Essays in International Macroeconomics

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Introduction

This thesis investigates the macroeconomic effects of fiscal policy, with a focus on austerity (or public-sector deleveraging), and private-sector deleveraging. It highlights the pivotal role of nonlinearities in generating different outcomes depending on the sign of the fiscal adjustment and how these nonlinearities shape the interaction between public and private deleveraging. In the following, I provide a short summary of the main findings of each chapter.

Chapter 1 is based on joint work with Benjamin Born, Gernot Müller, and Johannes Pfeifer. Under fixed exchange rates, fiscal policy is an effective tool. According to classical views because it impacts the real exchange rate, according to Keynesian views because it impacts output. Both views have merit because the effects of government spending are asymmetric. A spending cut lowers output but does not alter the real exchange rate. A spending increase appreciates the exchange rate but does not alter output unless there is economic slack. We establish these results in a small open economy model with downward nominal wage rigidity and provide empirical evidence on the basis of quarterly time-series data for 38 countries.

Chapter 2 takes a closer look at the Greek experience during the Great Contraction. Greece stands out as having the sharpest decline in GDP and government spending in Europe over the 2010-14 period. The aim of this paper is to assess the macroeconomic effects of public deleveraging, defined as government spending below forecast, and private deleveraging. The former mostly accounts for the output loss experienced by the country. However, the joint occurrence of public and private deleveraging generates quantitatively relevant nonlinear effects.

Chapter 3 critically reviews the literature assessing the individual and joint effects of public and private deleveraging. The amplification mechanism set in motion by their joint occurrence is likely to be quantitatively relevant. However, there is still limited evidence about the real extent of such interaction.

I hope the findings of this thesis can make policy makers in the euro area aware of the nontrivial consequences of their fiscal decisions.

Chapter 1

The worst of both worlds: fiscal policy and fixed exchange rates

Joint with Benjamin Born, Gernot Müller, and Johannes Pfeifer

1.1 Introduction

In theory, fiscal policy is a powerful stabilization tool in open economies when the exchange rate is fixed. Keynesian theories in the tradition of the Mundell-Fleming model emphasize that changes of government spending impact output strongly because prices and wages, and eventually the real exchange rate, are slow to adjust (Corsetti et al., 2013a; Nakamura and Steinsson, 2014; Farhi and Werning, 2016). Raising public spending stimulates output, while reducing it is detrimental to economic activity. In contrast, in classical theories the adjustment of the real exchange rate takes center stage (Corsetti and Müller, 2006). Raising spending does not stimulate output much because the exchange rate appreciates, while reducing it restores competitiveness (Sinn, 2014).

Both views seem to have some merit in light of the facts. Figure 1.1 shows data for individual countries in the euro area, distinguishing between two periods. In the left panel we measure, for the period from the introduction of the euro up until the end of 2007, the cumulative change in government spending on the horizontal axis. By and large it was a period of fiscal expansion. The vertical axis measures the change in the real effective exchange rate during that period. A decrease of the exchange rate corresponds to an appreciation. We observe that higher spending is associated with a sizable exchange rate appreciation—consistent with the classical view. In the right panel, we zoom in on the austerity period 2010–2015. While most countries experienced sizable spending cuts, exchange rates hardly moved—in line with the Keynesian view.

Can both views be correct? Recently, Schmitt-Grohé and Uribe (2016) have put forward a new paradigm for thinking about macroeconomic adjustment in open economies. Its key feature is downward nominal wage rigidity (DNWR).[1] A direct implication is that economies with an exchange-rate peg adjust asymmetrically to shocks. Expansionary shocks are largely absorbed by rising wages. The exchange rate appreciates. Contractionary shocks, instead, are absorbed by falling output. The exchange rate adjusts only sluggishly. In the first part of this paper, we formalize this idea for government spending, which we introduce in the original model of Schmitt-Grohé and Uribe (2016). In the second part of the paper, we provide supporting evidence based on a large panel data set. It includes quarterly observations for 38 countries since the early 1990s, both within and outside of the euro area.

The main result of our analysis—both in terms of theory and evidence—is that the effects of 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. At the same time, 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. Private expenditure is crowded out such that output and employment remain unchanged. In sum, the world appears to be neither purely Keynesian nor purely classical. Rather, as far as fiscal stabilization is concerned, we live in the worst of both worlds.

Our model-based analysis builds on Schmitt-Grohé and Uribe (2016). We extend the original two-sector model as we allow explicitly for government spending. Specifically, we assume that the government consumes an exogenously determined amount of nontraded goods. In order to finance these 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 the exchange rate adjusts in such a way as to offset the effect of DNWR altogether. In this case, output is always stabilized at the efficient level.

Under a float, the real exchange rate responds symmetrically to government spending shocks. A positive shock, that is, a spending increase, appreciates the real exchange rate because it raises the relative price of nontraded goods. This, in turn, crowds out

[1] For recent discussions on the empirical prevalence of DNWR, see Jo (2018) and Elsby and Solon (2019) and references therein. See also Knoppik and Beissinger (2003) and Knoppik and Beissinger (2009) for microevidence on substantial DNWR in Germany and, more generally, within the European Union, respectively.

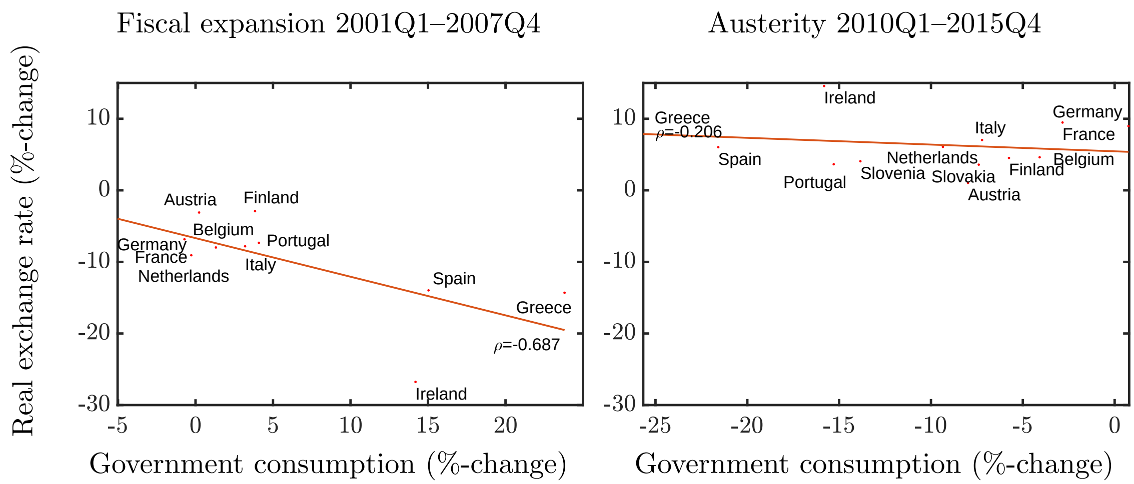


Figure 1.1: Government spending and real exchange rates: horizontal axis measures change of government consumption, vertical axis measures change of real effective exchange rate (positive change corresponds to depreciation); observations are for individual euro area countries, see Section 1.5 for details. Left panel shows changes for 2001Q1–2007Q4, right panel shows change for 2010Q1–2015Q4. Note that the correlation coefficient is significant only for the left panel at the 5% significance level.

private demand for nontraded goods. A cut to government spending, instead, lowers the relative price of nontraded goods, which stimulates private spending up to the point where economic activity is completely stabilized. The exchange rate depreciates. Under a peg, the adjustment is asymmetric. The response to a spending increase is the same as under a float. Yet, in response to a cut the real exchange rate does not adjust because of downward nominal wage rigidity. 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 to begin with. If, instead, there is slack, the effects of government spending shocks are symmetric under a peg, but still distinct from the float because the adjustment operates via output and not through the prices, irrespective of whether government spending is cut or raised.

We establish these results in closed form for a simplified version of our model. In this case, we restrict wages to be completely downwardly rigid and show that the effective supply curve of nontraded goods is kinked: it turns vertical at the point where the economy operates at full employment, but is horizontal if production falls short of that level. As a result, the adjustment to government spending shocks is asymmetric if the economy operates near full employment. In conceptually closely related work, Benigno and Ricci (2011) show that the Phillips curve is nonlinear in the presence of DNWR, while Dupraz et al. (2019) account for asymmetric labor market dynamics over the business cycle in a search model of the labor market which also features DNWR.

We then show the quantitative importance of the asymmetry characterizing the adjustment process in a fully stochastic model of the Greek economy. An increase of government spending appreciates the real exchange rate by six percent on impact. A cut of government spending of the same size, instead, induces a depreciation of less than one percent. The impact multiplier on nontraded output is about one after a spending cut and zero after a spending increase. It takes about 1.5 years for the adjustment dynamics to become roughly symmetric.

In the empirical part of the paper, we provide evidence for asymmetric effects of government spending shocks. For this purpose, we extend and update a fairly rich data set, originally assembled by Born et al. (2019). 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 runs from the early 1990s to the end of 2018. Importantly, the database includes two distinct measures of fiscal shocks. First, as in Ramey (2011b), 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 series in isolation. For this purpose, we rely on local projections à la Jordà (2005). This approach is particularly suitable for the purpose at hand, since it allows us to estimate responses for positive and negative shocks separately. Once we estimate the model on the full sample and do not distinguish between fixed and floating exchange rates, we find that the responses to spending shocks are fairly symmetric. Importantly, we find very similar results for both shock measures even though samples do not fully overlap for reasons of data availability. Specifically, negative spending shocks reduce output and depreciate the real exchange rate moderately. Positive spending shocks, instead, raise output and appreciate the exchange rate.

Our model predicts that the adjustment to spending shocks is asymmetric under an exchange-rate peg. To confront this prediction with the data, we estimate our empirical model on observations for the individual countries of the euro area because—from the perspective of the model—membership in the euro area boils down to an exchange-rate peg as far as the adjustment to government spending shocks is concerned. In our sample, approximately one third of our observations of the VAR-based shock measure (some 900 of a total of 2800 observations) pertain to countries in the euro area. For the shock measure based on professional forecasters, the euro sample is considerably smaller and the shocks turn out to be a poor predictor for actual government spending. Hence, as we zoom in on the euro sample we exclusively rely on the VAR-based shock measure.

For this sample, we establish evidence that is fully in line with the predictions of the model. A government spending cut reduces output but does not alter the real exchange rate. A spending increase appreciates the real exchange rate but does not alter output. Because DNWR should be less of a constraint in times of high inflation[2], we further condition our estimates on periods of high inflation. Indeed, we find that the economy responds much more symmetrically to government spending shocks if inflation is high. What changes is the adjustment to spending cuts: if inflation is high, the exchange rate depreciates and the output response is muted—the mirror image of what happens after a positive spending shock. Lastly, we condition on periods of economic slack and find that the adjustment to positive spending shocks changes in this case: the response of output becomes stronger and the response of the exchange rate weaker—just like the model predicts.

During the last decade, countless studies have investigated the effect of government spending on output, as a recent survey by Ramey (2019) illustrates. In a recent contribution, Barnichon et al. (2019) find that the contractionary multiplier is above 1 and even larger in times of economic slack, whereas the expansionary multiplier is substantially below 1 regardless of the state of the cycle. But there are also numerous studies of how government spending impacts the real exchange rate, with partly conflicting results (among others, Enders et al., 2011; Kim and Roubini, 2008; Monacelli and Perotti, 2010; Bénétrix and Lane, 2013; Ilzetzki et al., 2013; Miyamoto et al., 2019).[3] However, these studies do not allow for an asymmetric response of the exchange rate to government spending shocks. At the same

[2]The argument that positive inflation greases the wheels of the labor market by facilitating real wage cuts when nominal wages are sticky downward dates back to Tobin (1972). For more recent contributions, see for instance Addison et al. (2017) presenting evidence from Portugal that DNWR matters less in periods of high inflation.

[3]Standard models predict that positive (negative) government spending shocks appreciate (depreciate) the real exchange rate. A number of mechanisms have been put forward to rationalize exchange rate depreciation in response to (positive) shocks (Betts and Devereux, 2000; Corsetti et al., 2012a; Kollmann, 2010; Monacelli and Perotti, 2010; Ravn et al., 2012).

time, several authors have explored nonlinearities in the fiscal transmission mechanism. This includes the role of the business cycle and the zero lower bound on interest rates (Christiano et al., 2011; Ramey and Zubairy, 2018; Auerbach and Gorodnichenko, 2012), sovereign risk (Corsetti et al., 2013b; Born et al., 2019), and the sign and size of fiscal adjustments (Giavazzi et al., 2000). Shen and Yang (2018) analyze the role of DNWR in the transmission of fiscal shocks, just like we do. However, they perform a purely model-based analysis and, unlike us, do not consider the open economy dimension. Burgert et al. (2019) study the implications of DNWR for the effects of various fiscal instruments in a medium-scale DSGE model. Lastly, we refer to work which has highlighted features of particular relevance for the fiscal transmission mechanism in open economies, such as the role of the exchange rate regime (Erceg and Lindé, 2012; Corsetti et al., 2013a, 2012b; Born et al., 2013; Ilzetzki et al., 2013) or sudden stops (Liu, 2018). Bianchi et al. (2019), in turn, study optimal fiscal policy under a currency peg in the presence of sovereign risk and DNWR.

The remainder of the paper is organized as follows. Section 1.2 introduces the baseline model. In Section 1.3, we make a number of simplifying assumptions and derive closed-form results. Next, we solve the full model numerically and present quantitative results in Section 1.4. Section 1.5 introduces both our empirical strategy and our data set and establishes the empirical results in support of the theory. Section 1.6 concludes.

1.2 Model

Our model is an extension of Schmitt-Grohé and Uribe (2016). It features a small open economy with two types of goods. One good is not traded internationally, but produced by a representative firm with labor as the only production factor. Nominal wages are downwardly rigid. The other good is traded internationally by a representative household. In each period the household receives an endowment of traded goods and may borrow or lend internationally via non-contingent debt.

Our innovation relative to the original model by Schmitt-Grohé and Uribe (2016) is that we allow for government consumption. We assume that it fluctuates exogenously, is financed through lump-sum taxes, and falls exclusively on nontraded goods. We maintain the last assumption to enhance the tractability of the model and note that in practice governments tend to consume some imports. Yet, their weight in overall government spending is much smaller than for private spending (see e.g. Corsetti and Müller, 2006).

1.2.1 Household

There is a representative household 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

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{c_t^{1-\sigma} - 1}{1-\sigma} + \psi_g \frac{(g_t^N)^{1-\varsigma} - 1}{1-\varsigma} \right] , \tag{1.1}$$

where $\mathbb{E}_t$ is the mathematical expectations operator conditional on information available at time t, 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, and nontraded goods, c^N:

$$c_t = \left[\omega \left(c_t^T \right)^{\frac{\xi-1}{\xi}} + (1-\omega) \left(c_t^N \right)^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}} , \tag{1.2}$$

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

$$P_t = \left[\omega^{\xi} \left(P_t^T \right)^{1-\xi} + (1-\omega)^{\xi} \left(P_t^N \right)^{1-\xi} \right]^{\frac{1}{1-\xi}} , \tag{1.3}$$

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

The household receives labor income and firm profits as well as an endowment of traded goods. In addition, the household may borrow (or save) via a discount bond that pays one unit of the traded goods with a foreign-currency price P_t^{T*}. The household pays taxes and spends its income on traded and nontraded goods. Formally, the period budget constraint in domestic currency reads as follows:

$$\mathcal{E}_t P_t^{T*} d_t + P_t^T c_t^T + P_t^N c_t^N = \mathcal{E}_t P_t^{T*} \frac{d_{t+1}}{1+r_t} + P_t^T y_t^T + W_t h_t + \phi_t - \tau_t , \tag{1.4}$$

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 $t-1$, which is 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 exogeneity assumption 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 (1.1) subject to (1.4), and a no-Ponzi scheme constraint:

$$d_{t+1} \leq \bar{d} \; , \tag{1.5}$$

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

$$c_t^N : p_t^N = \frac{1-\omega}{\omega} \left(\frac{c_t^T}{c_t^N} \right)^{\frac{1}{\xi}} \tag{1.6}$$

$$c_t^T : \lambda_t = \omega \left[\omega \left(c_t^T \right)^{\frac{\xi-1}{\xi}} + (1-\omega) \left(c_t^N \right)^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}\left(\frac{1}{\xi}-\sigma\right)} \left(c_t^T \right)^{-\frac{1}{\xi}} \tag{1.7}$$

$$d_{t+1} : \frac{\lambda_t}{1+r_t} = \beta \mathbb{E}_t \lambda_{t+1} + \mu_t \tag{1.8}$$

$$\mu_t \geq 0 \wedge d_{t+1} \leq \bar{d} \text{ with } 0 = \mu_t (d_{t+1} - \bar{d}) \tag{1.9}$$

as well as a suitable transversality condition for bonds. Here, λ_t/P_t^T and μ_t, in turn, are the Lagrange multipliers associated with (1.4) and (1.5), and (1.9) is the complementary slackness condition.

1.2.2 Firm

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

$$y_t^N = h_t^{\alpha} \; , \tag{1.10}$$

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

$$\phi_t \equiv P_t^N y_t^N - W_t h_t \; . \tag{1.11}$$

Optimality requires the following condition to hold:

$$p_t^N = \frac{W_t/\mathcal{E}_t}{\alpha y_t^N/h_t} \; . \tag{1.12}$$

This condition that price equals marginal costs operates at the heart 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 in order to shift the supply curve outward and thus to stabilize the demand for labor. Such a decrease in costs will be passed on into the price of nontraded goods, counteracting the initial drop in demand. As equation (1.12) shows, an important factor in firm's real marginal costs consists of the wage in terms of traded goods. Thus, a decrease in real marginal costs can be brought about either by a decrease in the nominal wage, W_t, or by an exchange rate devaluation, that is, an increase in $\mathcal{E}_t$.

1.2.3 Labor market

The household faces no disutility from working and will therefore supply labor in order to meet labor demand to the extent that it does not exceed the total endowment of labor:[4]

$$h_t \leq \bar{h} \; . \tag{1.13}$$

Hours worked are determined in equilibrium by the firm's labor demand. Even though the labor market is competitive, it will generally not clear because of downward nominal wage rigidity. Specifically, as in Schmitt-Grohé and Uribe (2016), we assume that in any given period nominal wages cannot fall to a level smaller than $\gamma > 0$ times the wage in the previous period. Formally, the economy is subject to downward nominal wage rigidity of the form

$$W_t \geq \gamma W_{t-1} \; . \tag{1.14}$$

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

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:

$$(\bar{h} - h_t)(W_t - \gamma W_{t-1}) = 0 \; . \tag{1.15}$$

It 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

$$w_t \equiv W_t / \mathcal{E}_t \tag{1.16}$$

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 (1.14) can then be rewritten as

$$w_t \geq \gamma \frac{w_{t-1}}{\epsilon_t} \; . \tag{1.17}$$

This expression illustrates that downward nominal wage rigidity operates via effectively constraining real wages. At the same time, it shows how a currency devaluation, i.e. an increase in ϵ_t, may relax the tightness of the constraint.

1.2.4 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:

$$RER_t \equiv \frac{\mathcal{E}_t P_t^*}{P_t} \; , \tag{1.18}$$

where P_t^* denotes the price of foreign consumption expressed in foreign currency. 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 (1.3), we find that the real exchange rate is inversely related to the relative price of nontraded goods in the following way:

$$RER_t = \left[\omega^\xi + (1-\omega)^\xi (p_t^N)^{1-\xi} \right]^{-\frac{1}{1-\xi}} \; . \tag{1.19}$$

1.2.5 Government spending

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

$$P_t^N g_t^N = \tau_t \; . \tag{1.20}$$

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

1.2.6 Market clearing

Market clearing in the nontraded-goods sector requires

$$y_t^N = c_t^N + g_t^N \; , \tag{1.21}$$

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

$$c_t^T = y_t^T - d_t + \frac{d_{t+1}}{1 + r_t} \; . \tag{1.22}$$

Labor market equilibrium is characterized by equations (1.13)-(1.15). Appendix 1.A lists the full set of equilibrium conditions and provides a definition of the equilibrium for a given exchange rate policy $\{\epsilon_t\}_{t=0}^{\infty}$, to be specified next.

1.2.7 Exchange rate policy

In order to specify the exchange rate policy, we define the full-employment real wage:

$$w_t^f \equiv \frac{1-\omega}{\omega} \left(\frac{c_t^T}{\bar{h}^\alpha - g_t^N} \right)^{\frac{1}{\xi}} \alpha \bar{h}^{\alpha - 1} \; . \tag{1.23}$$

This expression is obtained by combining the demand and supply schedules of nontraded goods, (1.6) and (1.12), respectively, the definition of the real wage (1.16), the production technology (1.10), and the market clearing condition (1.21) when the labor market is operating at full employment, that is, $h_t = \bar{h}$. This is also 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 (1.17) above shows. This gives a role to monetary policy, which can stabilize economic activity by setting the nominal exchange rate. But there are infinitely many combinations of nominal wage and nominal exchange rate which imply the same real wage—see equation (1.16) above—and therefore the same real exchange rate. Hence, any exchange rate policy satisfying

$$\epsilon_t \geq \gamma \frac{w_{t-1}}{w_t^f} \tag{1.24}$$

will make the wage constraint slack and ensure 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

$$\epsilon_t = \max\left\{\gamma \frac{w_{t-1}}{w_t^f}, 1\right\} . \tag{1.25}$$

Intuitively, if the full-employment wage is above the lower bound γw_{t-1}, the nominal exchange rate will not be adjusted at all. Otherwise, it will increase by just enough to alleviate the constraint.

In our analysis below, we study, in addition to such a scenario of "fully" flexible exchange rates, the behavior of the economy under fixed exchange rates, as well as intermediate cases. Formally, we specify the following exchange rate rule (as in Liu (2018)) to capture alternative exchange rate arrangements:

$$\epsilon_t = \max\left\{\gamma \frac{w_{t-1}}{w_t^f}, 1\right\}^{\phi_\epsilon} , \tag{1.26}$$

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

1.3 Analytical results

In this section, we establish a number of closed-form results and illustrate the mechanism that operates at the heart of the model. For this purpose we make a number of simplifying assumptions and limit our analysis to a perfect foresight scenario. There is a fully unanticipated government spending shock in the initial period and everybody understands that no further shocks will ever materialize. After describing our simplifying assumptions, we first show that, starting from a full-employment equilibrium, the real exchange rate and nontraded output respond asymmetrically to negative and positive government spending shocks unless the exchange rate is flexible. Next, we show that—under a peg—the adjustment of the economy to a government spending shock is state-dependent, that is, the response differs depending on whether the shock happens when the economy is operating at full capacity or in a state of slack.

1.3.1 Simplifying assumptions

We simplify the model along a number of dimensions. First, following Schmitt-Grohé and Uribe (2016), 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 such that we may solve for the equilibrium in the market for nontraded goods while taking as given the level of traded-goods consumption.[5] Regarding the production function, we assume that $\alpha = 1$, so that the marginal product of labor is constant. We also assume that the endowment of traded goods, y^T, and the world interest rate, r, are constant over time. Without loss of generality, we set $y^T = 1$. The steady-state level of government consumption is denoted by $g < 1$. We also assume that wages are perfectly downwardly rigid, that is, we set $\gamma = 1$. In this case, any contractionary shock is sufficient to induce the wage constraint to become binding. Furthermore, we set $\bar{h} = 1$ and $\beta(1 + r) = 1$ and abstract from the borrowing constraint (1.5), but keep on ruling out Ponzi schemes. Lastly, we assume that initially there is no outstanding debt, $d_0 = 0$, and that the economy is in steady state.

We list the full set of equilibrium conditions of the simplified model in Appendix 1.B.1. In what follows, we focus on the optimality conditions that characterize the market for nontraded goods:

$$p_t^N = \frac{c_t^T}{y_t^N - g_t^N} \tag{1.27}$$

$$p_t^N = w_t \ . \tag{1.28}$$

Recall that p_t^N is the (relative) price of nontraded goods. Given our preference structure, it

[5] To see this formally, note that $\lambda = 1/c_t^T$ replaces condition (1.7): marginal utility of traded consumption goods does not depend on c_t^N. Note that this preference structure enhances the tractability of the model, but is not linear homogenous and therefore not nested by the specification in Section 1.2.

is inversely linked to the real exchange rate: $RER_t = 1/p_t^N$. Whenever the exchange rate increases, that is, whenever it depreciates, p_t^N declines and vice versa.

The first equation, (1.27), represents the demand for nontraded goods. It is "downward sloping" in nontraded output: $y_t^N = c_t^N + g_t^N$. The second equation, (1.28), represents the supply of nontraded goods. It is "horizontal", that is, independent of nontraded output, because in the simplified model marginal costs are constant. Combining both equations results in the equilibrium condition

$$w_t = \frac{c_t^T}{y_t^N - g_t^N} \ . \tag{1.29}$$

In the following, we state a number of propositions to present our main results. All propositions refer to the simplified model. To ease the exposition, we do not provide formal expressions and relegate the proofs to Appendix 1.B. To make our points as transparent as possible, we also focus on permanent shocks in this section. Given our assumptions, the simplified model features degenerate dynamics: in response to the permanent government spending shock, the economy immediately jumps to the new equilibrium and there are no further adjustment dynamics. In Section 1.4 below, we solve the full model numerically and study richer adjustment dynamics in response to non-permanent shocks.

1.3.2 Asymmetric effects of spending shocks

We consider, in turn, the effect of a negative and a positive government spending shock, both for an exchange-rate peg and for floating exchange rates. Importantly, in this subsection, we maintain the assumption that, prior to the shock, the economy resides in the full-employment steady state. We relax this assumption in the next subsection.

Consider first a permanent negative government spending shock taking place at time 0. Specifically, assume the following process for government spending:

$$g_t^N = \begin{cases} g & \text{if } t < 0 \\ 0 < \underline{g} < g & \text{if } t \geq 0 \ . \end{cases} \tag{1.30}$$

For this scenario we obtain our first result.

Proposition 1.1. *Under a float, a negative government spending shock brings about real exchange rate depreciation, the level of nontraded output is fully stabilized, and full* *employment is maintained. In contrast, under a peg, the real exchange rate does not depreciate, 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, decreases real marginal costs and therefore the relative price of nontraded goods. As a consequence, the demand for labor and nontraded output are stabilized. In contrast, under a peg real wages and therefore the relative price of nontraded goods cannot adjust. Nontraded output falls one-for-one with the decrease of government spending.

We compare this outcome to what happens in response to a positive spending shock. Specifically, we now assume:

$$g_t^N = \begin{cases} g & \text{if } t < 0 \\ g < \bar{g} < 1 & \text{if } t \geq 0. \end{cases} \tag{1.31}$$

For this scenario, we obtain our second result.

Proposition 1.2. *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 we assume full employment to begin with, raising government spending cannot induce a further increase of employment and output of nontraded goods. 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, they bring about the same extent of real appreciation under the peg and the float.

Comparing Proposition 1.1 and Proposition 1.2, we see directly 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 does not depreciate in response to a negative shock. Output, instead, does not respond to a positive shock, but declines in response to a negative shock. For 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.

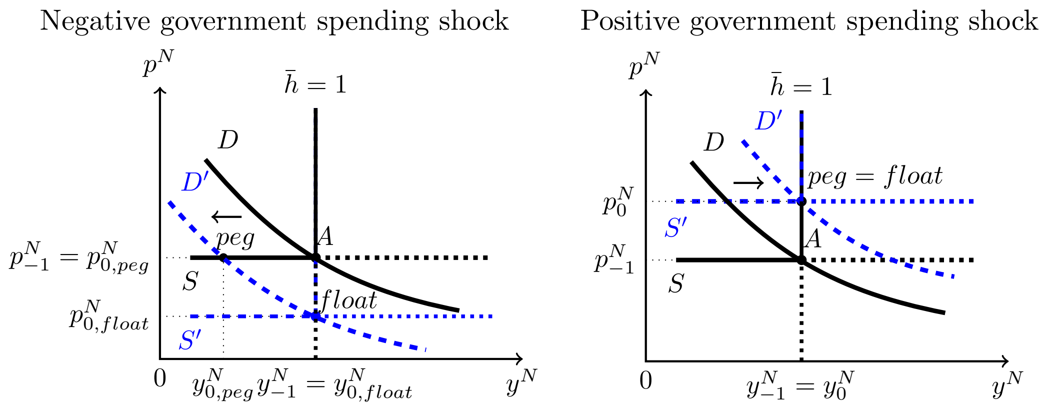


Figure 1.2: The effect of permanent government spending shocks starting from full employment. The horizontal axis measures the level of production of nontraded output. The vertical axis measures the price of nontraded goods (the inverse of the real exchange rate). The downward-sloping curves represent 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').

Proposition 1.3. *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 1.2 illustrates our results graphically. Both panels focus on the market for nontraded goods. In the left panel, we show the effect of a negative government spending shock; 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 (1.28) and the downward-sloping demand curve (1.27). 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, output of nontraded goods cannot be raised any further. It may decline, though, and this, in turn, depends on how the price of nontraded goods (or, equivalently, the real exchange rate) responds to the shock.

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 the relative price cannot fall. 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.

Note that the simplified model features degenerate dynamics: in response to a surprise permanent change in government spending, the economy immediately jumps to the new equilibrium and stays there. In case of a peg, the new equilibrium after a negative spending shock is characterized by permanently lower production and the presence of involuntary unemployment, with no tendency to return to full employment. The economy never recovers in this version of the model, because wages are downwardly perfectly rigid ($\gamma = 1$). Under a peg, this implies that the price of nontraded goods (or, equivalently, the real exchange rate) cannot adjust over time. In case of a float, the new equilibrium after a permanent negative shock is characterized by full employment and a permanently depreciated real exchange rate, driven by the depreciated nominal exchange rate.

Consider now the positive government spending shock, displayed in the right panel of Figure 1.2. 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 above, the increase in the price of nontraded goods is purely due to an increase in nominal wages, both under peg and float. For both exchange rate regimes, private consumption of nontraded goods is completely crowded out. The new equilibrium features unchanged levels of production of nontraded goods and employment, while the relative price of nontraded goods is higher (real appreciation). Put differently, the fiscal multiplier on nontraded output and employment is zero.

Comparing the adjustment across the both panels of Figure 1.2 we stress that adjustment under the float is symmetric, but asymmetric under the peg. We also compute impulse response functions for the simple model in order to illustrate the adjustment dynamics. Figure B.1 in the appendix shows the results.

Last, we briefly refer to Figure 1.2 in order to highlight a specific feature of the model in the adjustment to positive government spending shocks that are non-permanent. Consider once more the right panel of the figure. In response to such a shock the economy first settles at point “peg”, just like in the case of a permanent shock. Importantly, in this point nominal wages are higher than in the initial equilibrium A. Now assume that after a while the demand curve shifts back to S because the level of government spending is reduced to its initial level. In this case, because nominal wages cannot fall, the supply curve cannot shift back under the peg and, hence, the economy settles 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 will undergo a recession once the initial fiscal stimulus is turned off. We discuss the case of temporary shocks in more detail in Appendix 1.B.7.

1.3.3 Symmetric effects under a peg in times of slack

The previous results on 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, namely that the effects of spending shocks are symmetric, provided there is sufficient slack in the economy. For this purpose, in order to induce some slack, we first introduce an additional surprise contractionary shock. Specifically, we assume that there is now a permanent drop in the endowment of traded goods, y_t^T, in period 0. The path of y_t^T is perfectly known at time 0 and assumed to follow the process

$$y_t^T = \begin{cases} 1 & \text{if } t < 0 \\ y_0^T < 1 & \text{if } t \geq 0 \ . \end{cases} \tag{1.32}$$

This allows us to establish the following intermediate result.

Lemma. A drop in the endowment reduces consumption demand for traded and nontraded 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 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 situation (as opposed to full employment). The next proposition establishes our result formally.

Proposition 1.4. *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 insufficient to restore full employment.*

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

Figure 1.3 illustrates this result graphically. 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 1.2, there is now unemployment in the initial equilibrium represented by point A. As before, a reduction of government spending that shifts the demand curve from D to D' does not alter the relative price of nontraded goods under a peg. However, since the economy is operating below potential, an increase of 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 are moderate in the sense of not causing the capacity constraint to bind. Put differently, the effects of government spending shocks are symmetric in times of slack.[6] Since the price of nontraded goods remains unchanged, private consumption does not change in response to the fiscal shock. The output multiplier is unity in times of slack.

A corollary of proposition 1.4 is that, while the effects of government spending may be symmetric for small shocks in times of slack, the response will still be asymmetric for large enough shocks. If government spending increases shift demand beyond the point where full employment is restored, the additional adjustment will work via prices rather

[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 $\alpha < 1$.

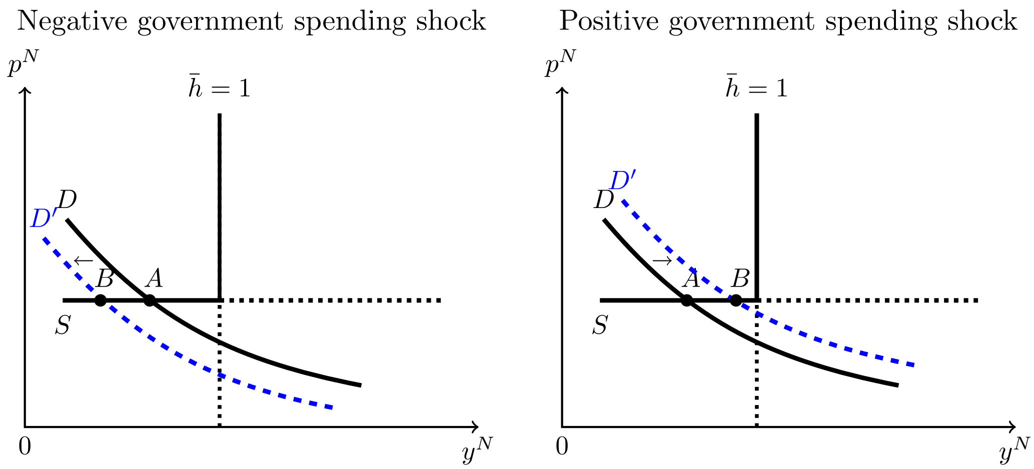


Figure 1.3: The effect of government spending shocks under a peg starting from slack. The horizontal axis measures the level of production of nontraded output. The vertical axis measures the price of nontraded goods (the inverse of the real exchange rate). The downward-sloping curves represent the demand for nontraded goods prior to the shock (D) and after the shock (D'). The kinked line represents the effective supply of nontraded goods.

than quantities, that is, the exchange rate will appreciate. In contrast, the adjustment to spending cuts will always be through output and employment and not via prices. We also compute the impulse responses to government spending shocks in times of slack and show the results in Figure B.2 in the appendix.

1.4 Quantitative analysis

We now solve the full model, as outlined in Section 1.2 above. Once we relax the simplifying assumptions made in Section 1.3, the model features richer adjustment dynamics. The downside is that we are no longer able to solve the model in closed form. Instead, we resort to numerical simulations which allow us to assess to what extent the asymmetry established in the previous section is quantitatively relevant.

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 Schmitt-Grohé and Uribe (2016) 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).

1.4.1 Model calibration and solution

Table 1.1 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 Schmitt-Grohé and Uribe (2016), 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 Schmitt-Grohé and Uribe (2016) 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 Schmitt-Grohé and Uribe (2016), 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 Schmitt-Grohé and Uribe (2016) 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`).

Table 1.1: 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

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 Schmitt-Grohé and Uribe (2016).

In order to solve the model, we largely follow Schmitt-Grohé and Uribe (2016). 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. Appendix 1.C.1 provides details on the discretization of the state space while Appendix 1.C.2 reports the unconditional moments of the model.

1.4.2 Model impulse responses

Figure 1.4 displays the model impulse responses to a government spending shock. Here we show generalized impulse response functions (GIRFs) in order to account for nonlinear adjustment dynamics in the model: for a given initial point in the state space, we compare how variables evolve over time in response to a shock relative to what happens in a baseline scenario where the shock does not occur. We then average over one million replications to integrate out the effect of future shocks. We consider both positive and negative shocks equal to ± 2.2 percentage points of steady state nontraded output. This corresponds to a one-standard-deviation shock. In the figure, the solid lines represent the dynamics due to 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 assuming flexible exchange rates. Recall that in this case the exchange rate is used to stabilize output at the full-employment level. 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-most column, instead, we consider an exchange rate peg with economic slack, captured by simulations with an average unemployment rate of 14%.[7] We also compute impulse responses for an intermediate exchange rate regime and find, perhaps unsurprisingly, that they are in between those obtained for the peg and the pure float (see Figure C.5 in the appendix).

The panels in the top row of Figure 1.4 show the dynamics of government spending. Since government spending is determined exogenously, the dynamics are the same across all columns. The second and third row show the adjustment of nontraded output, y^N, and the

[7]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 in order to minimize nonlinear interaction effects of 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.

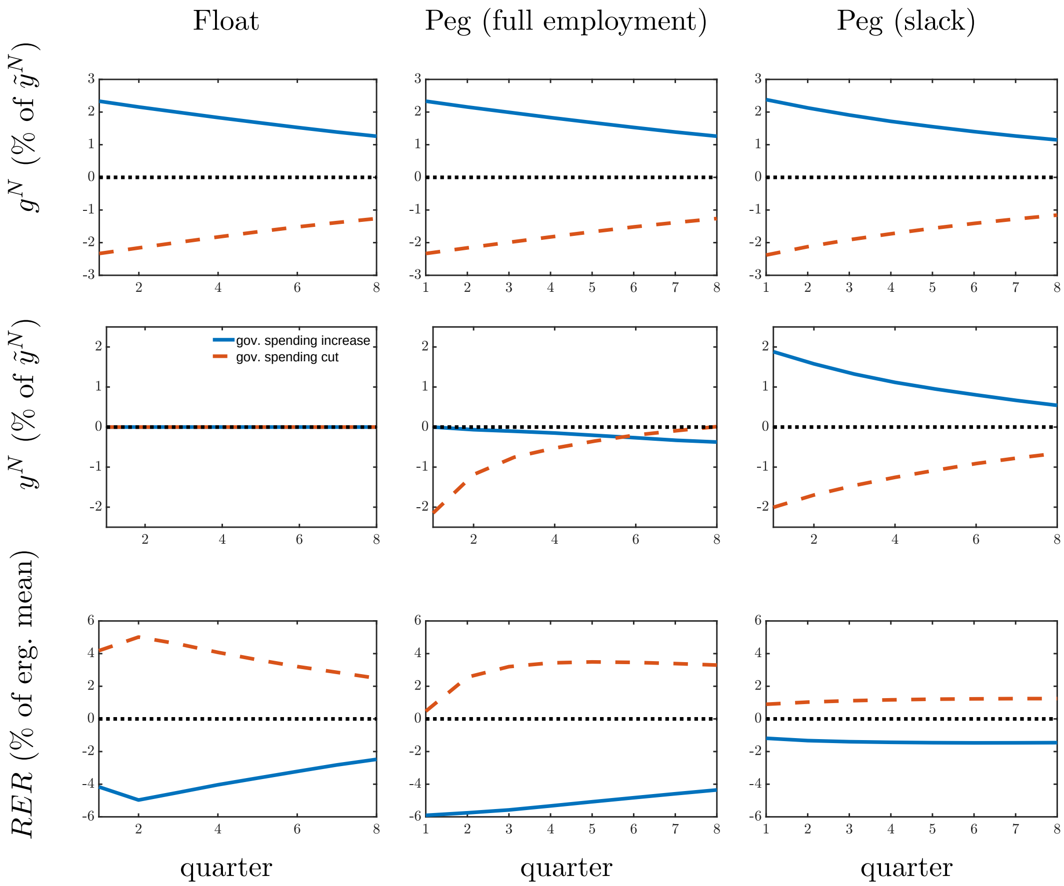


Figure 1.4: Generalized impulse responses to one-standard-deviation government spending shocks. Solid line: spending increase, dashed line: spending cut. Left column: flexible exchange rate. Middle: exchange rate peg and full employment, right: peg and economic slack. Top panels: government spending, middle: nontraded output, bottom: real exchange rate. Horizontal axis measures time in quarters, 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.

real exchange rate, RER, respectively.[8] Notice that, as before, a decline of RER represents

[8]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.

a real appreciation.

Overall, we find that the qualitative results established in Section 1.3 above turn out to be quantitatively important. A number of points are particularly noteworthy. First, as established in Proposition 1.1, a cut of 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 column), the real exchange rate response is much weaker. Now, and in contrast to Section 1.3, 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. As a consequence, nontraded output declines strongly and persistently in response to the spending cut.

Second, turning to positive spending shocks (solid lines), we obtain dynamics in line with Proposition 1.2. 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 in Section 1.3 above. However, as we simulate the full model, we now observe richer adjustment dynamics. While initially unaffected, output declines somewhat over time under the peg because the shock process is mean-reverting rather than permanent. As government spending gradually returns to its pre-shock level, real wages and the real exchange rate are required to decline in order to maintain full employment. This is what happens under the float (left column). Yet it happens more slowly under the peg (middle panel) because of the downward nominal wage rigidity.[9] Hence, 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.

Third, we find that the real exchange rate response is symmetric under a float, as established in Proposition 1.3. It is asymmetric under a peg with full employment. Positive shocks appreciate the real exchange rate, whereas negative spending shocks do 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 that to spending increases. Just like for 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 1.4 above. 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

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

exchange rate actually moves, 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.

1.5 Empirical evidence

In this section, we provide new evidence on how government spending impacts the real exchange rate. A number of earlier studies have explored the issue and reported different, partly conflicting results regarding the sign of the response (e.g. Kim and Roubini, 2008; Monacelli and Perotti, 2010; Corsetti et al., 2012a; Ravn et al., 2012; Ilzetzki et al., 2013). In what follows we take a fresh look: informed by the model-based analysis above, we ask whether spending increases and cuts impact the real exchange rate symmetrically or not.

Our analysis builds on Born et al. (2019), both in terms of data and in terms of identification. Our sample covers observations for 38 emerging and advanced economies. We consider two identification schemes going back to Blanchard and Perotti (2002) and Ramey (2011b), respectively (see also Ramey and Zubairy (2018) for a recent discussion). In both instances, the idea is to measure the surprise component of government spending, in the first case on the basis of an estimated vector autoregressive (VAR) model, in the second case on the basis of professional forecasts. In terms of identification, we assume that both fiscal surprise measures do not reflect an endogenous response of fiscal policy to other innovations in the economy. As a result, we may interpret them as shocks. We establish their effect on government spending, output, and the real exchange rate by means of local projections à la Jordà (2005).

1.5.1 Empirical specification

We briefly outline our empirical specification. It establishes the effect of government spending on the exchange rate on the basis of fiscal shocks, $\varepsilon^{g}_{i,t}$, computed in a first step. Here, indices i and t refer to country i and period t, respectively. We provide more details below.

In a second step, we estimate local projections, which are particularly suited to account for potentially asymmetric effects of positive and negative shocks. Specifically, we sort fiscal shocks according to their sign and define $\varepsilon^{g+}_{i,t} = \varepsilon^{g}_{i,t}$ if $\varepsilon^{g}_{i,t} \geq 0$ and 0 otherwise, and analogously for negative shocks, $\varepsilon^{g-}_{i,t}$ (see Kilian and Vigfusson, 2011, for this approach). 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:

$$x_{i,t+h} = \alpha_{i,h} + \eta_{t,h} + \psi_h^+ \varepsilon_{i,t}^{g+} + \psi_h^- \varepsilon_{i,t}^{g-} + \gamma Z_{i,t} + u_{i,t+h} \ . \tag{1.33}$$

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 zero mean and strictly positive variance. $\alpha_{i,h}$ and $\eta_{t,h}$ denote country and time fixed effects. We compute standard errors that are robust with respect to heteroskedasticity as well as serial and cross-sectional correlation (Driscoll and Kraay, 1998).

1.5.2 Identification

Our identification strategy is explained in Born et al. (2019) in some detail. Here we summarize the essential aspects. Importantly, we pursue two alternative strategies to construct fiscal innovations. One strategy has been introduced by Ramey (2011b). 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 realization of government consumption growth and $\mathbb{E}_{t-1}\Delta g_{i,t}$ is the previous period's forecast.

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

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

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 below 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

$\nu_{i,t}$, i.e. $\varepsilon^g_{i,t} = L^{-1}\nu_{i,t}$.[10]

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 obtained on the basis of professional forecasts. It is also implicit in Ramey (2011b), as she considers a measure of fiscal shocks based on professional forecasts. For identification to go through, her (implicit) assumption is that surprise innovations do not represent an endogenous response to other shocks. As discussed by Blanchard and Perotti (2002), the rationale for this assumption is that government spending can be adjusted only subject to decision lags. Also, there is no automatic response, since government consumption does not include transfers or other cyclical items.

1.5.3 Data

Our data set covers 38 countries and contains quarterly observations starting in the early 1990s and ending in 2018. See Table D.2 in the appendix for specific information on the country coverage and Born et al. (2019) for more details on the data set. Our measure of the real exchange rate is the broad real effective exchange rate index compiled by the BIS, complemented by data for Ecuador, El Salvador, and Uruguay based on the data for 38 trading partners compiled by Darvas (2012). Our quarterly measure is the logarithm of the average of the monthly index values. An increase in the index indicates a depreciation of the economy's currency against a broad basket of currencies. We proxy nontraded output by real GDP. Our measures of real GDP and government consumption are based on national accounts data. The vector of controls in the local projection (1.33) features four lags of log real government consumption, log real output, log real effective exchange rate, and the sovereign default premium to control for fiscal stress. The sovereign default premium measures the spread between foreign currency debt and the risk-free rate and is the end-of-quarter value. We allow for country-specific linear time trends in output and government spending. When conditioning on inflation and labor market slack, we use year-on-year GDP deflator inflation and unemployment as a percentage of the active

[10] The estimated shocks $\hat{\varepsilon}^g_{i,t}$ in this specification are generated regressors in the second stage. 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.

Table 1.2: Forecast errors of government consumption growth: descriptive statistics

	Prof. Forecasts	VAR
Countries	23	38
Observations	1696	2944
Mean	-0.016	0.000
$RMSE$	0.616	1.954
Wald F-statistic	4.9	849.2

Notes: Forecast errors 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.

population from the EU-LFS main indicators, respectively.

Professional forecasts are due to *Oxford Economics* and available for a subset of countries only. Instead, we are able to compute the VAR-based forecast error for all 38 countries. Table 1.2 provides a number of basic summary statistics regarding the forecast errors. Over the full sample, the average forecast errors are close to zero, by construction in the case of the VAR-based measure. On an individual country basis, *Oxford Economics* produces forecasts with a relatively low root mean squared error (RMSE). The VAR forecasts exhibit a somewhat larger RMSE, but note that in this case the sample is more challenging.

In the last row of Table 1.2, 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 (2011b) and Ramey and Zubairy (2018).[11] We find that the shock measure based on the forecasts of *Oxford Economics* do not pass the rule-of-thumb threshold of 10 proposed by Staiger and Stock (1997), while the VAR-based measure does with flying colors.[12]

[11]Technically, given our panel structure with potentially non i.i.d. errors, we follow the suggestion in Baum et al. (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 government consumption growth variable on the respective shock measure. Computing "naive" F-statistics in our pooled sample yields very similar values.

[12]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. The results for the measure based on professional forecasts are more favorable once we assess its predictive power for government spending as reported by *Oxford Economics* in real time, which is the relevant measure for the

1.5.4 Results

We now report our results for both shock measures. Consider Figure 1.5 first. It shows the results based on the VAR forecast error. The left column displays the impulse responses to a negative government spending shock, the right column displays the responses to a positive shock. Throughout, solid lines represent the point estimate, while the dark (and light) shaded areas indicate 68 (and 90) percent confidence intervals. 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 level. The response of government spending, shown in the top row, is fairly persistent in both cases, albeit more so in case of a hike (right column). We show the response of output in the middle row and observe that it is fairly symmetric. Not only is the initial response comparable in absolute value, the ensuing adjustment pattern is also quite similar. The strongest output effect obtains between 1 and 1.5 years after impact. Afterwards, output starts to converge back to its pre-shock level. From a quantitative point of view, the output response suggests a multiplier effect which is in line with earlier studies as surveyed, for instance, by Ramey (2011a). Assuming that government consumption accounts for about 15 percent of GDP on average, our finding that a change in government spending by one percent changes output by about 0.1 percent on impact, and by about 0.2 after approximately 1 to 2 years, implies a multiplier effect of about 0.67 and 1.33, respectively.[13]

Last, we turn to the response of the real exchange rate, shown in the bottom row of Figure 1.5. We find that a cut of government spending depreciates the real exchange rate—i.e. the price of foreign consumption in terms of domestic consumption goes up. In contrast, a spending increase appreciates it—i.e. the price of foreign consumption declines. The adjustment pattern is not fully symmetric. In particular, the exchange rate responds more strongly in the short run if spending is cut and more strongly in the medium run if government spending is raised. By and large, however, we fail to detect a strong asymmetry in the exchange rate response, and even less so for output. This result conforms well with the predictions of the model to the extent that there are many countries in our sample operating a flexible exchange rate regime—see Section 1.3 above.

Our result is also robust across shock measures. This becomes clear as we turn to

financial markets' assessment of current conditions, see Born et al. (2019). In the present paper, we focus on actual government spending as reported in the NIPA, in line with the model analysis performed above.

[13] Note that this ex-post conversion is meant as a rule-of-thumb conversion. See Ramey and Zubairy (2018) on the intricacies of computing output multipliers.

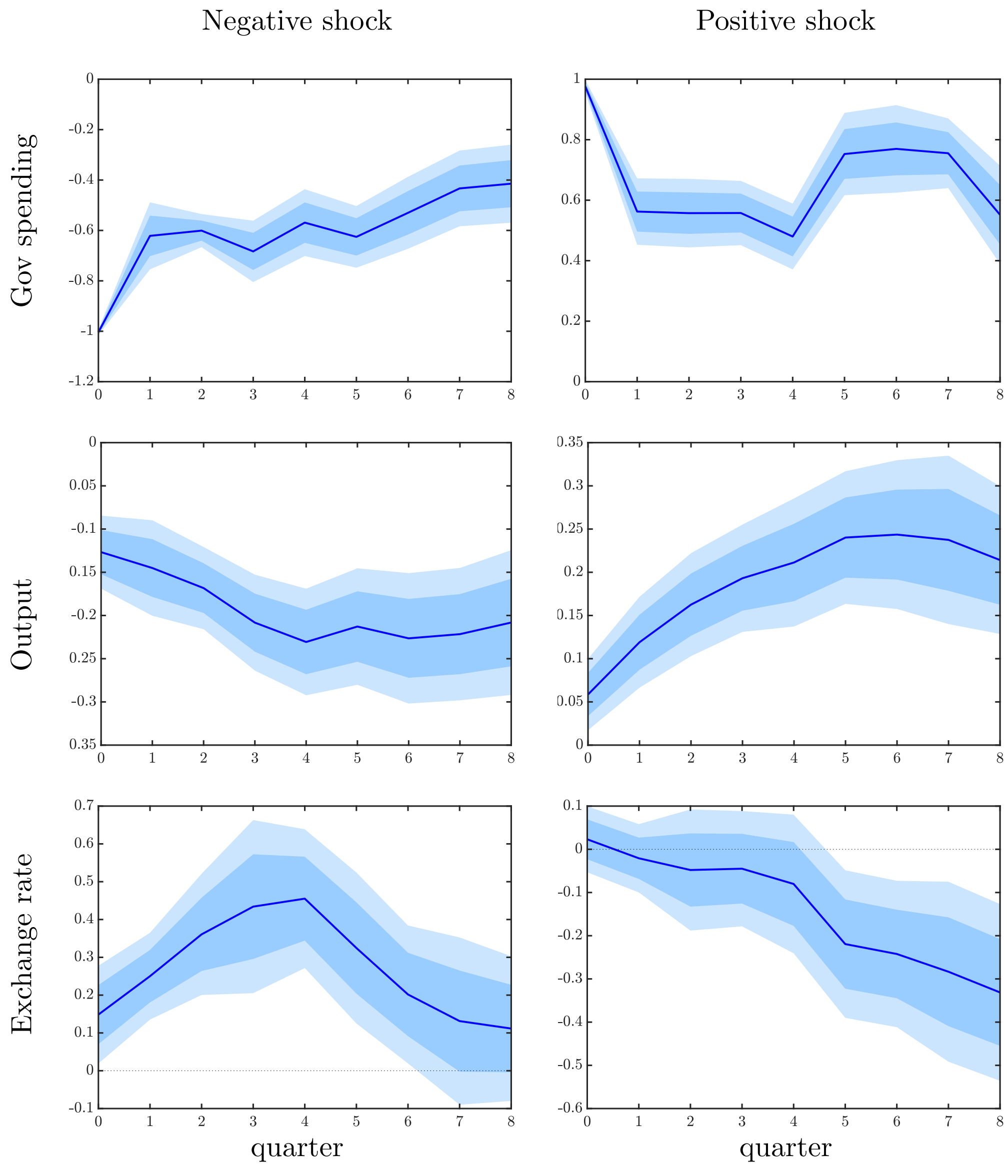


Figure 1.5: Adjustment to government spending shock. Identification based on VAR forecast error. Solid lines represent point estimates, light (dark) shaded areas represent 90 (68) percent confidence intervals. Horizontal axis measures time in quarters. Vertical axis measures deviation from pre-shock level in percent.

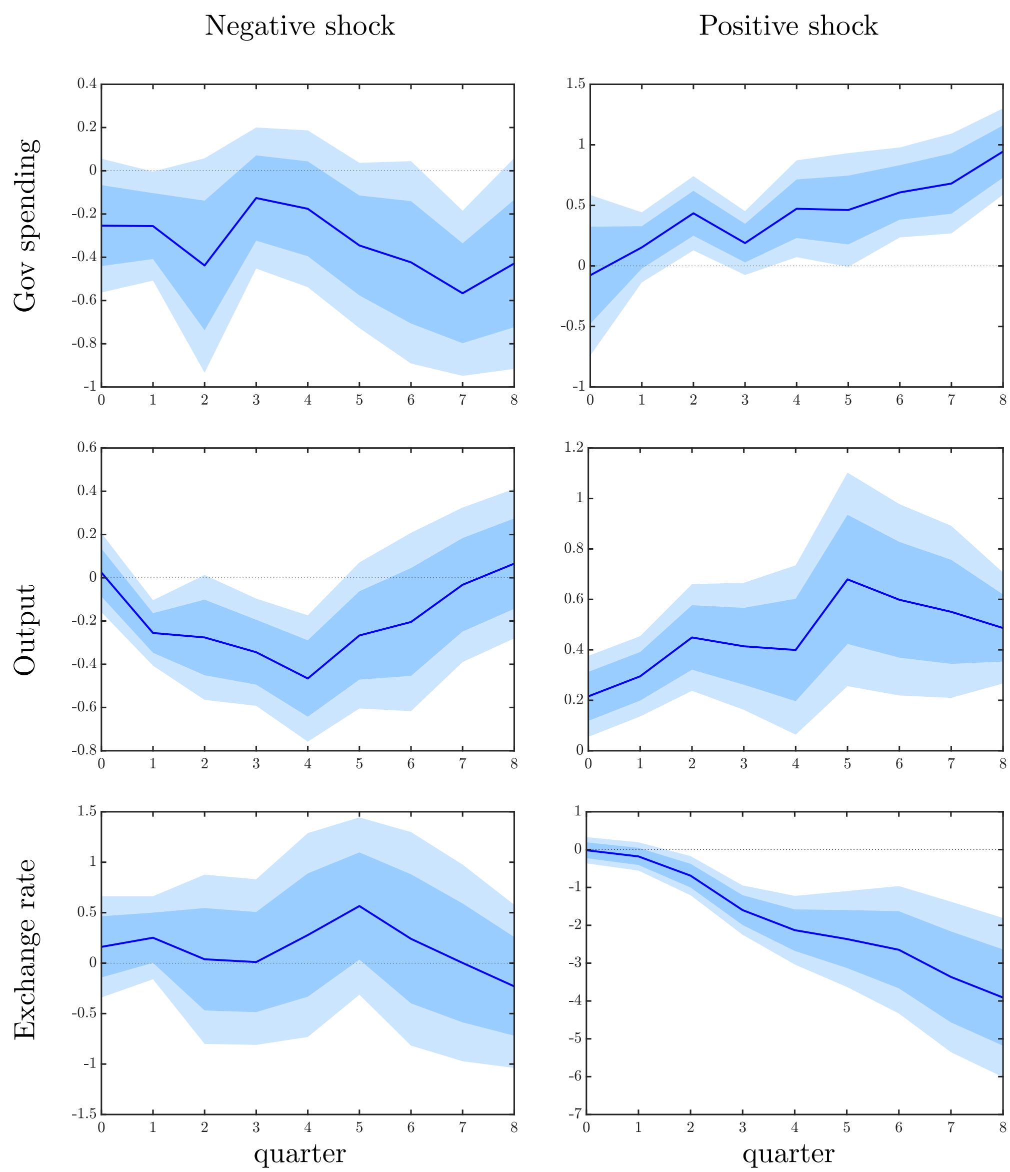


Figure 1.6: Adjustment to government spending shock. Identification based on forecast error of professional forecasters. Solid lines represent point estimates, light (dark) shaded areas represent 90 (68) percent confidence intervals. Horizontal axis measures time in quarters. Vertical axis measures deviation from pre-shock level in percent.

Figure 1.6, which shows results for fiscal shocks computed on the basis of forecast errors of professional (rather than VAR) forecasts. Note that in this case our sample is quite a bit smaller because we lack professional forecasts for a number of countries—see again Table D.2. And yet, even though the sample differs considerably, we find that the results shown in Figure 1.6 are comparable to those shown in Figure 1.5 above.

We again report the response of actual government spending in the top row, both to negative spending shocks (left column) and to positive spending shocks (right column). A noteworthy difference vis-à-vis the results shown in Figure 1.5 is that the response of government spending is quite a bit weaker—in general and on impact in particular. This reflects the fact that here we compute forecast errors on the basis of real-time forecasts and hence their effect on actually realized government spending is limited. This is also reflected in the F-statistic reported in the last row of Table 1.2 above.

And yet, the responses of output and the real exchange rate shown in Figure 1.6 are fairly similar to those shown in Figure 1.5 above. In particular, in Figure 1.6 we again observe a fairly symmetric output response and a pattern of the exchange rate adjustment that resembles the one shown in Figure 1.5 rather closely. We note, however, that the depreciation of the exchange rate in response to the spending cut is no longer significant—as our model-based analysis predicts for countries with a fixed exchange rate regime.

The central prediction of the model put forward in Section 1.3 above is that whether or not government spending shocks impact the real exchange rate asymmetrically depends on the exchange rate regime. There should be no asymmetric effects in case the exchange rate floats freely, but significant asymmetries under an exchange-rate peg. To explore this aspect further, we focus on the countries in the euro area.[14] Here the nominal exchange rate is permanently fixed and may not bring about the necessary adjustment of the real exchange rate in response to government spending shocks. Note that we rely only on the VAR-based forecast errors as we turn to the countries in the euro area because for this subsample we find that the forecast errors based on professional forecasts hardly impact actual government spending at all (the Wald F-statistic is 0.528 in this case). As a result, we are unable to obtain reliable estimates for this subsample once we use the shock measure computed on the basis of professional forecasts. The VAR-based shocks remain strong predictors of actual government spending (the Wald F-statistic is 376.14 in this case).

We report the results for the panel composed of the individual countries of the euro

[14] Here 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.2 for the detailed sample coverage.

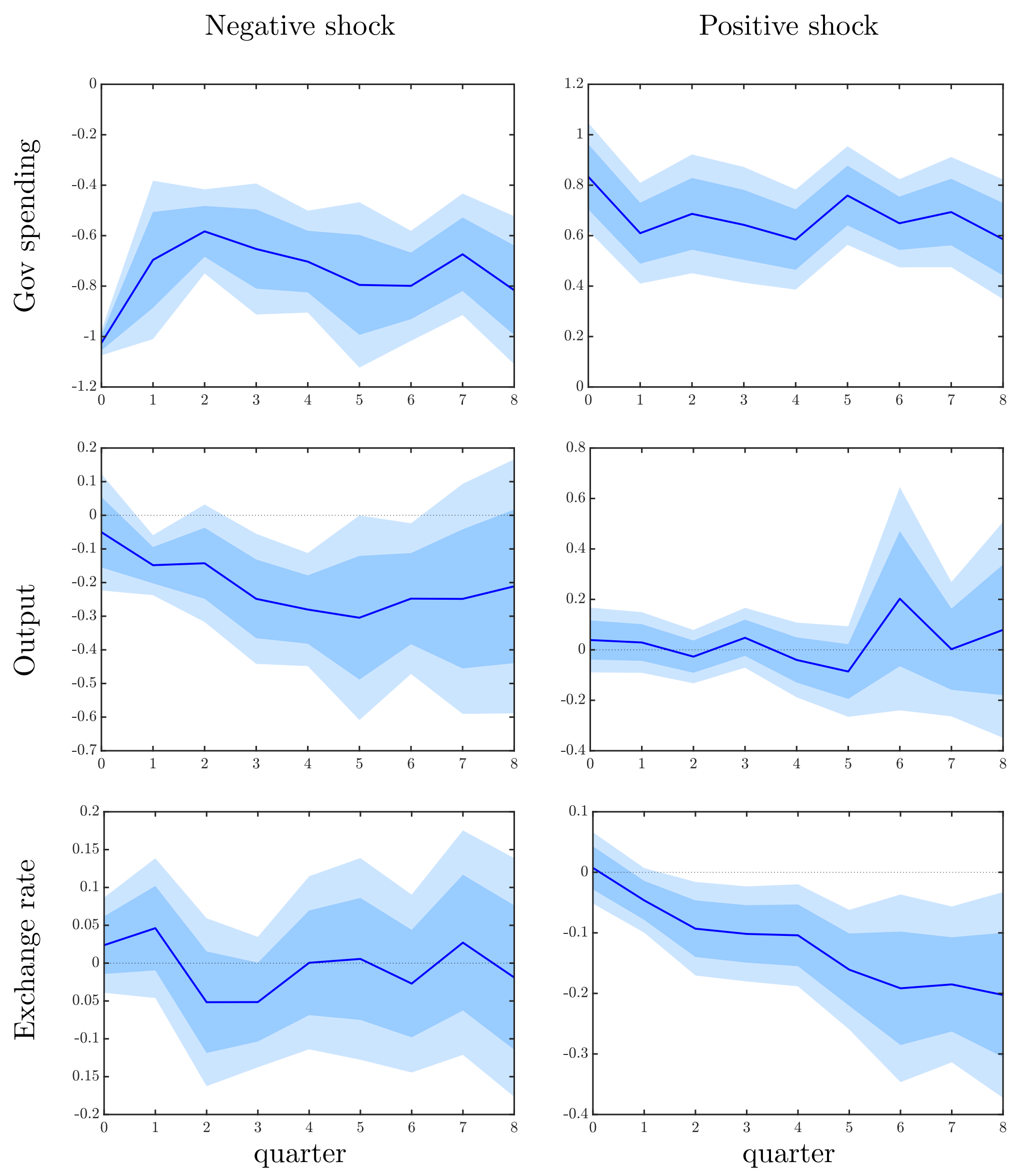


Figure 1.7: Adjustment to government spending shock in individual countries of the euro area. Identification based on VAR forecast error. Solid lines represent point estimates, light (dark) shaded areas represent 90 (68) percent confidence intervals. Horizontal axis measures time in quarters. Vertical axis measures deviation from pre-shock level in percent.

area in Figure 1.7. The figure is organized just like Figures 1.5 and 1.6 above. The fiscal shocks are computed on the basis of an estimated VAR model, as in Figure 1.5. The only difference is the underlying sample, since Figure 1.7 shows the results for euro area countries only. This has a strong bearing on the results.

The response of government spending (shown again in the top row) is fairly symmetric for spending cuts and spending hikes as before. However, we now find the model predictions fully borne out by the evidence: output drops in response to a spending cut, but is virtually unchanged if government spending is raised. Instead, the exchange rate does not respond to a spending cut, but appreciates in response to a spending increase. We stress once more that the asymmetry obtains only once we restrict our sample to countries that operate under fixed exchange rate—just like the model in Section 1.3 above predicts.

In the model, the asymmetric response to government spending shocks under a peg is caused by downward nominal wage rigidity. It prevents real wages to decline in response to a spending cut, but does not prevent them from rising in response to a spending increase. Yet, if inflation is high to begin with, downward nominal wage rigidity should have less of a bearing on the adjustment because in this case wages are adjusting in real terms, even if they are nominally rigid. To assess this implication of the model empirically, we estimate our empirical specification once more on the individual countries of the euro area but focus on high-inflation periods. Specifically, we specify a threshold for year-on-year inflation of 3 percent. In our sample, 25 percent of the observations qualify as high-inflation episodes on the basis of this definition.[15] We repeat our second-stage estimation on the high-inflation observations.

Figure 1.8 shows the results. The organization of the figure mimics again those of the figures above. However, we now show distinct impulse responses for high-inflation episodes (dashed lines) and contrast them with the baseline case for the euro area (solid lines). Here shaded areas indicate 90 percent confidence intervals. Overall we find that the adjustment dynamics are quite similar. However, there are also some differences and they align well with theory. In particular, we find that, in response to a spending cut, the exchange rate tends to depreciate when inflation is high. Put differently, the response of the exchange rate to government spending shocks is again symmetric provided that inflation is high—even if countries operate under a fixed exchange rate regime. Moreover, as the exchange rate depreciates in response to a spending cut, output tends to decline less during high-inflation

[15] This threshold is high enough for Germany to never experience a high-inflation episode.

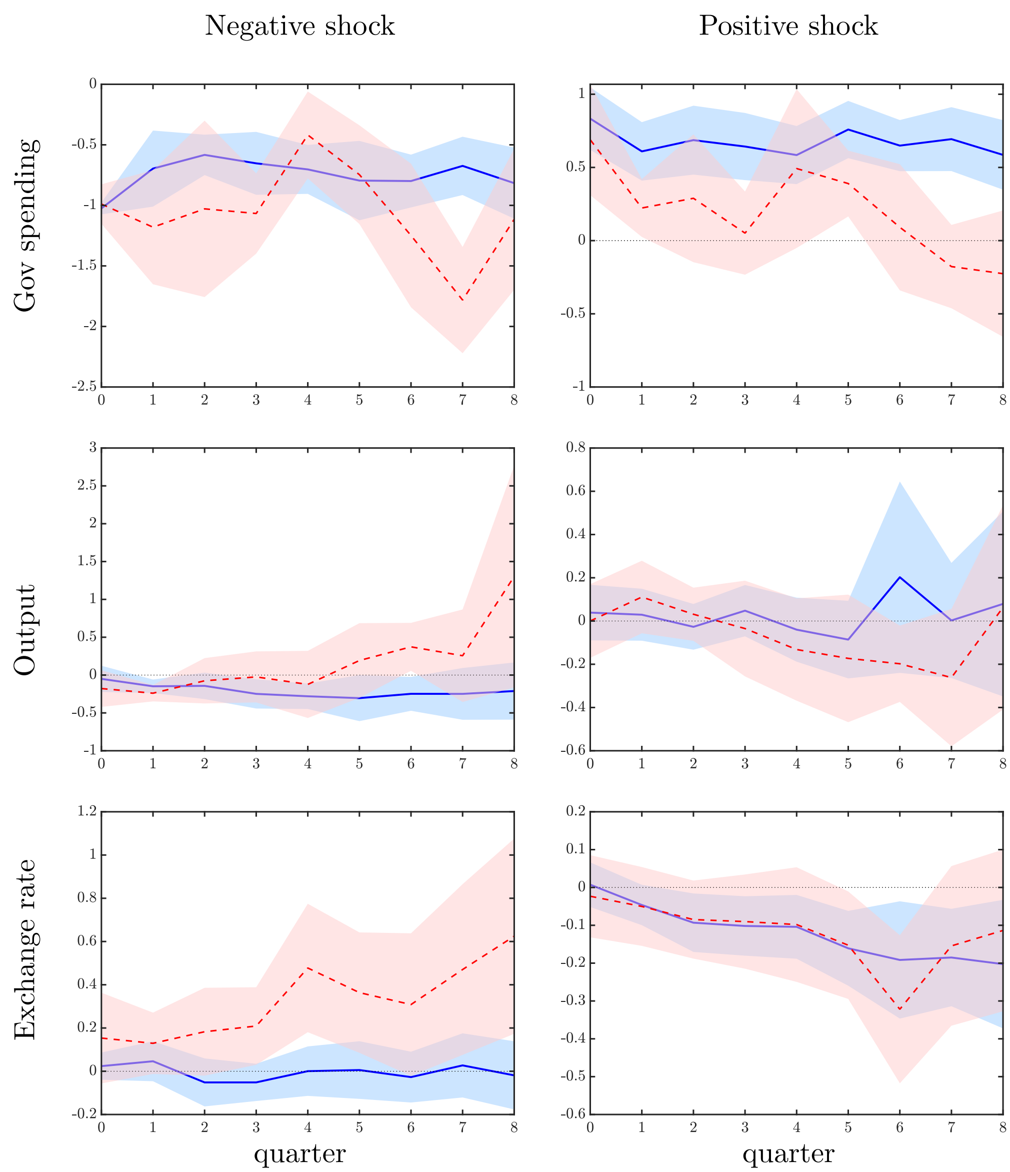


Figure 1.8: Adjustment to government spending shock in individual countries of the euro area when inflation is above 3 percent (dashed lines) and in the baseline euro-area sample (solid lines). Solid and dashed lines represent point estimates, shaded areas represent 90 percent confidence intervals. Horizontal axis measures time in quarters. Vertical axis measures deviation from pre-shock level in percent.

periods compared to the baseline. Whether inflation is high or not, instead, turns out to be largely inconsequential for the adjustment to spending hikes. Once more, these findings lend support to the model predictions derived in Section 1.3 above. For the model predicts that, in response to a positive spending shock, downward nominal wage rigidity is inconsequential. It is only in response to a spending cut that it matters—provided that inflation is sufficiently low.

In a last experiment, we condition the effects of government spending shocks on the extent of economic slack. In earlier empirical work Auerbach and Gorodnichenko (2012, 2013) find that the effects of fiscal policy are stronger in a recession than they are in a boom. Ramey and Zubairy (2018) instead find that multipliers generally do not depend on the extent of slack in the economy. Our model with DNWR provides a refinement for fixed exchange rate regimes. 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 impact output rather than the exchange rate, as opposed to when the economy is operating at full capacity. Put differently, the model predicts that, in times of slack, government spending shocks impact the economy symmetrically, even if there is an exchange rate peg.

We now take up this issue empirically and estimate the model for episodes of economic slack, again only within the euro-area sample. For this purpose we include only observations in our sample for which unemployment is above a country's median unemployment value, as in Barro and Redlick (2011). Figure 1.9 shows the results. Consider first the left column: as predicted by the model, slack (red line) does not alter the response to a spending cut relative to the baseline (blue line). Output contracts and the real exchange rate does not adjust. However, slack does alter the response to a spending hike. Just like the model predicts, output rises in response to a spending increase in times of slack, while the exchange rate response is muted and basically insignificant.

In sum, we find that the empirical evidence on the effects of government spending shocks aligns well with the predictions of the model. This holds for our main result, namely that economies with fixed exchange rates respond asymmetrically to positive and negative shocks. But it also holds for the predictions regarding the specific role of DNWR and economic slack.

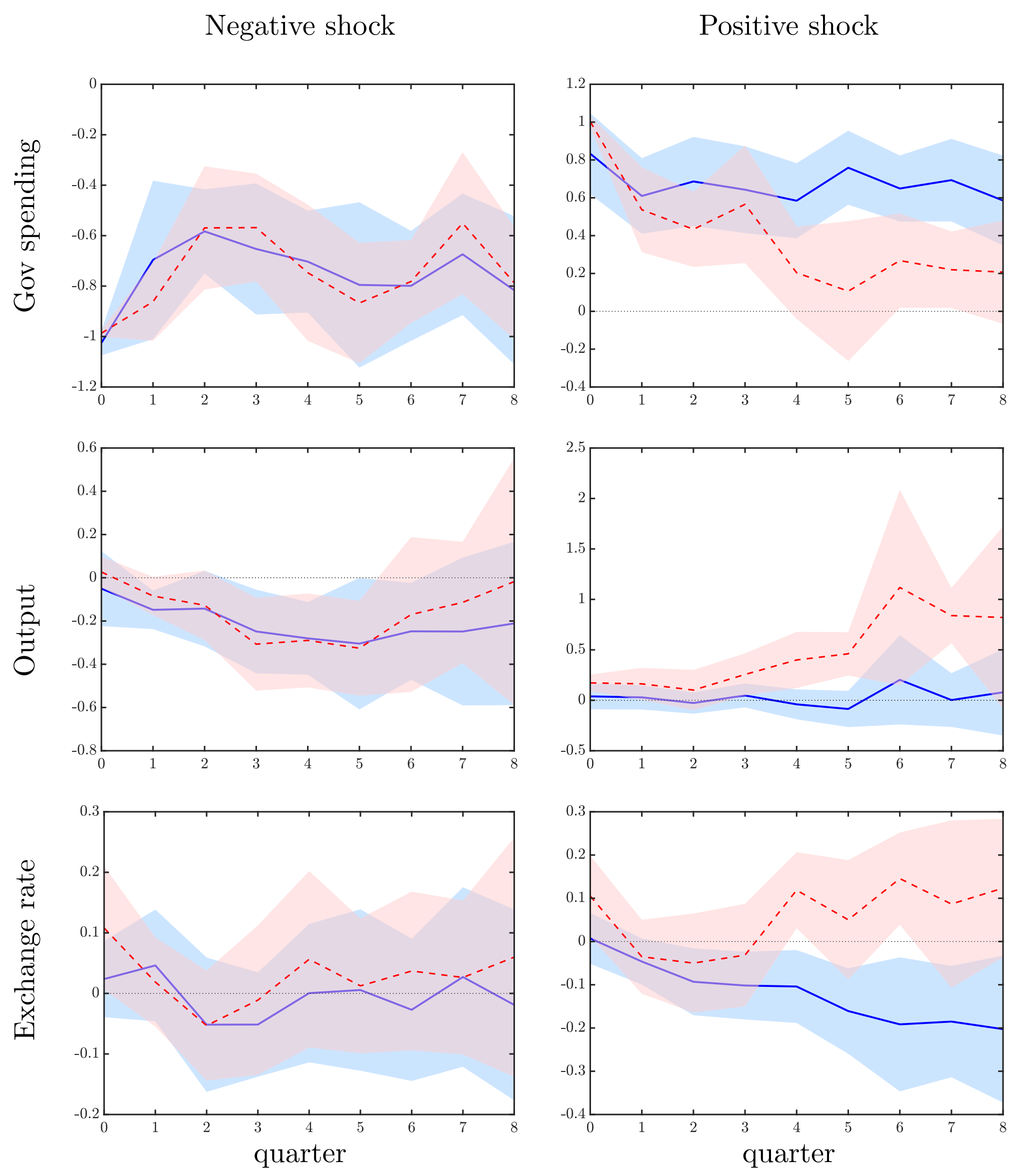


Figure 1.9: Adjustment to government spending shock in individual countries of the euro area in times of slack (dashed lines) and in the baseline euro-area sample (solid lines). Solid and dashed lines represent point estimates, shaded areas represent 90 percent confidence intervals. Horizontal axis measures time in quarters. Vertical axis measures deviation from pre-shock level in percent.

1.6 Conclusion

We show that the adjustment to government spending shocks is asymmetric under fixed exchange rates. Assuming full employment, an increase of government spending appreciates the real exchange rate and does not impact output and employment. A reduction of government spending, instead, lowers output and employment and does not impact the exchange rate very much. We derive these results in a stylized model of a small open economy which features downwardly rigid nominal wages as in Schmitt-Grohé and Uribe (2016). We establish new evidence based on a large panel data set and show that the predictions of the model are borne out in the data along several dimensions: the exchange rate regime, the state of the business cycle, and the level of inflation.

Our result has the potential to reconcile Keynesian and classical views on the role of fiscal stabilization policy in open economies. The Keynesian view holds that fiscal policy impacts economic activity strongly if the nominal exchange rate is fixed. According to the classical view, fiscal policy impacts mostly prices. In light of our analysis, both views appear to be (somewhat) correct—it is just a matter of the sign of the fiscal impulse. In a sense, this is bad news because raising government spending is likely to only appreciate the exchange rate, while austerity is likely to be particularly detrimental to economic activity.

Yet, our analysis also provides a rigorous argument for a strongly countercyclical conduct of fiscal policy under fixed exchange rates. After all, our results suggest that 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 note 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.

Appendix

1.A Full set of equilibrium conditions (baseline model)

Definition 1.5. 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

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

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

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

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

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

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

$$h_t \leq \bar{h} \tag{1.A.7}$$

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

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

1.B Analytical model

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

Given the preferences and the functional forms assumed in Section 1.3, we obtain the following equilibrium conditions:

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

$$y_t^N = h_t = c_t^N + g_t^N \tag{1.B.2}$$

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

$$p_t^N = \frac{c_t^T}{h_t - g_t^N} \tag{1.B.4}$$

$$p_t^N = w_t \tag{1.B.5}$$

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

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

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

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

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

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 $RER_{-1} = 1 - g$.

1.B.2 Proof Proposition 1.1

The Euler equation (1.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 (1.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 (1.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 $t \geq 0$.[16] In period 0, the nontraded goods resource constraint (1.B.2) implies $c_0^N = y_0^N - \underline{g}$, while equations (1.B.4) and (1.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 arrangement.

Peg ($\phi_\epsilon = 0$): Conjecture that the economy is in a situation of unemployment with $h_0 < 1$. In this case, the wage constraint (1.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 (1.30). 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 (1.B.9) as $\epsilon_0 = \max\left\{\frac{1-g}{1-\underline{g}}, 1\right\} = \frac{1-g}{1-\underline{g}}$. 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 (1.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. $\square$

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

1.B.3 Proof Proposition 1.2

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

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

Peg ($\phi_\epsilon = 0$): With a gross nominal exchange rate devaluation rate equal to $\epsilon_0 = 1$, equation (1.B.11) implies that $1 - g > 1 - \bar{g}$. This is true by assumption (1.31).

Float ($\phi_\epsilon = 1$): Equations (1.B.8) and (1.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 (1.B.4) then follows that the price of nontraded goods increases and therefore the real exchange rate appreciates by the same amount: $p^N_{0,peg} = p^N_{0,float} = \frac{1}{1-\bar{g}} > \frac{1}{1-g} = p^N_{-1}$. □

1.B.4 Proof Proposition 1.3

For a negative and a positive shock of the same magnitude, we have $\bar{g} - g = g - \underline{g}$. From equation (1.B.6) and propositions 1.1 and 1.2 then follows that in response to a negative shock

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

while for a positive shock

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

□

1.B.5 Proof Lemma 1.3.3

The resource constraint in (1.B.1) becomes

$$c_t^T = y_t^T - d_t + \frac{d_{t+1}}{1+r}. \tag{1.B.14}$$

We can solve the nontraded goods block by backward induction. The Euler equation (1.B.3) implies that traded consumption jumps to a new level and stays there, i.e., $c_t^T = c_{t+1}^T$ for all $t \geq 0$. The resource constraint (1.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 it will violate the transversality condition (1.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

$$c_0^T = y_0^T + \frac{d_1}{1+r} = 1 - \frac{r}{1+r} d_1 = c_1^T. \tag{1.B.15}$$

From this follows that the debt choice d_1 is given by

$$d_1 = 1 - y_0^T. \tag{1.B.16}$$

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:

$$c_0^T = 1 - \frac{r}{1+r}(1 - y_0^T). \tag{1.B.17}$$

Given the drop in traded consumption, equation (1.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 (1.B.5) as $p_0^N = w_0 = w_{-1}$. As a consequence, the traded goods endowment shock causes the economy to contract and unemployment to rise. □

1.B.6 Proof Proposition 1.4

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 (1.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 (1.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

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

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. □

1.B.7 IRFs to permanent shocks

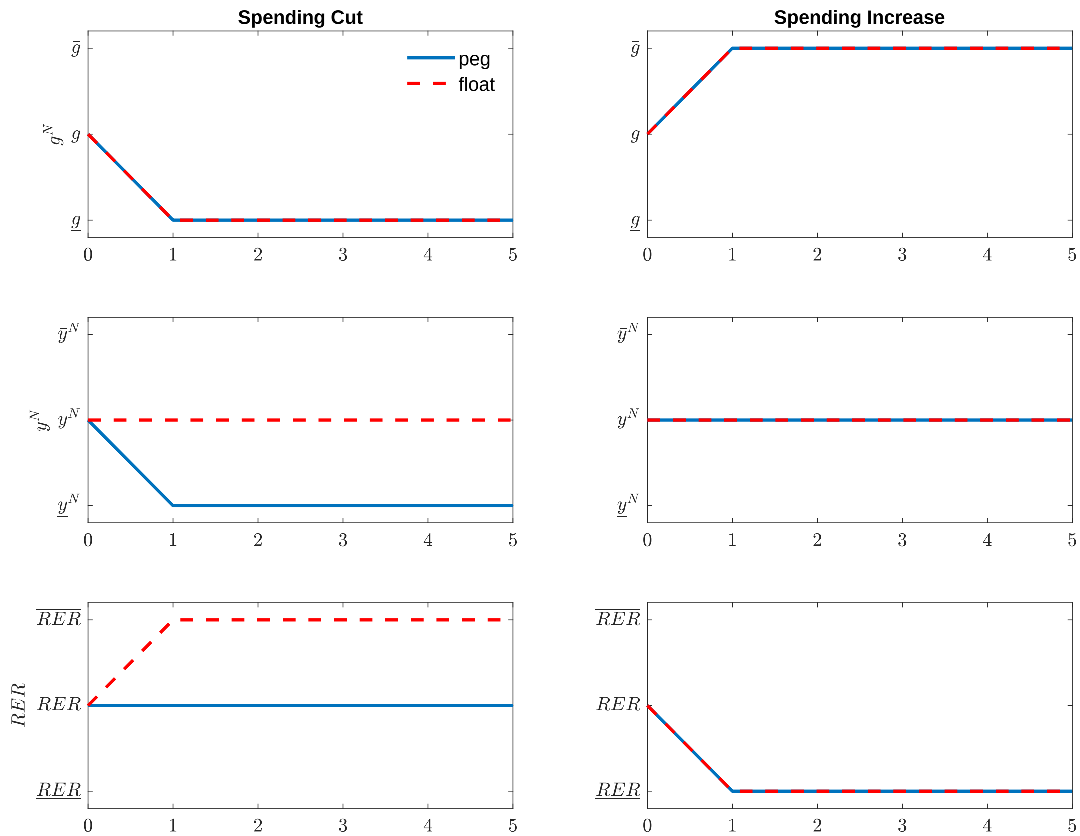
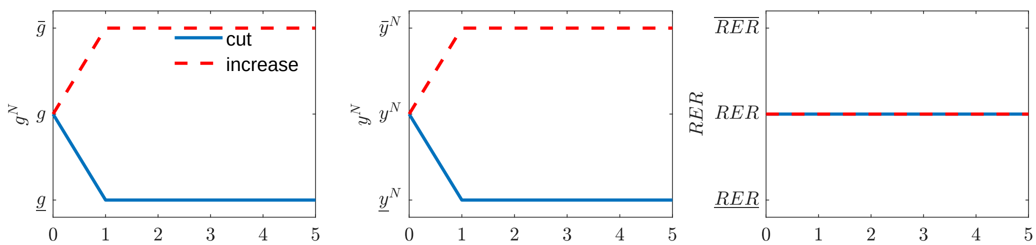
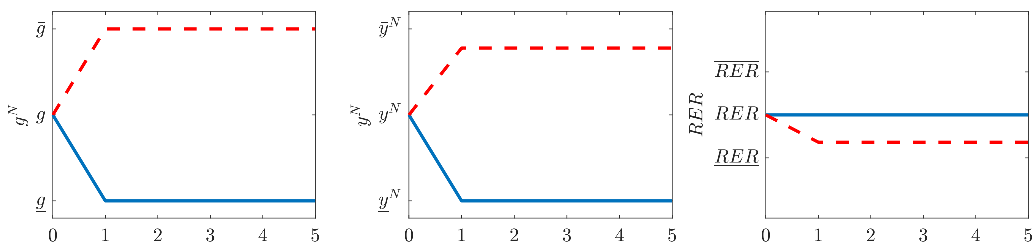


Figure B.1: Impulse responses in the analytical model to a permanent surprise government spending cut (left column) and permanent government spending hike (right column), starting from a full-employment steady state.



(a) Small spending shock



(b) Large spending shock

Figure B.2: Impulse responses in the analytical model to a permanent surprise government spending cut (solid line) and permanent government spending 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.

1.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. As a consequence, 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.

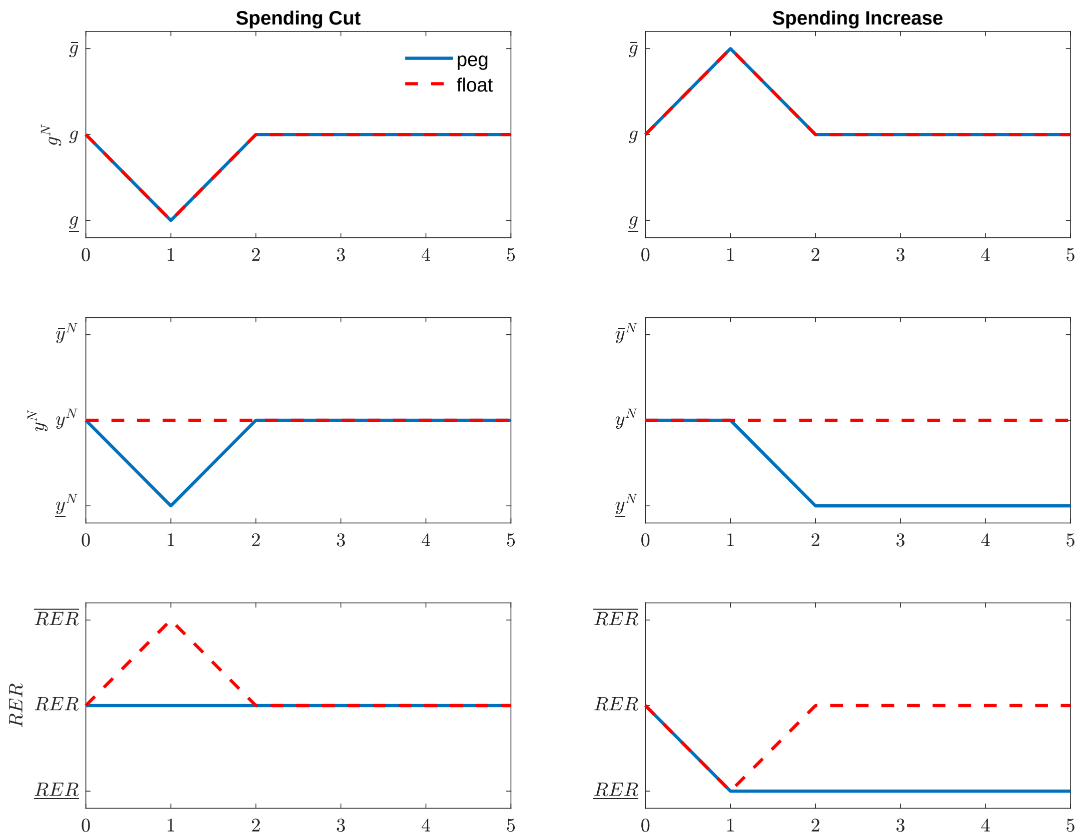


Figure B.3: Impulse responses in the analytical model to a one-period surprise government spending cut (left column) and one-period government spending hike (right column), starting from a full-employment steady state.

1.C Quantitative model

1.C.1 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. 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.

1.C.2 Unconditional moments and debt distribution

Table C.1 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.4, 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.1: First and second moments of indicators of interest in the three policy arrangements

	$Mean(peg)$	$Std(peg)$	$Mean(int)$	$Std(int)$	$Mean(float)$	$Std(float)$
$\bar{h} - h_t$	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.

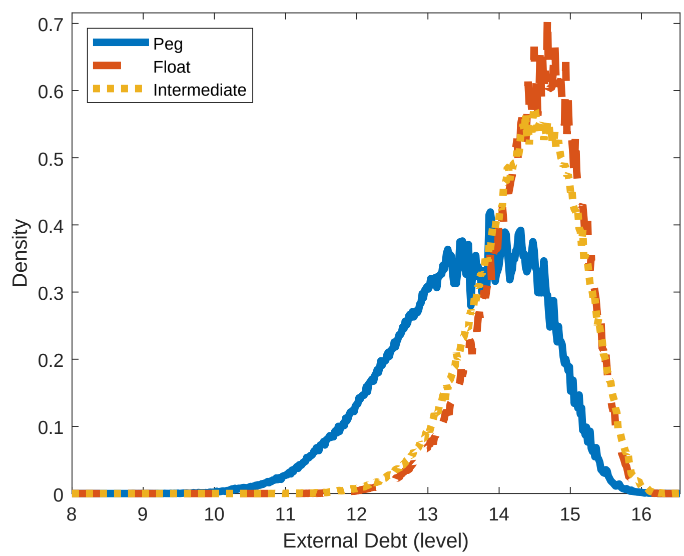


Figure C.4: Distribution of external debt in the three policy arrangements. Statistics are based on a simulation length of 1 million periods and a burn-in of 1000 periods.

1.C.3 GIRFs: Intermediate case

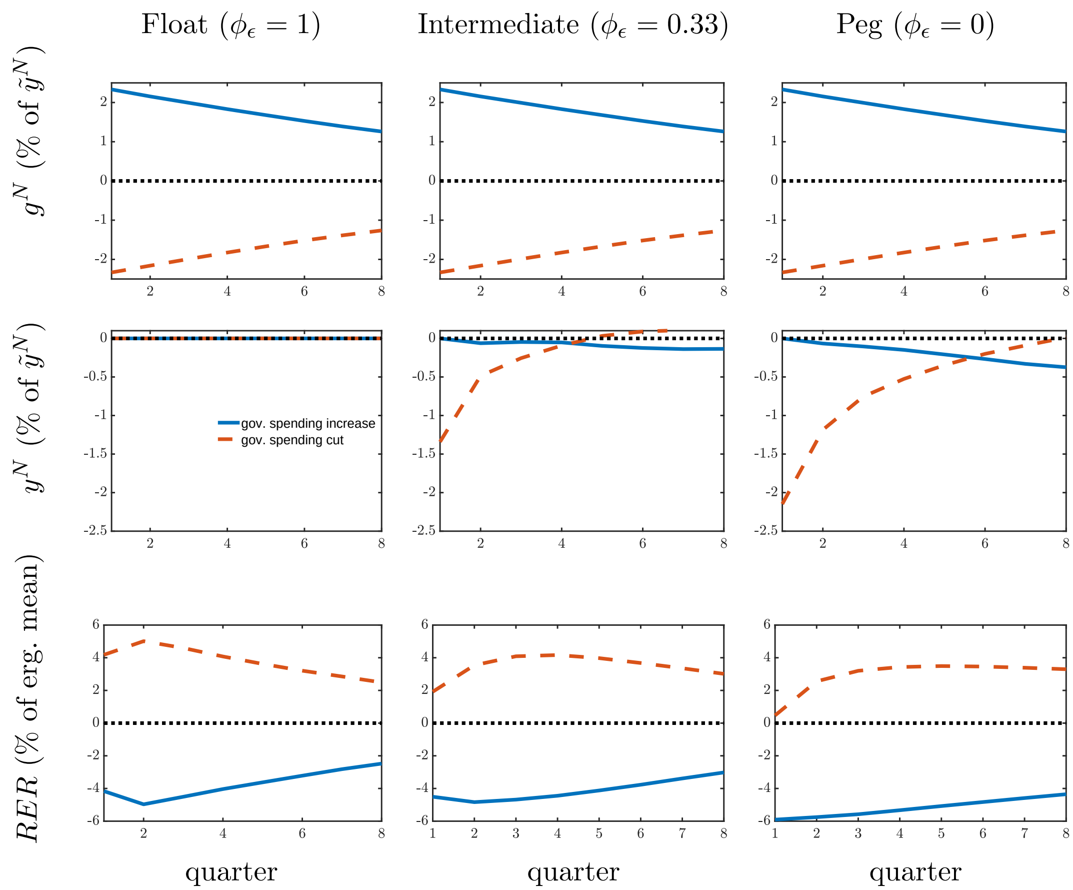


Figure C.5: Generalized impulse responses to positive and negative government spending shocks of 2.2 percentage points of nontraded output. GIRFs start from a situation of moderate debt and full employment at the boundary to the unemployment region (see main text for details). Solid blue line: positive shock; dashed red line: negative shock. Top panels: government spending, middle: nontraded output, bottom: real exchange rate. Horizontal axis measures time in quarters, 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.

1.D Empirical evidence: Sample

Table D.2: Sample ranges

	VAR		Oxford Economics		EMU	
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 in the unconditional model.

Chapter 2

Public and private deleveraging in Greece: 2010-2014

2.1 Introduction

How large are the contributions of public-sector deleveraging (or austerity) and private-sector deleveraging to the output contraction in Greece? This paper assesses the macroeconomic effects of the austerity policies implemented in Greece during the 2010-14 period, a period characterized by substantial cuts in government spending and exceptionally high debt, and the additional impact of a deleveraging shock in the private sector. Following an excessive increase in public sector employment and wages during the early 2000s, all peripheral countries in the euro area experienced a severe contraction due to a combination of downward nominal wage rigidity and fixed exchange rates, which made real wages too high to be compatible with full employment. However, Greece displayed the most dismal performance. It stands out as having the sharpest decline in GDP and government spending in the euro area. Per capita income at the end of 2014 was more than 25 per cent below its 2009 level. Over the same time period, government spending per capita decreased by almost 22 per cent. In this paper, I consider output in the nontraded sector, as this sector is relatively more important in Greece, and the foreign debt-to-GDP ratio, which rose by a staggering amount, as macro indicators of interest, thereby providing a minimal summary of the country's economic performance.

A joint analysis of public and private deleveraging is relevant because they are likely to interact in such a way that adverse dynamics reinforce each other. More precisely, efforts to reduce the level of borrowing in both sectors may raise the level of debt relative to current GDP because of their contractionary effect on economic activity. A joint deleveraging effort is likely to have more adverse effects than just the sum of the effects of each effort in isolation. As documented in the next chapter, both public and private deleveraging are highly correlated with unemployment rates in Europe and may help explain the heterogeneity in unemployment dynamics between core and peripheral countries. Countries which suffered from a strong increase in unemployment also implemented large austerity measures, mostly in the form of spending cuts, and experienced (sizable) private-sector deleveraging in the period after 2009.

From a methodological point of view, I measure austerity as in House et al. (2019), that is, as a shortfall in government spending relative to forecast. The drawback of this approach, which borrows heavily from Blanchard and Leigh (2013), is that in principle austerity may emerge following a huge expansion of the public sector in the years prior to the crisis just because government spending is below a steep trend. Figure 2.1 shows actual government spending and the predicted trend for Greece. The deviation from the forecast after 2010 is considerable, which suggests substantial austerity. The approach adopted here differs from Alesina and coauthors' approach in several dimensions. For instance, Alesina et al. (2015a) and Alesina et al. (2016) analyze multi-year fiscal plans using data since 1978, whereas this paper, following House et al. (2019), focuses on the 2010-14 period, that is, the aftermath of the crisis, and on the actual changes in government spending over the five years. This allows to capture the full effect of any policy that was actually implemented. Importantly, the narrative approach adopted by Alesina and coauthors addresses the endogeneity issue inherent in the identification but it requires judgment in interpreting policy statements. Moreover, I only consider austerity in the form of cuts in government spending and not increases in taxes, as House et al. (2019) find that the former is the most significant fiscal policy for explaining the decline in output in the 2010-14 period. I compare the baseline scenario with the currency peg and the counterfactual scenario without the euro, that is, with fully flexible exchange rates. A similar analysis has been conducted in the first chapter in a stochastic context, with the difference that here I feed actual shocks into the model and, crucially, study the joint effect of public and private deleveraging.

I develop a two-sector small open economy model featuring downward nominal wage rigidity à la Schmitt-Grohé and Uribe (2016). I assume that the government consumes an exogenously determined amount of nontraded goods. In order to finance these purchases, it levies lump-sum taxes so that its budget is balanced at all times. I contrast the case of an exchange-rate peg and the case of flexible exchange rates. More specifically, I consider a float where the exchange rate adjusts in such a way as to offset the nominal rigidity. In this case, output and employment are always stabilized at the efficient level.

Andrés et al. (2016), too, study a small open economy which operates in a currency union and analyze how fiscal consolidation interacts with private-sector deleveraging but they focus on long-term debt. Martin and Philippon (2017) quantify the importance of various factors for the crisis dynamics in the euro area–including private-sector deleveraging and fiscal policy. They rely on a linear semistructural model which combines a basic New Keynesian framework with ad-hoc rules for fiscal policy and private-sector deleveraging. My paper differs from the aforementioned studies and from House et al. (2019) as well, in that I solve the model globally to account for potential nonlinearities in the interaction of public and private deleveraging. Such nonlinearities are shown to be relevant in my quantitatively analysis. Moreover, the only nominal rigidity in my model is downward nominal wage rigidity, whereas in House et al. (2019)'s extended model prices are sticky as well. A model-based analysis by Batini et al. (2015) also illustrates how private and public deleveraging may interact. Specifically, they consider a temporary negative house-price shock that reduces the market value of constrained agents' collateral. Private borrowers respond to the tightening of the borrowing constraint by cutting consumption and investment, thus reducing output and government tax revenues. In the event, the government faces a higher debt-to-GDP ratio, which in turn raises the sovereign risk premium and its financing costs. Other authors have taken up the issue of the interaction from an empirical perspective. Baldacci et al. (2015) study the effects of fiscal consolidations during periods of private deleveraging. Their sample covers 107 countries and 79 episodes of public debt reduction during the period 1980 to 2012. They find that expenditure-based, front-loaded fiscal adjustments reduce growth, whereas gradual fiscal adjustments that rely on a mix of revenue and expenditure measures can support output growth and reduce public debt. Finally, Klein (2017) and Klein and Winkler (2018) focus on the effects of austerity on income inequality depending on the level of private debt.

In the analytical part of the paper, I inspect the transmission mechanism of government spending and deleveraging shocks making some simplifying assumptions. Under a peg, the contraction in the traded sector can be deleterious. Output and employment can fall sharply because of the insufficient downward adjustment of the real wage due to the combination of fixed exchange rate and downward nominal wage rigidity. The optimal devaluation implemented under a float, by contrast, prevents the contraction in the traded sector to spill over into the nontraded sector and fully offsets the government spending shock. Then, I feed in the full model the government spending shocks computed following House et al. (2019)'s methodology and compute the sequence of deleveraging shocks such that the

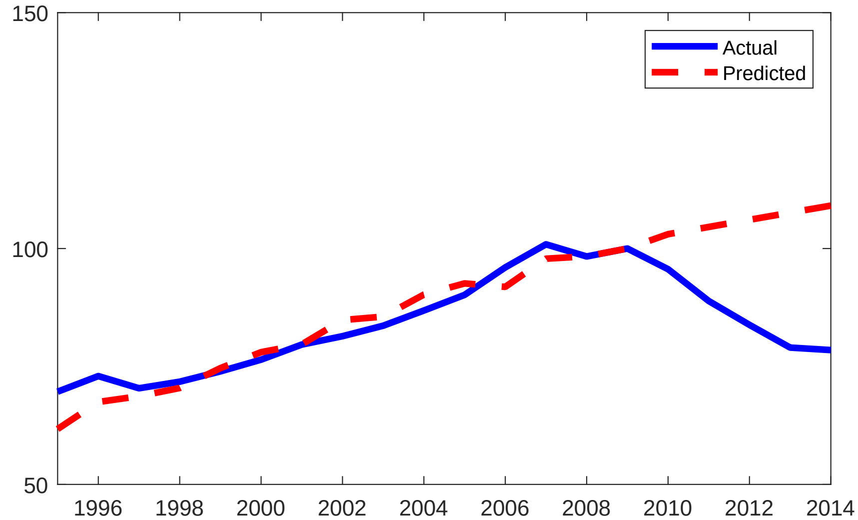


Figure 2.1: Real government spending per capita in Greece during the 1995-2014 period (normalized to 2009=100). Solid line: actual values, dashed line: predicted values.

model simulations for the shocks interaction track data reasonably well. The main result of my quantitative analysis is that public deleveraging mostly accounts for the output loss experienced by Greece and private deleveraging only accounts for a tiny part. However, the joint occurrence of public and private deleveraging generates quantitatively relevant nonlinear effects. Overall, the simulations point towards self-defeating austerity, that is, the debt-to-GDP ratio increases as a result of an endogenous output contraction.

The remainder of the paper is organized as follows. Section 2.2 introduces the model. Section 2.3 describes the shocks transmission mechanism through an analytical example and derives closed-form results. Next, I solve the full model numerically and present quantitative results in Section 2.4. Section 2.5 concludes.

2.2 Model

The model here described is the deterministic version of the one analyzed in the first chapter. It features a small open economy with two types of goods. One good is not traded internationally, but produced by a representative firm with labor as the only production factor. Nominal wages are downwardly rigid. The other good is traded internationally by a representative household. In each period the household receives an endowment of traded goods and may borrow or lend internationally via non-contingent debt.

Government consumption fluctuates exogenously, is financed through lump-sum taxes, and falls exclusively on nontraded goods[1]. Relatively to the model by House et al. (2019), I only assume wage stickiness but not price stickiness. In addition, in their model wages are sticky à la Calvo (1983) rather than à la Schmitt-Grohé and Uribe (2016).

2.2.1 Household

There is a representative household 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

$$\sum_{t=0}^{\infty} \beta^t \left[\frac{c_t^{1-\sigma} - 1}{1-\sigma} + \psi_g \frac{(g_t^N)^{1-\varsigma} - 1}{1-\varsigma} \right] , \tag{2.2.1}$$

where 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, and nontraded goods, c^N:

$$c_t = \left[\omega \left(c_t^T \right)^{\frac{\xi-1}{\xi}} + (1-\omega) \left(c_t^N \right)^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}} , \tag{2.2.2}$$

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

$$P_t = \left[\omega^{\xi} \left(P_t^T \right)^{1-\xi} + (1-\omega)^{\xi} \left(P_t^N \right)^{1-\xi} \right]^{\frac{1}{1-\xi}} , \tag{2.2.3}$$

[1] As explained in the first chapter, the last assumption is meant to enhance the tractability of the model. In practice governments tend to consume some imports. Yet, their weight in overall government spending is much smaller than for private spending (see e.g. Corsetti and Müller, 2006)

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

The household receives labor income and firm profits as well as an endowment of traded goods. In addition, the household may borrow (or save) via a discount bond that pays one unit of the traded goods with a foreign-currency price P_t^{T*}. The household pays taxes and spends its income on traded and nontraded goods. Formally, the period budget constraint in domestic currency reads as follows:

$$\mathcal{E}_t P_t^{T*} d_t + P_t^T c_t^T + P_t^N c_t^N = \mathcal{E}_t P_t^{T*} \frac{d_{t+1}}{1+r} + P_t^T y^T + W_t h_t + \phi_t - \tau_t \ , \tag{2.2.4}$$

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 $t-1$, which is 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 and the endowment of traded output y^T are assumed to be exogenous and constant.

I 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, I assume $P_t^*/P_t^{T*} = 1$, that is, I normalize the foreign relative price of consumption to unity. This exogeneity assumption is reasonable in the context of my analysis, for I study a small open economy.

Through its choice of c_t^T, c_t^N, and d_{t+1}, the representative household maximizes (2.2.1) subject to (2.2.4), and a no-Ponzi scheme constraint:

$$d_{t+1} \leq \bar{d}_t \ , \tag{2.2.5}$$

where $\bar{d}_t$ is positive. 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

$$c_t^N : p_t^N = \frac{1-\omega}{\omega}\left(\frac{c_t^T}{c_t^N}\right)^{\frac{1}{\xi}} \tag{2.2.6}$$

$$c_t^T : \lambda_t = \omega\left[\omega\left(c_t^T\right)^{\frac{\xi-1}{\xi}} + (1-\omega)\left(c_t^N\right)^{\frac{\xi-1}{\xi}}\right]^{\frac{\xi}{\xi-1}\left(\frac{1}{\xi}-\sigma\right)}\left(c_t^T\right)^{-\frac{1}{\xi}} \tag{2.2.7}$$

$$d_{t+1} : \frac{\lambda_t}{1+r} = \beta\lambda_{t+1} + \mu_t \tag{2.2.8}$$

$$\mu_t \geq 0 \wedge d_{t+1} \leq \bar{d}_t \text{ with } 0 = \mu_t(d_{t+1} - \bar{d}_t) \tag{2.2.9}$$

as well as a suitable transversality condition for bonds. Here, λ_t/P_t^T and μ_t, in turn, are the Lagrange multipliers associated with (2.2.4) and (2.2.5), and (2.2.9) is the complementary slackness condition.

2.2.2 Firm

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

$$y_t^N = h_t^\alpha\ , \tag{2.2.10}$$

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

$$\phi_t \equiv P_t^N y_t^N - W_t h_t\ . \tag{2.2.11}$$

Optimality requires the following condition to hold:

$$p_t^N = \frac{W_t/\mathcal{E}_t}{\alpha y_t^N/h_t}\ . \tag{2.2.12}$$

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2.2.3 Labor market

The household faces no disutility from working and will therefore supply labor in order to meet labor demand to the extent that it does not exceed the total endowment of labor:

$$h_t \leq \bar{h} \ . \tag{2.2.13}$$

Hours worked are determined in equilibrium by the firm's labor demand. Even though the labor market is competitive, it will generally not clear because of downward nominal wage rigidity. Specifically, as in Schmitt-Grohé and Uribe (2016), I assume that in any given period nominal wages cannot fall to a level smaller than $\gamma > 0$ times the wage in the previous period. Formally, the economy is subject to downward nominal wage rigidity of the form

$$W_t \geq \gamma W_{t-1} \ . \tag{2.2.14}$$

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:

$$(\bar{h} - h_t)(W_t - \gamma W_{t-1}) = 0 \ . \tag{2.2.15}$$

It 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, I use

$$w_t \equiv W_t / \mathcal{E}_t \tag{2.2.16}$$

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 (2.2.14) can then be rewritten as

$$w_t \geq \gamma \frac{w_{t-1}}{\epsilon_t} \ . \tag{2.2.17}$$

This expression illustrates that downward nominal wage rigidity operates via effectively constraining real wages. At the same time, it shows how a currency devaluation, i.e. an increase in ϵ_t, may relax the tightness of the constraint.

2.2.4 Government spending

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

$$P_t^N g_t^N = \tau_t \,. \tag{2.2.18}$$

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

2.2.5 Market clearing

Market clearing in the nontraded-goods sector requires

$$y_t^N = c_t^N + g_t^N \,, \tag{2.2.19}$$

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

$$c_t^T = y^T - d_t + \frac{d_{t+1}}{1+r} \,. \tag{2.2.20}$$

Labor market equilibrium is characterized by equations (2.2.13)-(2.2.15). Appendix 2.A lists the full set of equilibrium conditions and provides a definition of the equilibrium for a given exchange rate policy $\{\epsilon_t\}_{t=0}^{\infty}$, to be specified next.

2.2.6 Exchange rate policy

In order to specify the exchange rate policy, I define the full-employment real wage:

$$w_t^f \equiv \frac{1-\omega}{\omega} \left(\frac{c_t^T}{\bar{h}^\alpha - g_t^N} \right)^{\frac{1}{\xi}} \alpha \bar{h}^{\alpha-1} \,. \tag{2.2.21}$$

This expression is obtained by combining the demand and supply schedules of nontraded goods, (2.2.6) and (2.2.12), respectively, the definition of the real wage (2.2.16), the production technology (2.2.10), and the market clearing condition (2.2.19) when the labor market is operating at full employment, that is, $h_t = \bar{h}$. This is also 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 (2.2.17) above shows. This gives a role to monetary policy, which can stabilize economic activity by setting the nominal exchange rate. But there are infinitely many combinations of nominal wage and nominal exchange rate which imply the same real wage—see equation (2.2.16) above—and therefore the same real exchange rate. Hence, any exchange rate policy satisfying

$$\epsilon_t \geq \gamma \frac{w_{t-1}}{w_t^f} \tag{2.2.22}$$

will make the wage constraint slack and ensure full employment. In what follows, I pick from this class of full-employment exchange rate policies the one that minimizes movements in the nominal exchange rate. It is given by

$$\epsilon_t = \max\left\{\gamma \frac{w_{t-1}}{w_t^f}, 1\right\} . \tag{2.2.23}$$

Intuitively, if the full-employment wage is above the lower bound γw_{t-1}, the nominal exchange rate will not be adjusted at all. Otherwise, it will increase by just enough to alleviate the constraint.

In the analysis below, I study, in addition to the baseline scenario of fixed exchange rates, the behavior of the economy under "fully" flexible exchange rates. Formally, I specify the following exchange rate rule (as in Liu (2018)) to capture alternative exchange rate arrangements:

$$\epsilon_t = \max\left\{\gamma \frac{w_{t-1}}{w_t^f}, 1\right\}^{\phi_\epsilon} , \tag{2.2.24}$$

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

2.3 Inspecting the mechanism

This section illustrates the transmission mechanism of a negative government spending shock and a contemporaneous deleveraging shock in a perfect foresight setup. For this purpose, I make a number of simplifying assumptions. First, I assume that $U(c_t) = \ln(c_t)$ and $c_t = c_t^T c_t^N$. Regarding the production function, I assume that $\alpha = 1$, so that the marginal product of labor is constant. Without loss of generality, I set $y^T = 1$. The steady-state level of government consumption is denoted by $g < 1$. I also assume that wages are perfectly downwardly rigid, that is, I set $\gamma = 1$. In this case, any contractionary shock is sufficient to induce the wage constraint to become binding. Furthermore, I set $\bar{h} = 1$. Lastly, I assume that initially the economy is in full-employment steady state. Given the preferences and the functional forms assumed here, I obtain the following equilibrium conditions:

$$c_t^T = 1 - d_t + \frac{d_{t+1}}{1+r} \tag{2.3.1}$$

$$y_t^N = h_t = c_t^N + g_t^N \tag{2.3.2}$$

$$\frac{(1/c_t^T)}{1+r} = \beta(1/c_{t+1}^T) + \mu_t \tag{2.3.3}$$

$$p_t^N = \frac{c_t^T}{h_t - g_t^N} \tag{2.3.4}$$

$$p_t^N = w_t \tag{2.3.5}$$

$$w_t \geq \frac{w_{t-1}}{\epsilon_t} \wedge h_t \leq 1 \text{ with } 0 = (1 - h_t)\left(w_t - \frac{w_{t-1}}{\epsilon_t}\right) \tag{2.3.6}$$

$$w_t^f = \frac{c_t^T}{1 - g_t^N} \tag{2.3.7}$$

$$\epsilon_t = \max\left\{\frac{w_{t-1}}{w_t^f}, 1\right\}^{\phi_\epsilon}. \tag{2.3.8}$$

Both shocks hit the economy at time 0. They are fully unanticipated in the initial period and everybody understands that no further shocks will ever materialize. Consider first a permanent negative government spending shock. Specifically, assume the following process for government spending:

$$g_t^N = \begin{cases} g & \text{if } t < 0 \\ 0 < \underline{g} < g & \text{if } t \geq 0\ . \end{cases} \tag{2.3.9}$$

Consider then a permanent deleveraging shock, that is, a shock that permanently tightens the borrowing limit. I assume that the borrowing constraint is always binding, so that

$\mu_t > 0$ for all t. Specifically, next-period debt evolves according to the following process:

$$d_{t+1} = \begin{cases} \bar{d} & \text{if } t < 0 \\ 0 < d < \bar{d} & \text{if } t \geq 0 \ . \end{cases} \tag{2.3.10}$$

Since the intertemporal consumption choice is decoupled from the intratemporal choice, a shock to the nontraded sector will not spill over to the traded sector. However, the converse does not hold in general. In this analytical example, the deleveraging shock reduces traded consumption on impact: $c_0^T = 1 - \bar{d} + \frac{d}{1+r} < 1 - \bar{d} + \frac{\bar{d}}{1+r} = c_{-1}^T$. In period 0, the nontraded goods resource constraint (2.3.2) implies $c_0^N = y_0^N - \underline{g}$, while equations (2.3.4) and (2.3.5) imply that the real wage is given by $w_0 = \frac{c_0^T}{h_0 - \underline{g}}$. Thus, I need to solve for nontraded output y_0^N and hours worked h_0, which both depend on the exchange rate arrangement.

Peg ($\phi_\epsilon = 0$): Conjecture that the economy is in a situation of unemployment with $h_0 < 1$. In this case, the wage constraint (2.3.6) 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 $w_0 = \frac{c_0^T}{h_0 - \underline{g}} = \frac{c_{-1}^T}{1-g} = w_{-1}$, which implies $1 - g > h_0 - \underline{g} > h_0 - g$, as $c_0^T < c_{-1}^T$. This, in turn, requires $h_0 < 1$, which is true by assumption. This proves that $h_0 < 1$ indeed is the equilibrium employment level, which is associated with the output level $y_0^N = h_0 = \frac{c_0^T}{w_{-1}} + \underline{g} = \frac{1-\bar{d}+\frac{d}{1+r}}{1-\left(\frac{r}{1+r}\right)\bar{d}}(1-g) + \underline{g}$.

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 (2.3.8) as $\epsilon_0 = \max\left\{\frac{w_{-1}}{w_0^f}, 1\right\} = \frac{w_{-1}}{w_0^f} = \frac{1-\left(\frac{r}{1+r}\right)\bar{d}}{1-\bar{d}+\frac{d}{1+r}} \cdot \frac{1-\underline{g}}{1-g}$. The assumption that $h_0 < 1$ therefore leads to a contradiction: $w_0 = \frac{c_0^T}{h_0 - \underline{g}} = \frac{c_0^T}{1-\underline{g}} = w_0^f$, which requires $h_0 - \underline{g} = 1 - \underline{g}$, that is, $h_0 = 1$. Consequently, it must be that $y_0^N = h_0 = 1$ and the economy is at its full-employment equilibrium.

From (2.3.4) then follows that $p_{0,peg}^N = w_0 = w_{-1} = p_{-1}^N$ and $p_{0,float}^N = \frac{c_0^T}{1-\underline{g}} < \frac{c_{-1}^T}{1-g} = p_{-1}^N$, since $\frac{1-g}{1-\underline{g}} < \frac{c_{-1}^T}{c_0^T}$. Hence, the two shocks cause a fall in p^N under a float but not under a peg. Moreover, these equations show how harmful the contraction in the traded sector can be. The full-employment real wage w^f potentially falls a lot depending on the drop in traded consumption c^T (and government consumption g^N), as $\frac{w_0^f}{w_{-1}^f} = \frac{c_0^T}{c_{-1}^T}\frac{1-g}{1-\underline{g}} < 1$. By contrast, the real wage w_t stays put. The lack of downward adjustment in the real wage which would be necessary to ensure full employment is due to the combination of downward nominal wage rigidity and a peg and to the assumptions made in this analytical example. Therefore, the lack of adjustment causes disequilibrium in the labor market. The optimal devaluation, by contrast, prevents the contraction in the traded sector to spill over into the nontraded sector and offsets the government spending shock as well.

Figure 2.2 illustrates these results graphically. In the left panel, I show the effect of a deleveraging shock for a given g. Traded consumption declines and so does the full-employment real wage. This decline is exacerbated by the negative government spending shock, shown in the right panel. The initial equilibrium is given by point A, the intersection of the supply curve and the downward-sloping demand curve. Following the government spending shock, the demand for nontraded goods declines. The real wage cannot adjust downward under the peg because of perfect downward wage rigidity. This brings about involuntary unemployment and a permanently lower level of output (point "peg"). In case of a float, the nominal exchange rate depreciates, driving the real wage down to the full-employment equilibrium (point "float"). Hence, the level of output remains unaffected by the shock(s).

In section 2.4 below, I solve the full model numerically using global methods that allow to capture nonlinear adjustment dynamics.

2.4 Quantitative analysis

I now solve the full model numerically using two global methods, as explained in greater detail below.

I calibrate the model to capture key features of the Greek economy. I largely follow Schmitt-Grohé and Uribe (2016)'s calibration—except in those instances where I explicitly account for government spending.

2.4.1 Model calibration and solution

Table 2.1 summarizes the parameters of the model together with the values that I assign to them in our numerical analysis. A period in the model corresponds to one quarter. In the model, I abstract from both foreign inflation and long-run technology growth, which

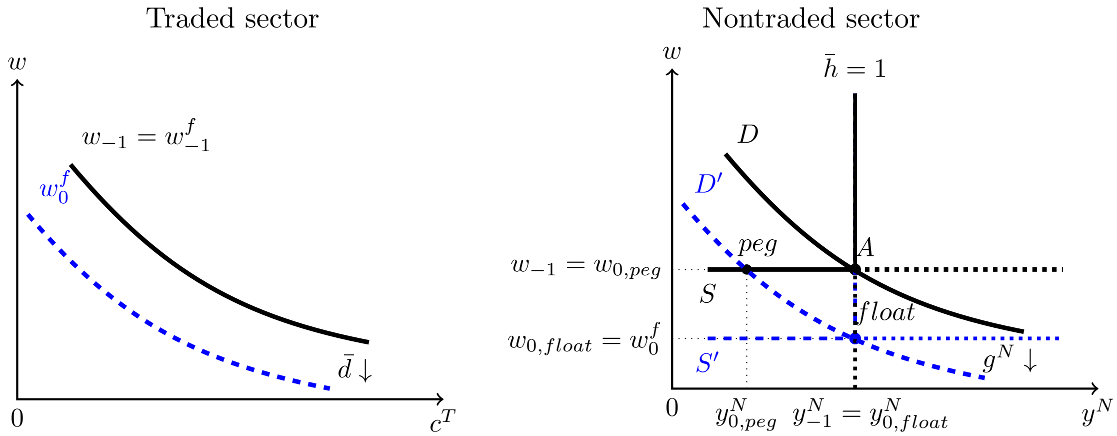

Figure 2.2: The effect of permanent deleveraging and government spending shocks starting from full employment.

mitigate the effect of downward nominal wage rigidity. Following Schmitt-Grohé and Uribe (2016), I 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%). I set γ to $0.9982/(1.003 \times 1.003) = 0.9922$. I set the intra- and intertemporal elasticities of substitution between traded and nontraded goods, ξ and σ, to 0.44 and 5, respectively, following again Schmitt-Grohé and Uribe (2016) and Reinhart and Végh (1995). In line with the estimate of Uribe (1997), I fix the labor share in the traded goods sector at $\alpha = 0.75$. I set $\bar{d} = 87.3136$, i.e. for numerical reasons I set the upper limit 5% below the natural debt limit. I normalize the endowment of hours $\bar{h}$ to unity. The subjective discount factor β is set to 0.9375, in line with Schmitt-Grohé and Uribe (2016), to obtain a plausible foreign debt-to-GDP ratio.

Finally, the weight of traded goods in aggregate consumption is determined by ω. I 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 Schmitt-Grohé and Uribe (2016).

In order to solve the model, I largely follow Schmitt-Grohé and Uribe (2016). 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 I solve the model numerically by value function iteration over a discretized state space. In case of a fixed exchange rate regime, that is, if $\phi_\epsilon = 0$, the lagged real wage is a state

Table 2.1: 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	$\sigma = 5$	Standard value
Labor exponent production function	$\alpha = 0.75$	Uribe (1997)
Debt limit	$\bar{d} = 87.3136$	95 % of natural debt limit
Endowment of hours worked	$\bar{h} = 1$	Normalization
Interest rate	$r = 0.011$	Average interest rate
Traded goods endowment	$y^T = 1$	Normalization
Discount factor	$\beta = 0.9375$	SGU (2016)
Weight on traded goods in CES	$\omega = 0.37$	traded goods share of 0.26

variable, as is the external debt position. To solve the model in this case, I resort to Euler equation iteration.

2.4.2 Government spending shocks and measures of economic performance

To compute government spending shocks, I follow the methodology explained in detail by House et al. (2019)[2]. More precisely, I adopt the following forecast specification:

$$\ln G_t = \ln G_{t-1} + \hat{g}_{EU} + \hat{\gamma}(\ln \hat{Y}_{EU,t-1} - \ln Y_{t-1}) + \varepsilon_t^G. \tag{2.4.1}$$

$\ln G_t$ is the log of real government spending (deflated by the GDP deflator) at time t, $\ln Y_t$ is the log of real nontraded output at time t and the parameter g_{EU} is the average growth rate of output in Europe. The hat denotes a predicted value of the variable. This forecast specification accounts for both average output growth and convergence dynamics. The underlying assumption is that all countries are converging to a common growth rate. The forecasting equation 2.4.1 requires estimates of g_{EU}, the convergence parameter γ and predicted values for average log real output in Europe $\ln \hat{Y}_{EU,t-1}$. These estimates are based on data up to 2005, thereby excluding the boom before the Great Recession. To

[2]My data source is Eurostat. The sample covers the period 1960-2014. See the Appendix for sources of all time series used.

estimate g_{EU} and $\ln \hat{Y}_{EU,t-1}$ I use annual data for twelve advanced euro area economies[3] over 1993-2005 using the specification

$$\ln Y_{EU,t} = \beta_{EU} + g_{EU} \cdot t + \varepsilon_{EU,t}. \tag{2.4.2}$$

The estimated value for g_{EU} is 0.019 (i.e., 1.9 percent annual growth) with a standard error of 0.0012. $\ln \hat{Y}_{EU,t}$ are the fitted values from 2.4.2. To estimate the convergence parameter γ I run the regression

$$g_t - \hat{g}_{EU} = \gamma(\ln \hat{Y}_{EU,t-1} - \ln Y_{t-1}) + \varepsilon_t^{\gamma}. \tag{2.4.3}$$

The estimated value for γ is 0.023 with a standard error of 0.002. In addition to the forecast for government spending, I compute two measures of economic performance: the debt-to-GDP ratio and real GDP. The forecast for the foreign debt-to-GDP ratio $\hat{d}_t$ for dates t after 2009 is

$$\hat{d}_t = \frac{1}{2} \sum_{s=2008}^{2009} d_s. \tag{2.4.4}$$

Finally, I adopt the following specification for nontraded output:

$$\ln Y_t = \ln Y_{t-1} + \hat{g}_{EU} + \hat{\gamma}(\ln \hat{Y}_{EU,t-1} - \ln Y_{t-1}) + \varepsilon_t^{Y}. \tag{2.4.5}$$

As with the forecast for government spending, this forecast specification accounts for both average output growth and convergence dynamics. The parameters g_{EU} and γ are estimated over the 1993-2005 period using quarterly data and $\ln \hat{Y}_{EU,t-1}$ is the fitted values from 2.4.2.

Once estimated the deviations of government spending from their forecasts over the years 2010-14, the period of interest, I treat those deviations as shocks and feed them into the model. For the year 2010, I use the actual realizations of $\ln G_{2009}$ and $\ln Y_{2009}$ in equation 2.4.1. Starting from 2011, I replace $\ln G_{t-1}$ and $\ln Y_{t-1}$ with their predicted values. As for equation 2.4.5, up to $t = 2010{:}1$ I use actual output data for $\ln Y_{i,t-1}$ and replace it with its forecast $\ln \hat{Y}_{i,t-1}$ thereafter. Since the model is calibrated at quarterly frequency, I use Chow and Lin (1971)'s method to convert the predicted annual government spending series to quarterly series. As an auxiliary high-frequency indicator, I rely exclusively on

[3] Belgium, Denmark, Germany, Ireland, Spain, France, Italy, Luxembourg, Austria, Netherlands, Portugal, and Finland.

real quarterly output. Moreover, given that the model is cast in terms of traded output, I divide the government spending series by average output in the pre-crisis period—i.e. the 1993-2005 period—and adjust it to account for the government spending share being expressed in total output. The government spending shocks fed into the model are then the deviations of actual government spending from its predicted quarterly level.

Alternatively, I could use the following forecast specification for real government spending, which includes contemporaneous output and therefore a feedback mechanism in equation 2.4.1:

$$\ln G_t = \ln G_{t-1} + \hat{g}_{EU} + \hat{\gamma}(\ln \hat{Y}_{EU,t-1} - \ln Y_{t-1}) + \theta^G(\ln Y_t - \ln \hat{Y}_{EU,t}) + \varepsilon_t^G. \quad (2.4.6)$$

I estimate the cyclicality parameter θ^G by least squares using all available data up to 2005. The estimated value is 0.38 with a standard error of 0.06.

As shown in figure 2.3, using a linear or a quadratic trend rather than House et al. (2019)'s methodology to compute forecast errors would yield a less substantial amount of austerity over the 2010-14 period.

2.4.3 Model and data comparison

In addition to the government spending shocks, I consider the additional effect of exogenous deleveraging shocks in the private sector. More specifically, I feed in the model government spending shocks and compute the series of deleveraging shocks such that model simulations for the shocks interaction track the data reasonably well. Figure 2.4 displays the model impulse responses to the government spending shocks, the deleveraging shocks, and the interaction of the shocks under a peg. In this figure, the solid blue lines represent the responses to the government spending shock, the dashed red lines represent the responses to the deleveraging shock, the solid gray lines represent the interaction, and the dotted black lines correspond to actual data. The model simulations track the data reasonably well. The government spending shocks induce a large contraction in nontraded output through the mechanism described in Section 2.3. The additional deleveraging shocks, which lower traded consumption and therefore spill over to the nontraded sector, initially reduce output but also dampen the increase in the debt-to-GDP ratio. The output contraction is very mild, when compared to government spending shocks, and very transitory. This happens for the following reasons. The magnitude of the deleveraging shock in percentage points is about one fourth of the spending shock on impact. Moreover, the spending shocks increase

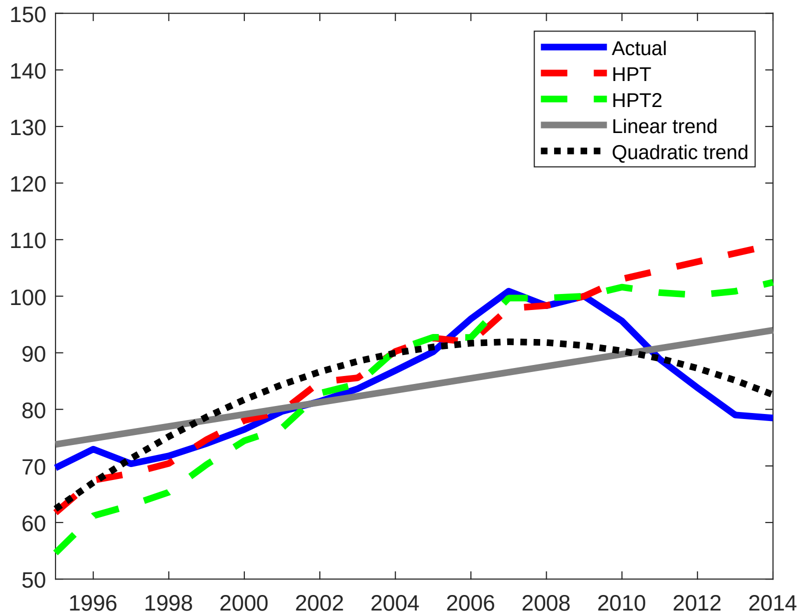

Figure 2.3: Real government spending per capita in Greece during the 1995-2014 period (normalized to 2009=100). Solid line: actual values, red dashed: prediction using House et al. (2019)'s methodology, green dashed: prediction using House et al. (2019)'s forecasting equation 2.4.6, gray solid: linear trend, black dotted: quadratic trend.

considerably in size over the time horizon, as opposed to deleveraging shocks, which fade away at the end of the horizon. In a perfect foresight setup, agents know at time 0 that deleveraging shocks are only transitory and government spending shocks are permanent. Therefore, the contraction in the traded sector has a limited and temporary impact on the mismatch between full-employment and actual real wage and ultimately on the labor market whereas in response to the government spending shocks the economy enters a permanent state of depression. Overall, austerity is so contractionary that the debt-to-GDP ratio increases as a consequence of an endogenous output reduction. Public deleveraging contributes on average almost 92 percent to the nontraded output contraction, whereas the contribution of private deleveraging is about 1 percent. The remaining 7 percent is due to the nonlinear effects stemming from the interaction of the shocks which makes both the wage constraint and the debt constraint binding.

In a second experiment, I consider the counterfactual scenario of fully flexible exchange

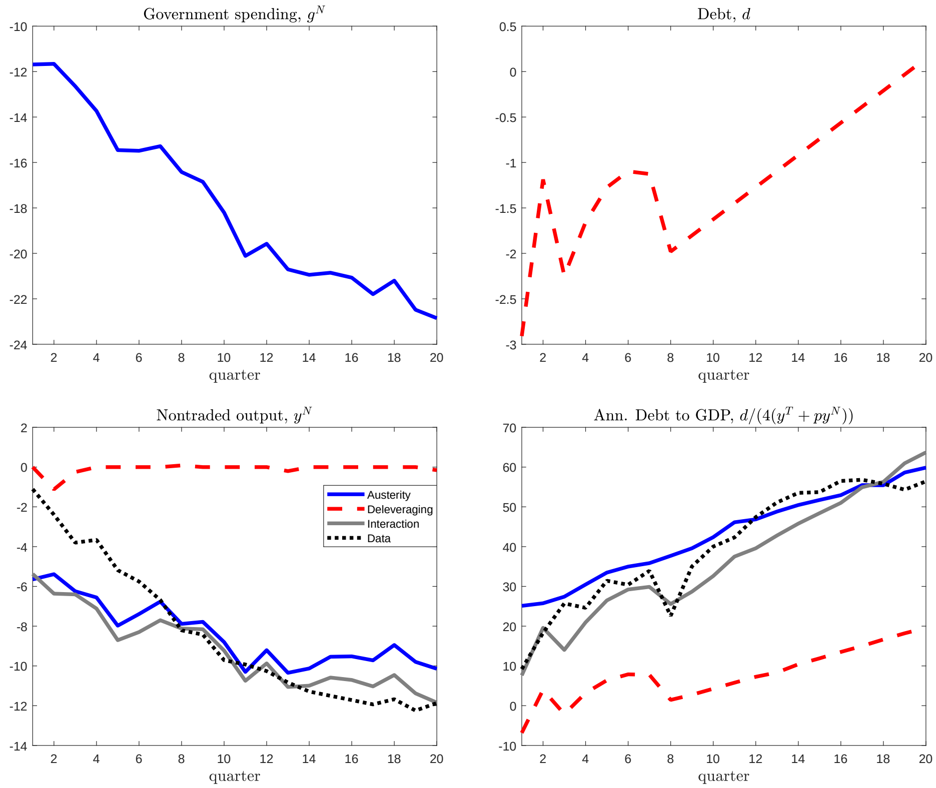

Figure 2.4: Model responses to government spending shock, deleveraging shock, and joint shocks and data comparison under peg. First row: government spending and debt. Second row: nontraded output and debt-to-GDP ratio. Solid blue line: austerity, dashed red: deleveraging, dashed gray: interaction, dotted: data. Horizontal axis measures time in quarters, vertical axis measures the effect of shock in pp for government spending, debt and the debt-to-GDP ratio and in percent deviation from the mean for nontraded output. 'Data' refers to forecast errors from regression (2.4.5) for nontraded output and regression (2.4.4) for the debt-to-GDP ratio.

rates, that is, a float. This exchange rate regime is designed in such a way that the nominal exchange rate can adjust every period so as to ensure full employment in the labor market. For this reason, Schmitt-Grohé and Uribe (2016) refer to this regime as the "optimal exchange rate policy". This specific adjustment of the exchange rate may be difficult to bring about in practice, either because of external constraints like having given up independent monetary policy or domestic ones like monetary policy having other objectives.

In my counterfactual experiment, I operate under the assumption that Greece has withdrawn from the euro area, thereby restoring monetary policy independence, and abstract from other objectives that may prevent the central bank to pursue full employment. Figure 2.5 shows the model responses to the joint occurrence of public and private deleveraging under peg and float and actual data. The float fully stabilizes nontraded output through a strong currency depreciation. Moreover, the optimal devaluation prevents the contraction in the traded sector to spill over into the nontraded sector. The debt-to-GDP ratio is much lower than it is under the peg. Eventually this ratio increases as a consequence of a massive fall in the relative price of nontradables. To take a closer look, figure 2.6 shows the effect on price of traded goods, nontraded goods and the CPI in levels. The responses shown in the previous figures are the difference between actual (blue lines) and predicted (red lines) values. On impact the price of tradables jumps, that is, there is depreciation of the nominal exchange rate. The price of nontradables, however, declines more strongly, which results in deflation. Under a peg, as shown in figure 2.7, the price of traded goods does not change and the price of nontraded goods moves by less than it does under a float. The result is milder deflation.

2.5 Conclusion

In this paper, I have analyzed the effects of public and private deleveraging in Greece during the 2010-14 period, as Greece stands out as having the sharpest decline in GDP and government spending over this period. First, I establish the contribution of public deleveraging relative to private deleveraging under the peg. Second, I run a counterfactual experiment to study the dynamics in a float scenario. According to the model simulations, austerity mostly accounts for the large output contraction experienced by the country. The nonlinear effects generated by the joint occurrence of public and private deleveraging are quantitatively relevant. Overall, the model simulations point towards self-defeating austerity, that is, the debt-to-GDP ratio increases as a result of an endogenous output contraction.

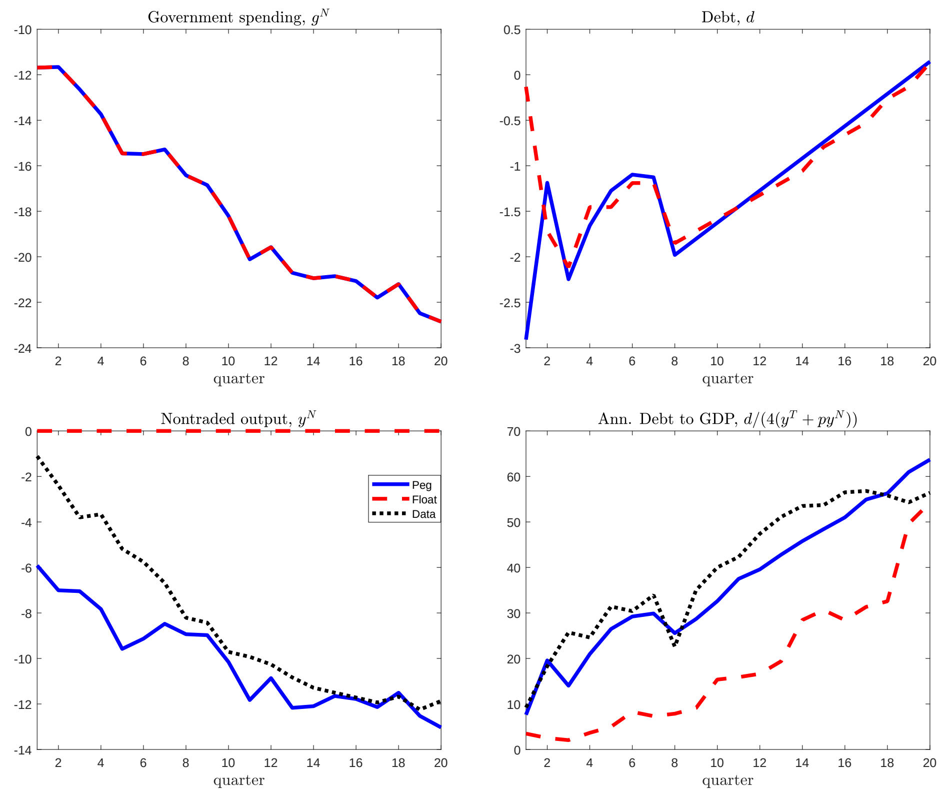

Figure 2.5: Model responses to joint shocks under peg and float and data comparison. First row: government spending and debt. Second row: nontraded output and debt-to-GDP ratio. Solid blue line: austerity, dashed red: deleveraging, dotted: data. Horizontal axis measures time in quarters, vertical axis measures the effect of shock in pp for government spending, debt and the debt-to-GDP ratio and in percent deviation from the mean for nontraded output. 'Data' refers to forecast errors from regression (2.4.5) for nontraded output and regression (2.4.4) for the debt-to-GDP ratio.

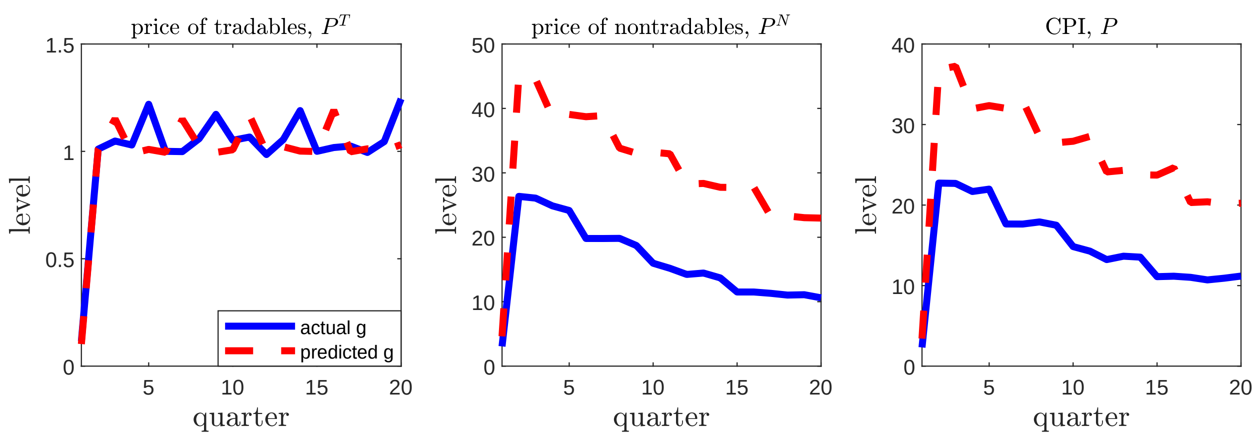

Figure 2.6: Responses of prices and CPI under float. Solid line: actual values, dashed line: predicted values.

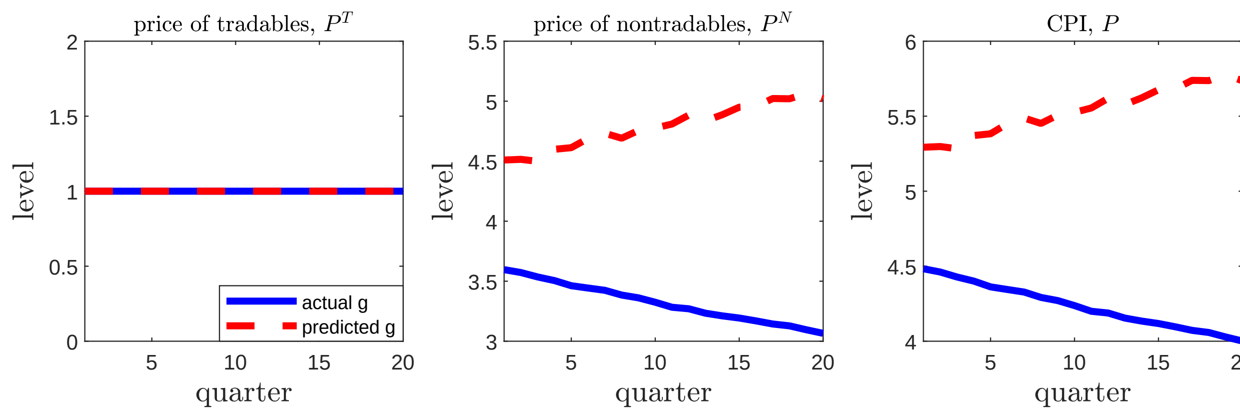

Figure 2.7: Responses of prices and CPI under peg. Solid line: actual values, dashed line: predicted values.

Appendix

2.A Full set of equilibrium conditions

The Lagrangean reads:

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta^t \Bigg\{ \left[\frac{\left(\left[\omega \left(c_t^T\right)^{\frac{\xi-1}{\xi}} + (1-\omega)\left(c_t^N\right)^{\frac{\xi-1}{\xi}}\right]^{\frac{\xi}{\xi-1}}\right)^{1-\sigma} - 1}{1-\sigma} + \psi_g \frac{(g_t^N)^{1-\varsigma} - 1}{1-\varsigma} \right]$$
$$- \lambda_t / P_t^T \left[\mathcal{E}_t P_t^{T*} d_t + P_t^T c_t^T + P_t^N c_t^N - \mathcal{E}_t P_t^{T*} \frac{d_{t+1}}{1+r} - P_t^T y^T - W_t h_t - \phi_t + \tau_t \right] \Bigg\}$$
$$- \mu_t (d_{t+1} - \bar{d}).$$

The first-order conditions are:

$$\frac{\partial \mathcal{L}}{\partial c_t^N} : \frac{P_t^N}{P_t^T} - \frac{1-\omega}{\omega} \left(\frac{c_t^T}{c_t^N} \right)^{\frac{1}{\xi}} = 0 \tag{2.A.1}$$

$$\frac{\partial \mathcal{L}}{\partial c_t^T} : \lambda_t - \omega \left[\omega \left(c_t^T\right)^{\frac{\xi-1}{\xi}} + (1-\omega)\left(c_t^N\right)^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}\left(\frac{1}{\xi} - \sigma\right)} \left(c_t^T\right)^{-\frac{1}{\xi}} = 0 \tag{2.A.2}$$

$$\frac{\partial \mathcal{L}}{\partial d_{t+1}} : \lambda_t \frac{\mathcal{E}_t P_t^{T*}}{P_t^T} \frac{1}{1+r} - \beta \lambda_{t+1} \frac{\mathcal{E}_{t+1} P_{t+1}^{T*}}{P_{t+1}^T} - \mu_t = 0 \tag{2.A.3}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_t / P_t^T} : \mathcal{E}_t P_t^{T*} d_t + P_t^T c_t^T + P_t^N c_t^N - \mathcal{E}_t P_t^{T*} \frac{d_{t+1}}{1+r} - P_t^T y^T - W_t h_t - \phi_t + \tau_t = 0. \tag{2.A.4}$$

Using the assumptions that $P_t^T = \mathcal{E}_t$ and $P_t^{T*} = 1$ and the definition of relative price $p_t^N \equiv \frac{P_t^N}{P_t^T}$, (2.A.1)-(2.A.3) become:

$$p_t^N - \frac{1-\omega}{\omega} \left(\frac{c_t^T}{c_t^N} \right)^{\frac{1}{\xi}} = 0$$

$$\lambda_t - \omega \left[\omega \left(c_t^T\right)^{\frac{\xi-1}{\xi}} + (1-\omega)\left(c_t^N\right)^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}\left(\frac{1}{\xi} - \sigma\right)} \left(c_t^T\right)^{-\frac{1}{\xi}} = 0$$

$$\frac{\lambda_t}{1+r} - \beta \lambda_{t+1} + \mu_t.$$

In addition, using the definition of firm profits $\phi_t \equiv P_t^N y_t^N - W_t h_t$, the process for government spending $P_t^N g_t^N = \tau_t$, and the market clearing condition for nontraded goods $y_t^N = c_t^N + g_t^N$, (2.A.4) becomes the market clearing condition for traded goods:

$$
\begin{aligned}
&P_t^T d_t + P_t^T c_t^T + P_t^N c_t^N - P_t^T \frac{d_{t+1}}{1+r} - P_t^T y^T - W_t h_t - \phi_t + \tau_t = 0 \\
&P_t^T d_t + P_t^T c_t^T + P_t^N c_t^N - P_t^T \frac{d_{t+1}}{1+r} - P_t^T y^T - W_t h_t - (P_t^N y_t^N - W_t h_t) + P_t^N g_t^N = 0 \\
&P_t^T d_t + P_t^T c_t^T + P_t^N c_t^N - P_t^T \frac{d_{t+1}}{1+r} - P_t^T y^T - W_t h_t - P_t^N (c_t^N + g_t^N) + W_t h_t + P_t^N g_t^N = 0 \\
&P_t^T d_t + P_t^T c_t^T - P_t^T \frac{d_{t+1}}{1+r} - P_t^T y^T = 0 \\
&d_t + c_t^T - \frac{d_{t+1}}{1+r} - y^T = 0.
\end{aligned}
$$

Definition 2.1. An equilibrium is defined as a set of deterministic processes $\{c_t^T, h_t, d_{t+1}, w_t, \lambda_t, \mu_t, \}_{t=0}^{\infty}$ satisfying

$$c_t^T = y^T - d_t + \frac{d_{t+1}}{1+r} \tag{2.A.5}$$

$$\lambda_t = \omega \left[\omega (c_t^T)^{\frac{\xi-1}{\xi}} + (1-\omega)(h_t^\alpha - g_t^N)^{\frac{\xi-1}{\xi}}\right]^{\frac{\xi}{\xi-1}\left(\frac{1}{\xi}-\sigma\right)} (c_t^T)^{-\frac{1}{\xi}} \tag{2.A.6}$$

$$\frac{\lambda_t}{1+r} = \beta \lambda_{t+1} + \mu_t \tag{2.A.7}$$

$$\mu_t \geq 0 \wedge d_{t+1} \leq \bar{d}_t \text{ with } 0 = \mu_t (d_{t+1} - \bar{d}_t) \tag{2.A.8}$$

$$\frac{w_t}{\alpha h_t^{\alpha-1}} = \frac{1-\omega}{\omega} \left(\frac{c_t^T}{h_t^\alpha - g_t^N} \right)^{\frac{1}{\xi}} \tag{2.A.9}$$

$$w_t \geq \gamma \frac{w_{t-1}}{\epsilon_t} \tag{2.A.10}$$

$$h_t \leq \bar{h} \tag{2.A.11}$$

$$0 = (\bar{h} - h_t) \left(w_t - \gamma \frac{w_{t-1}}{\epsilon_t} \right), \tag{2.A.12}$$

as well as a suitable transversality condition, given initial conditions $\{w_{-1}, d_0\}$, exogenous deterministic processes $\{g_t^N, \bar{d}_t\}_{t=0}^{\infty}$, and an exchange rate policy $\{\epsilon_t\}_{t=0}^{\infty}$.

2.B Data sources

- **Government consumption (annual data)**: Eurostat. GDP and main components (output, expenditure and income) [nama_10_gdp], Chain linked volumes (2010), million units of national currency. Final consumption expenditure of general government. Extracted on 19.04.19.

- **Net external debt (annual/quarterly data)**: Eurostat. Main Balance of Payments and International Investment Position items as share of GDP (BPM6) [bop_gdp6_q]. Percentage of gross domestic product (GDP). Unadjusted data (i.e. neither seasonally adjusted nor calendar adjusted data). Net external debt. Net liabilities (liabilities minus assets). Rest of the world. Extracted on 11.11.19.

- **Real nontraded output (annual data)**: Eurostat. Gross value added and income A*10 industry breakdowns [nama_10_a10]. Sectors: Industry (except construction), Construction, Financial and insurance activities, Real estate activities, Professional, scientific and technical activities; administrative and support service activities, Public administration, defence, education, human health and social work activities, Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies. Chain linked volumes (2010), million euro. Seasonally and calendar adjusted data. Value added, gross. Extracted on 26.02.19.

- **Real nontraded output (quarterly data)**: Eurostat. Gross value added and income A*10 industry breakdowns [namq_10_a10]. Sectors: Industry (except construction), Construction, Financial and insurance activities, Real estate activities, Professional, scientific and technical activities; administrative and support service activities, Public administration, defence, education, human health and social work activities, Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies. Chain linked volumes (2010), million euro. Seasonally and calendar adjusted data. Value added, gross. Extracted on 26.02.19.

- **Population (annual data)**: Eurostat. Population on 1 January by age and sex [demo_pjan]. Total. Extracted on 19.04.19.

- **Real effective exchange rate (annual data)**: Eurostat. Industrial countries' effective exchange rates - quarterly data [ert_eff_ic_a], Real effective exchange rate (deflator: consumer price index - 19 trading partners - euro area), Index, 2010=100. Extracted on 31.07.18.

- **Real effective exchange rate (quarterly data)**: Eurostat. Industrial countries' effective exchange rates - quarterly data [ert_eff_ic_q], Real effective exchange rate (deflator: consumer price index - 19 trading partners - euro area), Index, 2010=100. Extracted on 31.07.18.

Chapter 3

Joint deleveraging in the public and private sector: a review of the macroeconomic effects

3.1 Introduction

How strong is the interaction of public and private deleveraging? In order to address this question, this paper presents a critical review of the literature assessing the individual and joint effects of debt deleveraging in the public and in the private sector, as they have been widely debated in the context of the euro-area crisis. Moreover, they are conceptually closely related and likely to interact in important ways. In both instances, efforts to reduce the level of borrowing may raise the level of debt relative to current GDP because of their contractionary effect on economic activity. This analysis is particularly relevant in light of the following four observations:

1. Macroeconomic performance in the euro area is very heterogeneous after 2009. While the macroeconomic performance of the euro area as a whole has been rather poor, there are striking differences across countries. The upper-left panel of Figure 3.1 displays the unemployment rate in selected countries of the euro area: the southern "peripheral" countries (Greece, Italy, Portugal and Spain) and two "core" countries (Germany and France). Unemployment rates reached record levels in Spain and Greece, but remained moderate in Germany throughout the crisis.

2. Public-sector deleveraging and unemployment rates are correlated. Those countries which suffered from a strong increase in unemployment also implemented large austerity measures in the period after 2009. The upper-right panel of Figure 3.1 relates annual changes in the cyclically adjusted primary fiscal balance to the change in the unemployment rate (in the peripheral countries). The correlation is striking.

3. Private-sector deleveraging and unemployment rates are correlated. Those countries which suffered from a strong increase in unemployment rates experienced sizable private-sector deleveraging. The lower-left panel of Figure 3.1 relates the annual reduction in private credit to the change in the unemployment rate. The correlation is smaller than in the upper-right panel, but still large.

4. Fiscal adjustment in Europe is mostly expenditure-based. As shown by Alesina et al. (2015b) and reproduced in the lower-right panel of Figure 3.1, the share of expenditure-based (EB) fiscal adjustments has been significantly larger than the share of tax-based (TB) adjustments in most countries.

There is evidence that cuts to government spending are less costly in terms of output losses than tax increases. The difference is likely to be even stronger in economies which are subject to private-sector deleveraging. Specifically, it is possible that the composition of fiscal adjustments interacts with private-sector deleveraging in important ways. This is likely to have first-order implications for welfare and the optimal design of fiscal adjustments. Consider, for instance, a government consumption cut. To the extent that it has deflationary effects, it raises the real burden of debt, thereby redistributing wealth from borrowers to savers. A likely consequence is that both deleveraging and inequality intensify. A cut to unemployment benefits, in contrast, has an immediate re-distributional effect, but is likely less detrimental to economic activity–unless the highly indebted individuals are also the unemployed.

The focus of section 3.2 is on the output and unemployment effects of public-sector deleveraging, as well as its welfare and distributional consequences. Section 3.3 deals with the macroeconomic effects of private-sector deleveraging, but also how the presence of financial frictions, in the form of borrowing constraints, affects macroeconomic dynamics. Section 3.4 focuses on both factors jointly, since they are conceptually closely related and likely to interact in such a way that potentially adverse dynamics are reinforcing each other. Section 3.5 concludes.

3.2 Public-sector deleveraging

3.2.1 State of the economy and macroeconomic performance

As "public-sector deleveraging" I define efforts by governments to reduce borrowing levels. This may include cuts to government spending and transfer payments or tax hikes

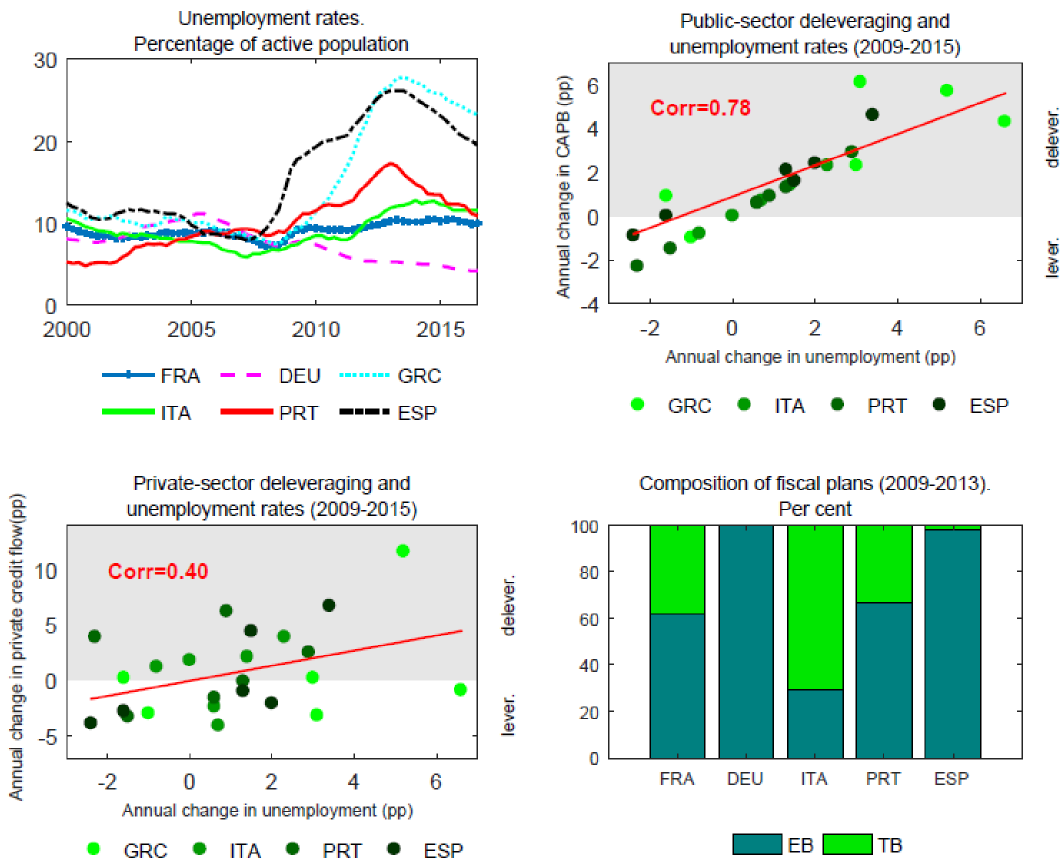

Figure 3.1: Upper-left panel: unemployment rate in selected euro area countries. Upper-right panel: annual change in unemployment rate (horizontal axis) against annual change in the cyclically adjusted primary balance, expressed in percentage of potential GDP (vertical axis), both measured in percentage points. Lower-left panel: annual change in unemployment rate (horizontal axis) against annual reduction in consolidated private sector credit flow, expressed in percentage of potential GDP (vertical axis), both measured in percentage points. Lower-right panel: share of expenditure-based (EB) and tax-based (TB) fiscal adjustments, weighted for size of consolidation. Sources: Eurostat, OECD Economic Outlook No 100, November 2016 and Alesina et al. (2015b).

("fiscal adjustment/consolidation" or "austerity" for short). The focus of this section is on austerity, as to date it remains a highly controversial topic in the academic and policy debate (see, for instance, Alesina et al. (2019)). The complexity of the issue is such that economists disagree on the size and even on the sign of the effects on GDP. For instance, Auerbach and Gorodnichenko (2013) find negative multipliers during expansions. Alesina et al. (2019) present a synopsis of studies estimating government spending multipliers: most of the values range between 0.6 and 1.5. As for tax multipliers, the interval of estimates is even wider, ranging from -0.5 in Evans (1969) to -5.25 in Mountford and Uhlig (2009). These estimates are summarized in Table 3.1. Gechert (2015) applies a meta-regression analysis to a dataset of 104 studies on multiplier effects across a variety of countries and using different statistical techniques. He finds that spending multipliers are close to 1 and about 0.3 to 0.4 units larger than tax and transfer multipliers. Variations in public investment have even larger multiplier effects than those of spending in general by approximately 0.5 units. The effects of fiscal adjustments on the macroeconomy certainly represent a topical issue in view of the recent experience of the euro area. Furthermore, lack of conclusive evidence in this regard keeps alive the everlasting debate about the real extent of austerity. According to many observers (see, for instance, Blyth (2013) and some authors in Konzelmann (2014)), austerity measures have been excessive and are responsible for the poor macroeconomic performance observed in those countries. Dawn and Portes (2012) show that coordinated fiscal consolidation in EU countries during the Great Contraction has had larger negative impacts on growth than expected and raised rather than lowered debt-to-GDP ratios. Other authors take the opposite view (see Alesina and Giavazzi (2013)). More specifically, there is lack of consensus regarding the appropriate timing and composition of austerity. Some authors have argued that sharp fiscal adjustments may make recessions shorter and less painful (see for instance Clinton et al. (2012) and Guajardo et al. (2014)). Others advocate a more gradual approach and support the view that delaying fiscal consolidation until the economy starts recovering is preferable (see Blanchard and Leigh (2013); Corsetti et al. (2010); DeLong and Summers (2012); Fletcher and Sandri (2015)). Importantly, the appropriate timing of austerity may vary on a country-by-country basis. To be more precise, it depends on conditions such as the risk of sovereign default. The appropriate composition of austerity measures is also a subject of debate. While Alesina and Giavazzi in their numerous contributions view spending cuts as less recessionary, Blyth (2013) argues that tax increases are highly preferable.

Austerity differs from conventional fiscal policy measures in that it is typically undertaken under special circumstances and on a larger scale. In this regard, the finding that government spending multipliers tend to be larger during recessions than during booms is particularly noteworthy and has received much attention (Auerbach and Gorodnichenko (2012, 2013)).

Yet, it remains controversial to date. In particular, Ramey and Zubairy (2018) show that high multipliers during recessions might be due to data inconsistent assumptions. Using local projection methods à la Jordà (2005), they find no evidence of high spending multipliers during high unemployment states. Crucially, they demonstrate that most of the differences between their work and that of Auerbach and Gorodnichenko (2012) stem from nonlinear impulse response functions, on which the multipliers are based. Notably, Blanchard and Leigh (2013) put forward the hypothesis that fiscal multipliers changed after the crisis. Alesina et al. (2015b) reject this hypothesis on the ground that they find no significant effect of fiscal shocks on the forecast errors for output growth. In contrast, there is little doubt that multipliers are larger in situations when the zero lower bound on interest rates constrains monetary policy (e.g., Christiano et al. (2011)), even though some authors (e.g., Ramey and Zubairy (2018)) find mixed evidence on the size of the multiplier at the zero lower bound. Corsetti et al. (2012b) assess additional determinants of the government spending multiplier and find it particularly large during financial crises–in line with other results on the role of borrowing constraints for the fiscal transmission mechanism (Bilbiie et al. (2008))–as well as in case the exchange rate is fixed. Noteworthy in this regard is the analysis of Born et al. (2013). They find empirical evidence for 17 OECD countries that government spending multipliers are considerably larger under fixed exchange rate regimes and that a small open economy New Keynesian model provides a satisfactory account of the evidence. Spending multipliers change depending on other factors, such as the health of public finances and the occurrence of a financial crisis. Ilzetzki et al. (2013) show also that multipliers in closed economies are larger than in open economies, they are larger in industrial than in developing countries, and negative in high-debt countries. In earlier work, Corsetti et al. (2013b, 2014) investigated to what extent the presence of sovereign default risk–often the trigger of fiscal adjustments–impacts the fiscal transmission mechanism. It turns out that how sovereign default risk, as reflected in default premia, impacts the fiscal multiplier is ambiguous from a theoretical point of view. Born et al. (2019) take up the issue empirically and find government spending multipliers to be larger in the presence of sovereign risk. In a related study, Bandeira et al. (2018) consider a two-country model of a currency union and establish that in a low inflation environment, contrary to what happens in normal times, fiscal adjustment has a negative effect on demand and the private sector is not able to absorb the heightened number of jobseekers. There is thus plenty of evidence that the fiscal multiplier is state-dependent. The timing of austerity is therefore crucial. This is also illustrated by Corsetti et al. (2010) and Corsetti et al. (2012b). Specifically, they have shown that the effectiveness of fiscal stimulus is increased considerably if it induces expectations of future spending restraint. Key in this regard is that spending restraint is expected to take place not before the effective lower bound on nominal interest rate ceases to bind. More recently, House et al. (2019) show that cross-country differences in austerity measures account for a large share of the observed cross-sectional variation in output in advanced economies during the period 2010-2014. Moreover, counterfactual experiments suggest that, without austerity, output losses in Europe would have been substantially lower. Overall, we may conclude that cuts in government spending have, at least at times, adverse effects on macroeconomic performance.

In addition to the state of the economy, the composition of fiscal adjustments also matters for how it impacts macroeconomic performance. Macroeconomic performance, measured by either unemployment or output, is of interest in its own right. It also matters, however, for the success of fiscal adjustments, as it is frequently assessed in terms of the change of the debt-to-GDP ratio (e.g. Müller (2014b)). Using the narrative approach introduced by Romer and Romer (2010) in order to identify fiscal shocks, tax hikes are found to be much more detrimental to economic activity than spending cuts (see Alesina and Ardagna (2010), Alesina et al. (2015a), Alesina et al. (2015b), Alesina et al. (2017) and Alesina et al. (2018b)). Guajardo et al. (2014) confirm this finding, although the difference between spending cuts and tax hikes is less stark according to their estimates. In particular, Alesina et al. (2015a) argue that the effects of fiscal consolidations should be evaluated on the basis of multi-year fiscal plans, rather than on individual fiscal shocks, in order to control for anticipation effects. Using this approach[1], Alesina et al. (2015b) show that there was significant heterogeneity in the effects of austerity policies over the years 2009-13 depending on their composition, but remain silent on the optimality of such adjustments, as this would require a structural model. Alesina et al. (2018b) find that the composition of fiscal adjustments is more relevant than the state of the economy in determining output effects, that is, adjustments based upon permanent spending cuts are consistently much less costly than those based upon permanent tax increases. Using an extended narrative dataset[2], Alesina et al. (2017) find that government spending and transfer cuts reduce output by less than tax hikes. A standard New Keynesian closed economy model with

[1] The model estimated in Alesina et al. (2015a) uses data up to 2007. Alesina et al. (2015b) simulate the model over the years 2009-13 feeding in the actual fiscal plans implemented by ten EU countries and by the United States in those years.

[2] Devries et al. (2011)'s dataset is extended by collecting additional information on every fiscal measure, specifying details on its legislative source for a total of about 3500 measures over the entire sample.

distorting taxes matches these results when fiscal shocks are persistent. The mechanism is as follows: the rising wealth effect on aggregate demand dampens the impact of a persistent cut in government spending, whereas static labor distortions caused by persistent wage tax hikes induce larger shifts in aggregate supply under sticky prices. Erceg and Lindé (2013) perform a model-based analysis of the effects of tax-based versus expenditure-based consolidations in a currency union. Tax-based consolidations turn out to be more costly than expenditure-based ones in the long term, but the opposite holds in the short run. Batini et al. (2012) perform a model-based analysis of the optimal timing and composition of fiscal consolidations and find, instead, that a gradual fiscal adjustment relying on a mix of expenditure cuts and tax increases is more likely to rapidly reduce the debt-to-GDP ratio than a front-loaded one. Moreover, a sharp but temporary increase of taxes accompanied by gradual spending cuts may be desirable in terms of minimizing the output costs of consolidations. Bianchi et al. (2019) investigate the short-run and medium-run consequences of the austerity measures taken in European countries in the context of a two-country model with endogenous technology adoption. They find negative effects on productivity and output, as well as on capital and investment in the adoption of new technologies, which leads to a deeper recession in the short run and a slower recovery. In particular, the negative effects are the strongest when consolidation relies on a labor tax.

3.2.2 The issue of identification

To estimate the causal effects of austerity on the economy, one needs to identify exogenous shifts in fiscal variables, that is, changes in government spending and/or taxes which are not dictated by the cycle or motivated by the need to stimulate the economy. Many techniques have been developed to deal with the identification of the effects of shifts in spending or taxes. The *Vector Autoregression (VAR)* approach, adopted for the first time by Blanchard and Perotti (2002), was one of the first approaches used to identify exogenous shifts in fiscal variables. VARs consist of a system of multiple dynamic equations which are jointly estimated. The residuals in the estimated equations for the policy variables approximate deviations of these variables from a rule. Such deviations, however, also contain the contemporaneous response of fiscal policy to the cycle. In order to measure the effects of exogenous shifts in policy, one needs to back out structural shocks from VAR innovations. Blanchard and Perotti (2002) recover discretionary policy changes in two steps. First, they purge out “the automatic stabilization component” from the VAR innovation relying on

Table 3.1: Selected estimates of spending and tax multipliers on output

Study	Sample	Identification	Spending	Taxes
Evans (1969)	Quarterly, 1966-74	Based on estimates of equations of Wharton, Klein-Goldberger, and Brookings models		-0.5 to -1.7, depending on horizon, type of tax, and model
Blanchard and Perotti (2002)	Quarterly, 1960-67	SVAR, Choleski decomposition with G ordered first	0.9 to 1.29 (peak multipliers)	-0.78 to -1.33 (peak to impact)
Mountford and Uhlig (2009)	Quarterly, 1955-2000	Sign restrictions on a SVAR	0.65 for a deficit-financed increase in spending	-5.25 for a tax decrease that is deficit-financed
Romer and Romer (2010)	Quarterly, 1947-2007	Legislated tax changes, narrative evidence		-3 (peak)
Barro and Redlick (2011)	Annual historical samples	Military spending as instrument for government spending	0.6 to 1	-1.1
Ramey (2011b)	Quarterly, 1939-2008 and subsamples	Military shocks, narrative evidence	0.6 to 1.2, depending on sample	
Auerbach and Gorodnichenko (2013)	Quarterly, 1947-2008	SVAR that controls for professional forecasts, Ramey news, regime switching model	Expansion: -0.3. Recession: 2.2. (-0.4 and 1.7 for defense spending)	

Notes: This table is adapted from Ramey (2016) institutional information about the automatic response of transfer, spending, and taxes to the state of the economy. Second, they assume that it takes at least one quarter for fiscal policy to react to the state of the economy, so that there is no discretionary deviation from the rule. With these shocks at hand, one can trace their impact on macroeconomic variables. Importantly, it should be noted that the exogenous fiscal shifts crucially depend on the particular specification of the model, that is, a misspecification due to the omission of relevant variables could contaminate innovations. Moreover, the exogeneity of the policy shifts extracted from innovations in policy variables rests on a specific assumption; for instance, on the assumption that it takes at least one quarter for the fiscal authority to respond to the state of the economy. Another drawback of the VAR approach relates to fiscal foresight, that is, if fiscal policy measures are anticipated, it is difficult to recover structural shocks from VAR innovations[3]. The quantitative relevance of this argument is, however, unclear, as controlling for anticipation seems not to have a significant impact on the results (see, for instance, Corsetti et al. (2013b); Born et al. (2013)).

An early literature tried to identify exogenous fiscal adjustments using a cyclically adjusted measure of the deficit (e.g., Alesina and Ardagna (2010, 2013); Giavazzi and Pagano (1990)). The issue with cyclically adjusted numbers, however, is that they cannot filter out all policy actions correlated with the cycle, such as discretionary measures adopted in response to a contraction. Another challenge is to isolate the effects of fiscal policy from other concurrent policy interventions, such as devaluations, monetary policy, or labor market reforms, to mention just a few. Perotti (2013), too, in his analysis of large fiscal consolidations stresses how critical other policy changes are. In order to overcome these limitations, a novel approach, known as *narrative identification*, was proposed in the context of fiscal policy by Romer and Romer (2010). Early narrative studies (see Barro (1984); Barro and Redlick (2011); Ramey (2011b,a); Ramey and Shapiro (1998)) focused on military spending buildup during wars, as this was not related to recessions most of the time. However, some military spending may happen in anticipation of a war, thereby affecting private spending before the war begins. Ramey (2011b) addressed this concern using information from *Business Week*–what has then become known as "Ramey's news variable"–to isolate political announcements that led to increases in military spending. Crucially, these estimates are limited to multipliers associated with military spending. Therefore, it is not entirely clear to what extent they can be used to assess the value of

[3]See Ramey (2011b); Leeper et al. (2013) for a detailed discussion of this issue.

multipliers in contexts unrelated to a war or a military buildup. Romer and Romer (2010) went beyond the case of wars analyzing other episodes of exogenous shifts in fiscal variables, namely changes in US federal taxes. The Romers define as exogenous all episodes of changes in US federal taxes from 1947 to 2007 which were motivated by the aim of either improving "long-run growth" or "reducing an inherited deficit". The tax multipliers so estimated are large[4] and have attracted a lot of attention (see, for instance, Favero and Giavazzi (2012)). Devries et al. (2011) have adopted this methodology to construct a time series–known as the "IMF dataset"–of shifts in both taxes and spending for 17 OECD countries during the period 1978-2009. The episodes identified by these authors only include fiscal consolidations, that is, the adjustments are solely motivated by the aim of reducing an inherited deficit. Guajardo et al. (2014) have used this data set to estimate fiscal multipliers for the OECD countries in the sample. Unlike the Romers, they assume that a fiscal measure affects output growth only when it is implemented, while nothing happens at the time of the announcement. Their main finding, consistent with earlier studies based on cyclically adjusted deficits, is that tax-based adjustments are more contractionary than expenditure-based ones. Alesina et al. (2015a) build on the fiscal consolidation episodes identified by Devries et al. (2011) and propose a methodological innovation. They document that fiscal corrections occur in multi-year plans, some are announced in advance whereas other are unexpected and often revised in mid course. Ignoring these possibilities, that is, simulating the effects of isolated one-time shifts in fiscal variables rather than plans, might result in biased estimates of the effects of fiscal consolidation.

The exogeneity of fiscal policy measures identified on a narrative ground, as in Alesina and coauthors (e.g., Alesina et al. (2015a,b, 2018b, 2017, 2018a)), has, however, been challenged (e.g., Born et al. (2019)). These measures, the argument goes, are usually implemented to reduce public debt or budget deficits, which tend to co-move systematically with the sovereign default premium and with the business cycle. As a result, they are likely endogenous with respect to default premia and may not be suited to identify the causal effect of fiscal policy on the sovereign default premium.

[4]Over the course of three years an increase in taxes equivalent to 1% of GDP reduces output by 3%.

3.2.3 Political economy

There is by now an extensive literature on fiscal policy and electoral results[5]. The conventional wisdom suggests that governments tend to get reelected when they increase deficits, because voters reward short-run benefits without internalizing the future costs implied by the government's budget constraint. Contrary to this belief, recent historical evidence on the electoral effects of austerity shows that austerity does not systematically lead to an electoral defeat. Using a sample of OECD countries, Alesina et al. (1998) find that austerity has a weakly positive electoral effect, that is, governments that have reduced deficits are more likely to be reelected. Alesina et al. (2013) analyze large multi-year fiscal adjustments in OECD countries and "find no evidence that the turnover of governments during those periods was significantly higher than the average of the entire sample" (page 532). In fact, they find some evidence that fiscally loose governments are more often subject to electoral losses than average. These results are shown to be robust to alternative specifications, time periods, and countries. Passarelli and Tabellini (2017) confirm that neither small nor large fiscal adjustments are systematically associated with an electoral defeat. They also find no conclusive evidence that only strong and popular governments[6] were reelected after the implementation of fiscal consolidations. In another contribution on the austerity effects on voting, Fetzer (2018) uses regional-level data on spending and voting behavior, as well as individual-level survey data, to argue that the austerity policies in place in the United Kingdom since 2010 have been a fundamental factor behind the Brexit vote. Had austerity not happened, Leave support could have been at least 6 percentage points lower.

3.2.4 Welfare and distributional effects

Fiscal adjustments are often very controversial, not least because of their direct distributional consequences. This holds for cuts in transfers and tax increases, but also for spending cuts, to the extent that public goods are consumed to a different degree by different constituencies or generations. Still, as they impact macroeconomic performance, fiscal adjustments also have indirect distributional consequences–which may or may not offset the direct effects. A key aspect in this regard is the effect of fiscal adjustments on

[5] See Alesina and Passalacqua (2016) for a comprehensive survey.

[6] The "strength" of a government is measured either in terms of its composition–for instance, it may be formed by a coalition of parties–or in terms of stability–a dummy variable equal to 1 if the party has an absolute majority in the house with lawmaking powers.

unemployment. Another important aspect is that the short-run and long-run effects of fiscal adjustments may differ. Coenen et al. (2008), for instance, find that fiscal consolidation gives rise to sizable short-run adjustment costs, but has positive long-run effects on key macro variables such as output and consumption (see also Born et al. (2019)). Given the (immediate) distributional implications, specific preferences of a given society play a pivotal role in determining the appropriate composition of austerity measures (Müller (2014a)). To date, only a few studies have looked at the distributional effects of fiscal consolidation. These studies suggest that austerity measures are generally associated with an increase in poverty and an increase in income inequality. Mulas-Granados (2005) examines a sample of 53 adjustment episodes occurred in the fifteen EU Member States between 1960-2000 and shows that expenditure-based adjustments may be expansionary under specific circumstances, albeit at the expense of higher income inequality, whereas the opposite is true for revenue-based adjustments. Using a sample of 17 OECD countries over the period 1978–2009, Ball et al. (2013) find that fiscal consolidations tend to raise inequality and long-term unemployment. Furthermore, spending-based adjustments are found to have larger inequality effects than tax-based adjustments. Agnello and Sousa (2014) analyze a panel of 18 industrialized countries and find that, while spending-based consolidation seems to be detrimental for income distribution, tax increases seem to have an equalizing effect. Woo et al. (2017) show that the composition of consolidation measures also matters: progressive taxation and targeted social benefits can help offset some of the adverse distributional effects of consolidation. In conclusion, the literature on welfare and distributional effects of fiscal consolidation is still at an early stage; therefore, more research is needed to attain a more comprehensive understanding of austerity.

3.3 Private-sector deleveraging

3.3.1 Macroeconomic performance

As "private-sector deleveraging" I define efforts by the private sector to reduce borrowing levels. Such efforts may be a result of deliberate decisions by borrowers in light of reduced net worth, less benign or less certain income prospects. It may also be imposed by lenders which seek to repair their own balance sheets. Importantly, just like in case of public deleveraging, such efforts may fail to lower the level of debt relative to current GDP in the short run because of their contractionary effect on economic activity. In a series of influential papers, Atif R. Mian and Amir Sufi have illustrated the importance of both the build-up of private-sector debts prior to the crisis, as well as the severe consequences of private-sector deleveraging. Notably, they make use of zip-code data to identify the effects of private-sector deleveraging, without relying on a fully-specified model. A benefit of such an approach is that one can limit the number of restrictive assumptions. Mian et al. (2013) and Mian and Sufi (2014a,b, 2016) present evidence for the United States and, in particular, its counties. They document both the dramatic increase of household debt between 2000 and 2007 and the severe consequences of the house price collapse for consumption and employment after 2007. More specifically, they find that household leverage is a powerful predictor of the ensuing recession and that the response of consumption to a drop in asset prices depends on the extent of leverage. Mian and Sufi (2016) document similar effects for an unbalanced panel of 30 countries and data for 1960–2012. Similarly, Jauch and Watzka (2012) find that the level of household-sector debt in Spanish provinces in 2007 predicts changes in aggregate demand and accounts for about one third of the increase of unemployment between 2007 and 2010. At a more general level, Schularick and Taylor (2012) document that financial crises are preceded by excessive growth of private debt made possible by failures in the operation and/or regulation of the financial system.

3.3.2 Borrowing constraints

Eggertsson and Krugman (2012) present a tractable modeling framework to study the macroeconomic implications of private-sector deleveraging. A key result of their analysis is that a large deleveraging shock pushes an economy to the zero lower bound. In their framework, a fraction of households is impatient and borrowing-constrained. Deleveraging results from an exogenous tightening of the borrowing constraint. In the event, natural interest rates may fall so much that monetary policy becomes constrained by the zero lower bound and the economy enters a severe recession. Benigno et al. (2016b) develop a model with richer dynamics. Dynamic deleveraging is shown to amplify the effect of monetary policy at the zero lower bound as it directly affects the natural rate of interest. In open economies there are additional complications of the deleveraging process. Benigno and Romei (2014) examine the international implications of debt deleveraging in one country and study the spillovers onto the world economy through trade and the exchange rate. The adjustment to the deleveraging shock requires movements in the exchange rate and the real interest rate. The former rebalances resources across countries. The latter's movements depend on home bias in consumers' preferences. Fornaro (2018) analyzes deleveraging countries which operate within a currency union and finds that the impossibility of depreciating the currency amplifies the fall in consumption and the downward pressure on the interest rate. As a result, deleveraging can lead to a liquidity trap and an aggregate recession. In related work, Kuvshinov et al. (2016) build on this literature, but, rather than assuming that an entire economy deleverages, they assume that there are borrowing-constrained and unconstrained households within a country. They further assume that wages are downwardly rigid as in Schmitt-Grohé and Uribe (2016) and that the economy operates within a currency union. They find that the deleveraging shock lowers domestic output strongly. Yet, the real exchange rate may fail to depreciate if there are sizable inflation spillovers to the rest of the union. This, in turn, depends on the size of the crisis country relative to the rest of the union. As stressed above, private-sector deleveraging may be the result of a reduction of credit supply, but also of a reduction of credit demand. A reduction of credit demand is likely to result if households' net worth collapses or if income and/or employment risk increase and households expect to be borrowing-constrained in some states of the world. In this case, the desire to raise precautionary savings becomes a severe drag on aggregate demand. Guerrieri and Lorenzoni (2017) study a tightening of borrowing constraints in an heterogeneous-agent incomplete-market model. As a result, in their analysis credit demand declines in addition to the reduction of credit supply. They find a negative impact on interest rates and output even if prices are flexible, although the output drop is larger with sticky prices. Similarly, the analysis of Jones et al. (2011) features both credit supply and credit demand effects. They find that deleveraging alone cannot account for the large drop in unemployment in the United States. Still, in the presence of other shocks, as a result of which the zero lower bound becomes binding, deleveraging intensifies and accounts for about half of the decline in employment. Justiniano et al. (2015) explore the role of borrowing constraints jointly with house prices. They find that the credit cycle in the United States cannot be accounted for by exogenous shifts in credit availability but was more likely driven by factors that affected house prices more directly. However, they also point out that the macroeconomic consequences of the leveraging cycle are relatively minor within the class of dynamic general equilibrium models they consider, since the responses of borrowers and lenders wash out in the aggregate.

There is by now a nascent literature which explores the interaction of borrowing constraints and uncertainty and documents sizable effects. Bayer et al. (2019) quantify the aggregate consequences of precautionary savings and portfolio adjustments in response to shocks to household income risk in a model with two types of assets. Higher income risk leads to increasing precautionary savings and to a portfolio rebalancing toward the liquid asset, as it provides better short-run consumption smoothing. Challe and Ragot (2016) analyze the macroeconomic implications of time-varying precautionary saving over the business cycle in a model featuring both aggregate and idiosyncratic labor income shocks. Due to imperfect insurance against unemployment risk, households respond by adjusting their buffer stock of wealth, which, in turn, amplifies the consumption response to aggregate shocks that affect unemployment. In Den Haan et al. (2018), the interaction of borrowing constraints and sticky nominal wages is shown to amplify the business cycle through precautionary savings. Gornemann et al. (2016) show that in a heterogenous-agent New Keynesian (HANK) model featuring incomplete asset markets households are impacted differently by economic downturns depending on their wealth and other characteristics. Ravn and Sterk (2016) incorporate search and matching frictions in a HANK model and derive tractable results making the assumptions of limited participation in the equity market combined with a borrowing constraint in the bond market. Notably, they address potential equilibrium multiplicity which may be overlooked when solving incomplete markets numerically. In a similar setup, Ravn and Sterk (2017) study the effect of an exogenous increase in job uncertainty. They show that shocks impacting on future job prospects can be amplified significantly by a number of frictions, such as asset market incompleteness.

A relevant strand of literature is concerned with overborrowing in open economies featuring a collateral constraint linked to market prices. This type of collateral constraint gives rise to a pecuniary externality because the price of the object pledged as collateral is taken as given by individual agents but is endogenous in equilibrium. As a result, the economy in normal times borrows more than it would if agents internalized the externality (see, for instance, Bianchi (2011), Bianchi et al. (2016), Jeanne and Korinek (forthcoming), and Bianchi and Mendoza (2018) on optimal time consistent macroprudential policy). In contrast to the overborrowing result, Schmitt-Grohé and Uribe (2019) formally establish that, under plausible parametrizations, the same class of models may feature excessive precautionary saving as a way to self-insure against self-fulfilling crises, which ultimately leads to underborrowing. This result emerges because the collateral constraint model can generate non-convexities in the equilibrium resource constraint, thus giving rise to multiple equilibria, as suggested heuristically by Jeanne and Korinek (forthcoming) and Benigno et al. (2016a) in the context of an economy featuring a stock collateral constraint and a flow

Table 3.2: Selected findings on private deleveraging

Study	Type of study	Main result
Bianchi (2011)	Theoretical Quantitative	Pecuniary externality generates overborrowing in a DE; SP accumulates sufficiently large precautionary savings to make large reversals in capital flows a much lower probability event
Eggertsson and Krugman (2012)	Theoretical Quantitative	Large deleveraging shock pushes an economy to the ZLB and causes a severe recession
Schularick and Taylor (2012)	Empirical	Financial crises are preceded by excessive growth of private debt; smaller deleveraging in crisis episodes in the second half of the twentieth century
Guerrieri and Lorenzoni (2017)	Theoretical Quantitative	Deleveraging causes output drop even with flexible prices but effect is stronger with sticky prices
Mian et al. (2013); Mian and Sufi (2014a,b)	Theoretical Empirical	Response of consumption to asset price drop depends on the extent of leverage

collateral constraint, respectively[7].

Table 3.2 summarizes the major findings on private deleveraging discussed above.

3.4 The interaction

A further layer of complexity emerges when studying public and private deleveraging jointly and, specifically, the nonlinear effects arising from their joint occurrence. Public-sector deleveraging, as it triggers a recession and raises the level of unemployment, increases unemployment risk and thus induces an increase in precautionary savings. Private deleveraging, in turn, responds endogenously to public deleveraging as a consequence of lower income being available as collateral (see, for instance, Bianchi et al. (2018)). These features call for a (global) solution of the model under uncertainty while considering occasionally binding constraints and allowing for uncertainty as an amplification mechanism. In a linearized model setup, interaction effects may be captured to the extent that one compares model dynamics across steady states, which differ in the level of private or public indebtedness. Yet, there are additional interaction effects. For instance, as private and public sector deleveraging are both potentially deflationary, a joint deleveraging effort is likely to have more adverse effects than just the sum of the effects of each effort in isolation. Certainty equivalence rules out precautionary saving motives, which imply that the borrowing constraint is not necessarily binding in the stochastic steady state. Therefore, linear approximation methods (see Guerrieri and Iacoviello (2015)) are not able to capture precautionary behavior due to

[7] Ad-hoc calibrations, as in Bianchi (2011) and Ottonello (2015), rule out multiplicity.

the possibility that the constraint may become binding in the future as a result of shocks yet unrealized.[8]

Evidence on how public and private deleveraging interact in shaping macroeconomic outcomes is to date still limited. My second chapter assesses how the interaction of these factors contributed to the output contraction in Greece over the 2010-14 period. Baldacci et al. (2015) conduct an empirical analysis of the effects of fiscal consolidations during periods of private deleveraging. Their sample covers 107 countries and 79 episodes of public debt reduction during the period 1980 to 2012. They find that expenditure-based, front-loaded fiscal adjustments reduce growth, whereas gradual fiscal adjustments that rely on a mix of revenue and expenditure measures can support output growth and reduce public debt. Klein (2017), in another empirical analysis, finds that the costs of fiscal consolidations depend on the level of private indebtedness: they are high when private debt is high and low (or non-existent) when private debt is low. Klein and Winkler (2018), in turn, find that austerity leads to a strong and persistent increase in income inequality, but only during periods of private debt overhang. Unlike the previous studies, which do not make a distinction with respect to the initial level of inequality, Brinca et al. (2016) stress its relevance and document a strong correlation between wealth inequality and the magnitude of fiscal multipliers. They establish that the fiscal multiplier is highly sensitive to the fraction of population facing borrowing constraints and negatively related to the average wealth level in the economy. A model-based analysis by Batini et al. (2015) also illustrates how private and public deleveraging may interact. Specifically, they consider a temporary negative house-price shock that reduces the market value of constrained agents' collateral. Private borrowers respond to the tightening of the borrowing constraint by cutting consumption and investment, thus reducing output and government tax revenues. In the event, the government faces a higher debt-to-GDP ratio, which in turn raises the sovereign risk premium and its financing costs. Andrés et al. (2016) study a small open economy which operates in a currency union and analyze the role of the size, timing, and composition of fiscal consolidations and how these factors interact with private-sector deleveraging. They solve the model under perfect foresight and find that medium-run multipliers, in particular, increase with the size of the consolidation and make the private deleveraging phase longer and deeper. In terms of composition, consolidation programs based on spending cuts or capital tax hikes are found to have particularly adverse effects

[8]At a more general level, local approximation is not well suited in the presence of occasionally binding constraints because it fails to deal with points of non-differentiability.

as they extend the private deleveraging phase. The authors also contrast the welfare effects of alternative consolidation strategies, but in doing so they assume that income risk due to unemployment spells is insured across households. Martin and Philippon (2017) quantify the importance of various factors for the crisis dynamics in the euro area–including private-sector deleveraging and fiscal policy. They rely on a linear semistructural model which combines a basic New Keynesian framework with ad-hoc rules for fiscal policy and private-sector deleveraging. A key result of their analysis is that, had fiscal policy been less expansionary in the build up to the crisis, there would have been less need for austerity during the crisis–given the assumed fiscal rule. They also stress that macroprudential policies interact with fiscal policies: if tighter macroprudential policies had limited the build-up of private debts, fiscal policy–again under their assumed rule–would have been more expansionary and hence would have undone some of the effect on overall indebtedness.

3.5 Concluding remarks

How strong is the interaction of public and private deleveraging? To date, there is still limited evidence about their joint effects, so a definitive answer is not yet possible. In line with previous studies on the individual effects of private and public deleveraging, the timing and composition of fiscal adjustment as well as the (initial) level of private indebtedness seem to be determining factors. This is certainly an interesting area of research, particularly in view of the recent experience of the euro area. The amplification mechanism stemming from the joint occurrence of private and public deleveraging shocks is likely a great force behind the dismal macroeconomic performance of peripheral countries during the Great Contraction. A quantitative assessment of these effects on a country-by-country basis for the periphery of the euro area is, however, still missing. This analysis is required 1) to establish whether the fiscal consolidation measures implemented over the years 2009-13 were the main culprit for the recessions experienced by those countries, 2) to test the alternative hypothesis that the macroeconomic performance was to a larger extent the result of private-sector deleveraging, and ultimately 3) to assess the quantitative relevance of joint deleveraging efforts.

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