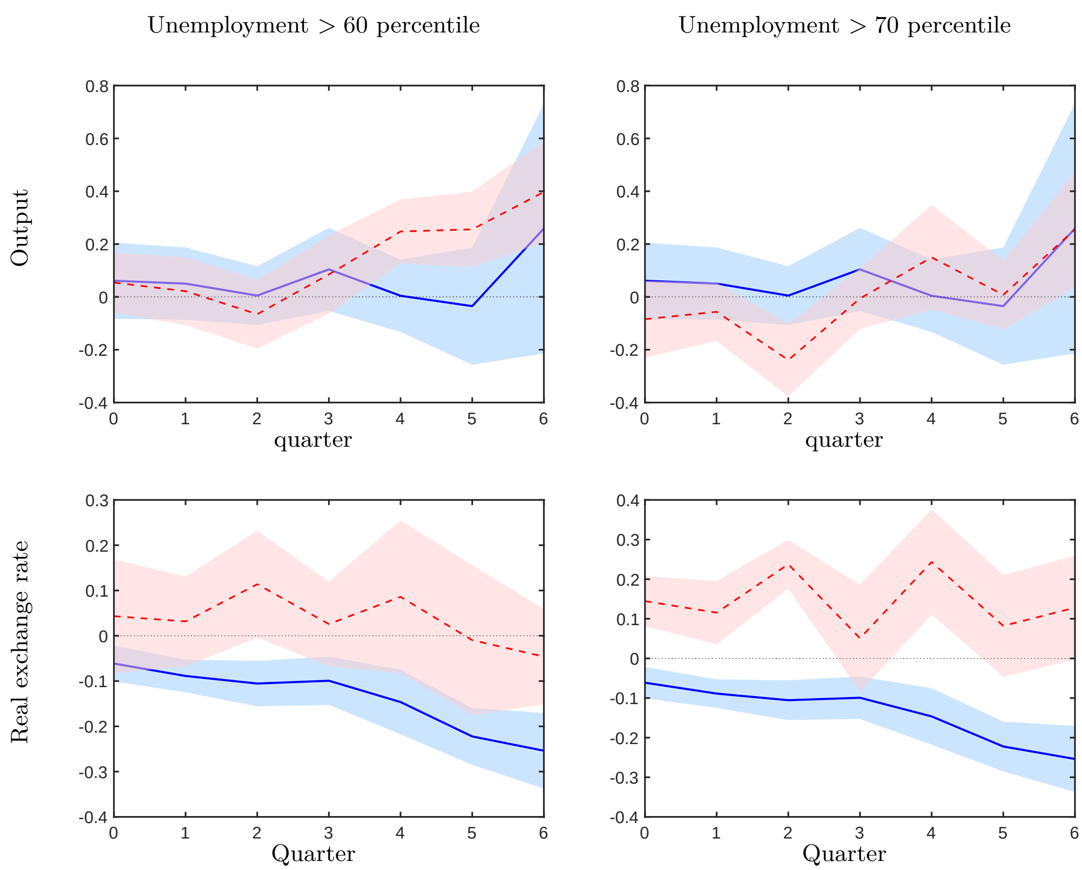
Notes: Adjustment to government spending shocks, identified using *VAR forecasts*. Sample: EA countries except Greece (red/dashed) and baseline EA sample (blue/solid). Lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Figure E.5: IRFs – ea with broad real effective exchange rate v baseline



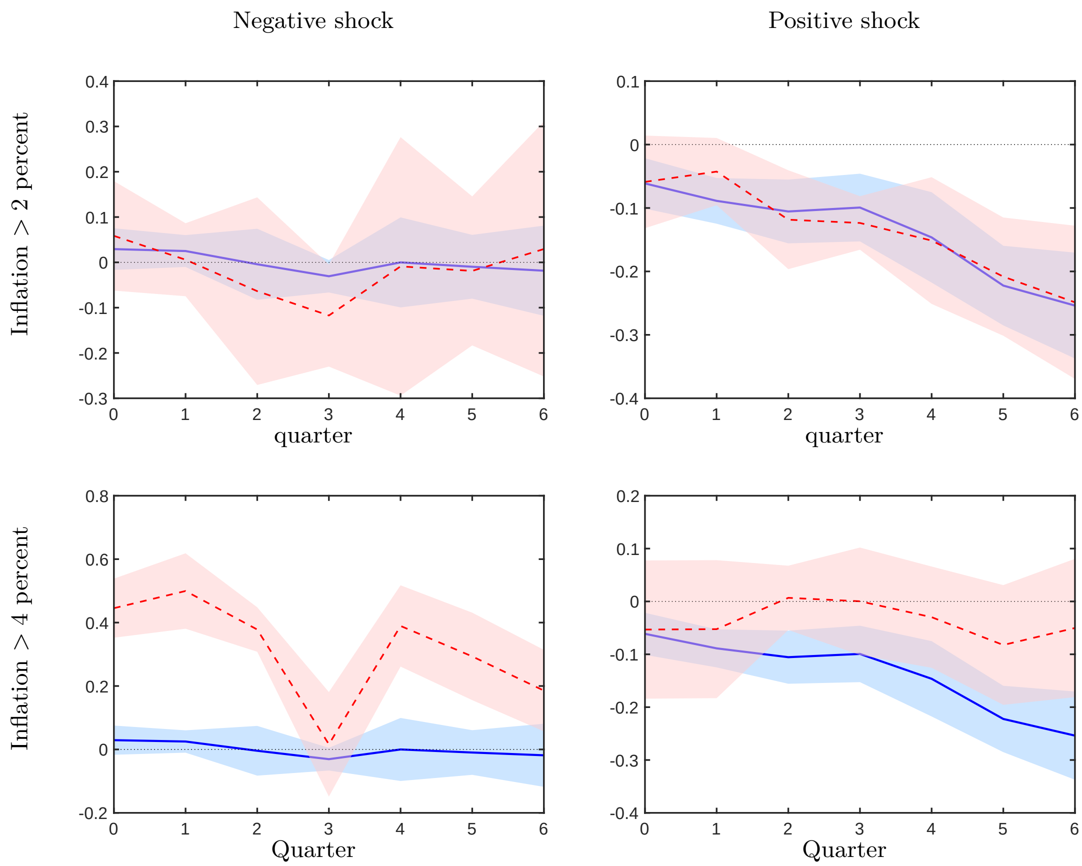
Notes: Adjustment to government spending shocks, identified using *VAR forecasts*. Sample: EA countries. Red dashed line shows results for specification based on broad real effective exchange rate, blue solid line shows baseline based on intra-EA real effective exchange rate. Solid and dashed lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Figure E.6: IRFs – different slack thresholds



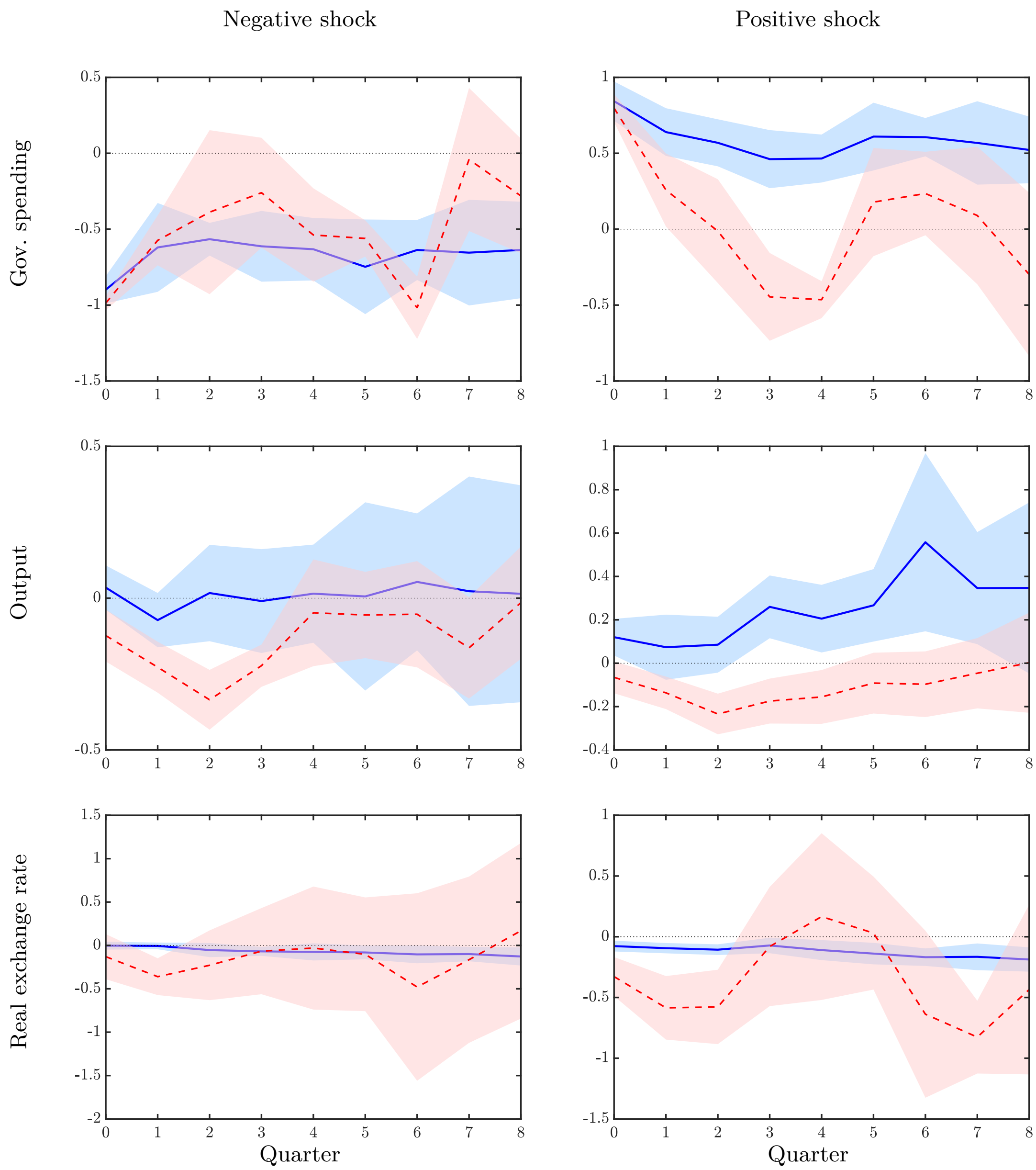
Notes: Adjustment to a positive government spending shock, identified using *VAR forecasts*. Sample: EA countries. Red dashed line shows results for when the unemployment rate is above its 60th percentile (dashed lines in left column) and 70th percentile (dashed lines in right column), respectively. Solid line represents baseline estimate. Shaded shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Figure E.7: IRFs – different high inflation thresholds



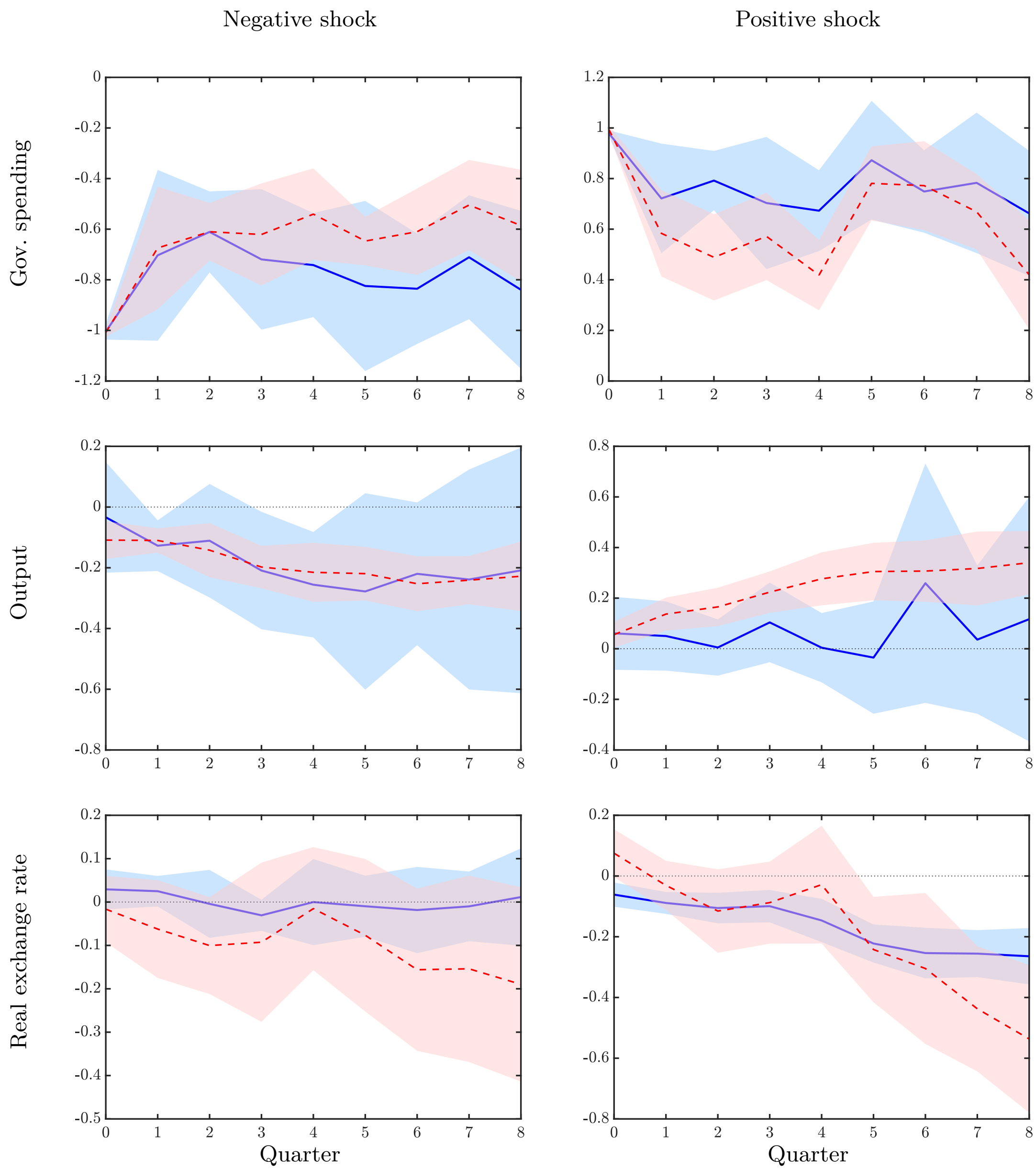
Notes: Real exchange rate adjustment to negative and positive government spending shocks, identified using *VAR forecasts*. Sample: EA countries. Red dashed lines show results for when inflation is above 2 percent (dashed lines in top row) and 4 percent (dashed lines in bottom row), respectively. Solid line represents baseline estimate. Shaded shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Figure E.8: IRFs – pegs without EA v baseline



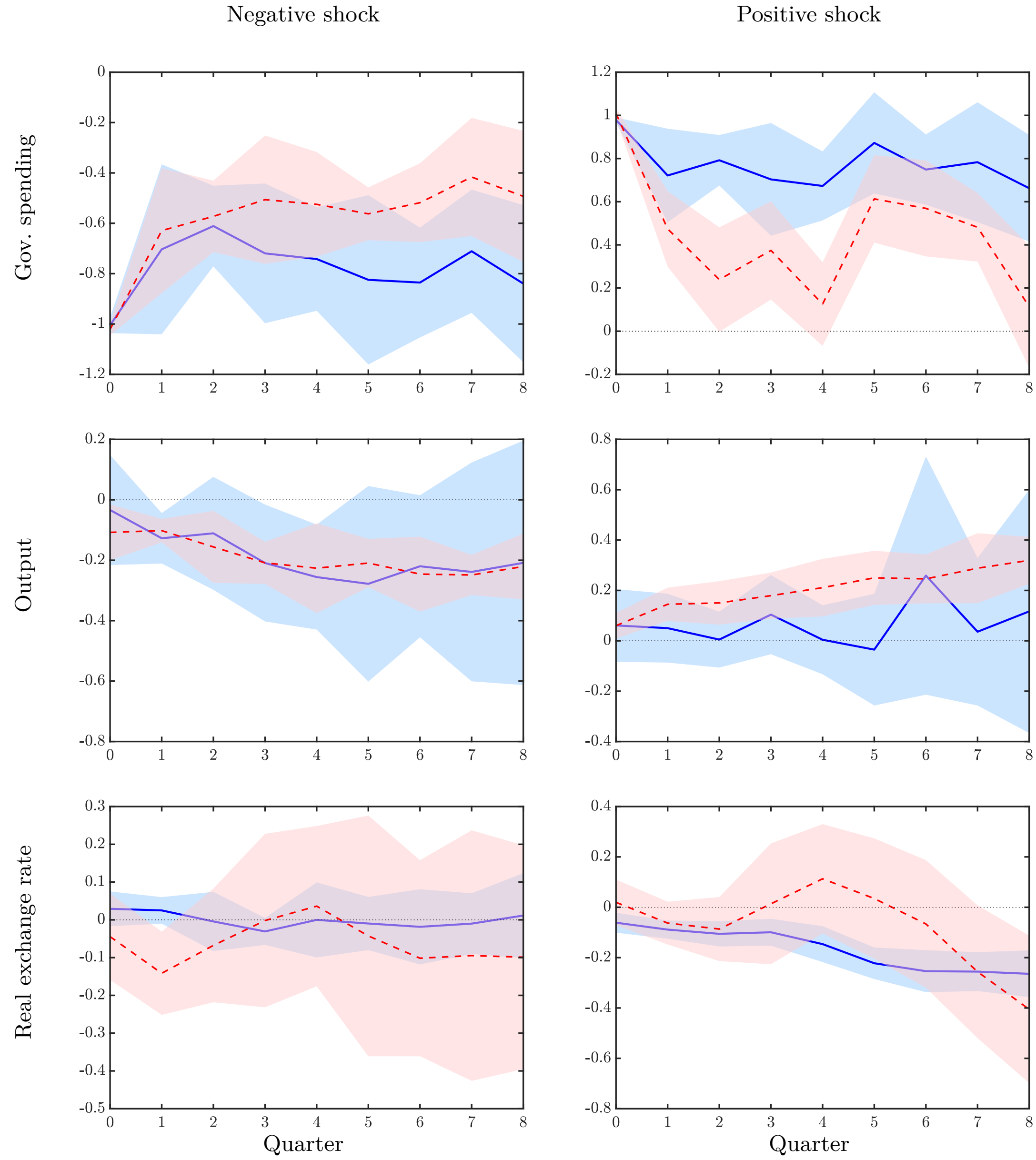
Notes: Adjustment to negative and positive government spending shocks, identified using *professional forecasts*. Blue/solid: EA sample; red/dashed: pegs without EA. Lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Figure E.9: IRFs – all pegs v baseline



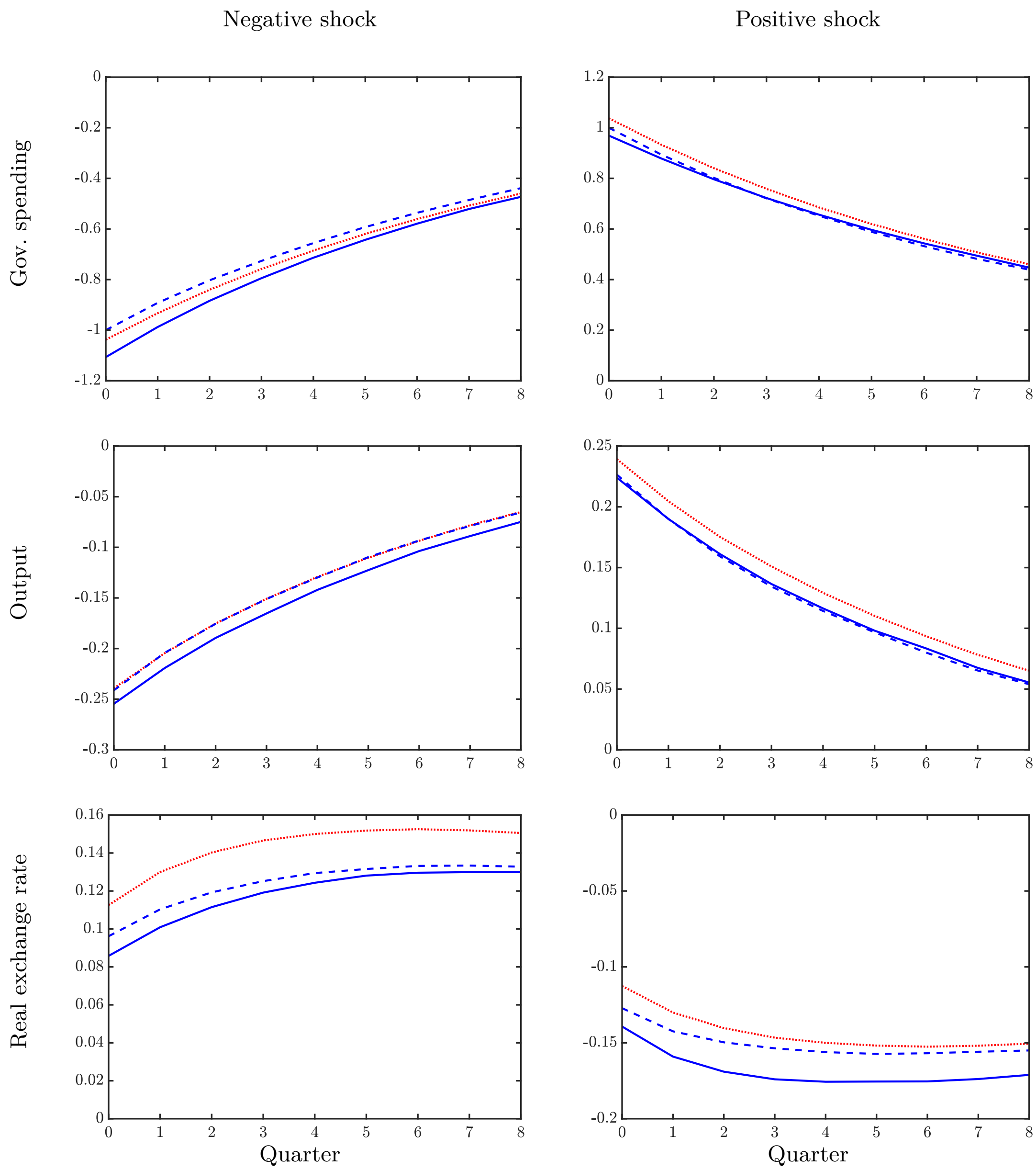
Notes: Adjustment to negative and positive government spending shocks, identified using *VAR forecasts*. Blue/solid: EA sample; red/dashed: all pegs. Lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Figure E.10: IRFs – pegs without EA v baseline



Notes: Adjustment to negative and positive government spending shocks, identified using *VAR forecasts*. Blue/solid: EA sample; red/dashed: pegs without EA. Lines represent point estimates, shaded areas represent 90 percent confidence intervals. Vertical axis measures deviation from pre-shock trend/level in percent.

Figure E.11: Monte Carlo irf – ergodic distribution



Notes: Adjustment to negative and positive government spending shocks identified using *VAR forecasts*. Sample: 1 million observations generated by the quantitative model. Blue solid lines: empirical two-stage approach estimate allowing for asymmetric effects. Blue dashed lines: generalized impulse responses of model under a peg with full employment (scaled to a 1% government spending shock). Red dotted line: empirical two-stage approach estimate restricted to symmetric effects. Vertical axis measures deviations from pre-shock level in percent.