



Essays on Macroeconomic Policy

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Thesis submitted for assessment with a view to obtaining the degree of
Doctor of Economics of the European University Institute

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Department of Economics

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I confirm that chapter 2 was jointly co-authored with Ms Evi Pappa and Ms Eugenia Vella, and I contributed 50% of the work, and it draws upon an earlier article published in the *Journal of International Economics* (2015, Volume 96, Edition S1).

I confirm that chapter 3 was jointly co-authored with Ms Evi Pappa and Ms Eugenia Vella, and I contributed 50% of the work. This work was awarded a grant by the European Commission for a workshop titled “Fiscal Policy after the Crisis” and will be published soon as part of the proceedings from this workshop.

Signature and Date:

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01/03/16

Abstract

This thesis looks at the interactions between fiscal, monetary and structural policies along three dimensions.

The first paper looks at the dynamic effects of structural reforms when monetary policy is constrained. Structural reforms entail short run output costs that can be offset by a demand expansion. When monetary policy cannot carry out this short run expansion, there is a role for fiscal policy. In this case, reforms imply a fiscal cost in the short run, which can be justified by a long run improvement in public finances. This paper quantifies the short run costs and long run benefits of potential reforms in Europe. Results show that output losses from reforms can be fully offset with a modest fiscal stimulus. While for product market reforms this cost is justified by the long run fiscal gains, labour market reforms alone do not provide a sufficient boost to long run tax revenues.

The second paper looks at the transmission of fiscal policy in an economy characterised by tax evasion and corruption. Cross-country evidence highlights the importance of these features in determining fiscal multipliers, and VAR evidence suggests that spending cuts reduce tax evasion, while tax hikes increase it. In a model with an underground sector, spending cuts reallocate production towards the formal sector, thus reducing tax evasion. Tax hikes increase incentives to produce in the less productive informal sector, implying higher output losses. Embezzlement of public revenues further amplifies these losses by requiring larger tax hikes to reduce debt. The model corroborates the evidence of increased levels of tax evasion during recent fiscal consolidations in southern Europe.

The final paper compares price-based and quantity-based fiscal adjustments when inflation is low. Focusing on the public wage bill, this translates to fiscal consolidation through cuts to public wages or public employment. In both cases, low inflation eliminates the expansionary effects of the consolidation for the private sector. The drag in economic activity is substantially amplified, with increased debt-to-GDP levels during the consolidation.

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Summary

This thesis consists of three papers looking at the interactions between fiscal, monetary and structural policies.

The first chapter looks at the relationship between structural reforms and fiscal policy, quantifying both the short run fiscal costs of reforms, and the long run impact of reforms on public finances, with the aim of seeing the extent to which the latter justify the former.

The slow recovery of countries within the Euro-area since the Great Recession has been widely documented. In this climate, policy makers are turning to alternative policy measures to boost economic growth, with particular focus on structural reforms. Reducing structural rigidities can improve the efficiency of resource allocation, the competitiveness of countries within the single market and resilience to economic shocks. As well as uncertainty about their future benefits, and their redistributive effects, the main obstacles for carrying out structural reforms are the potential short run costs.

While reforms are expected to increase activity in the long run, this comes at the expense of a short run contraction, which can be countered by short run policy measures to boost demand. These expansionary policies would typically be carried out by monetary policy. Therefore, in situations when monetary policy is constrained, reforms can be costly. As in other contexts, policy makers have looked at the possibility of using fiscal policy to provide the necessary demand expansion, in order to mitigate the short run costs and so reduce the obstacles to reform. While a fiscal expansion can reduce the short run output or employment costs of reform, this can be costly in terms of public debt and deficit, and so requires sufficient fiscal space. The short run fiscal expansion is desirable so long as the reform has a positive effect on public finances in the long run. This is particularly important at a time when fiscal consolidation itself is a key policy concern.

Whether future gains can repay the costs of reforms, and the horizon over which this effect can materialise, is ultimately a quantitative question. This chapter stud-

ies this issue using a general equilibrium model, based on Eggertsson, Ferrero and Raffo (2014), extended to include a richer fiscal block. Reforms are simulated as a transition to a new steady state in which the wage and price mark-ups are reduced. The simulations show that while reforms in normal times boost output in every period, reforms implemented during the zero lower bound (ZLB) crisis entail output losses in the short run. Furthermore, this model shows that the fall in output also leads to a rise in the deficit-to-GDP ratio during the reform, even absent any active fiscal stimulus. These results also hold true in the case where the monetary policy constraint is imposed exogenously and the nominal interest rate is fixed at its steady state. In this case, abstracting from the direct negative effects of the ZLB crisis, the reforms are again found to be contractionary in the short run. Next, an active fiscal stabilisation rule is introduced, which induces a fiscal stimulus that offsets the short run output costs of the reforms under constrained monetary policy. This will entail an additional rise in the deficit, which captures the short run fiscal costs of the reform. In the long run, the deficit will reach a lower post-reform steady state, this is the long run fiscal gains from the reform.

The size of both the long run fiscal gains and the short run cost of the fiscal stimulus will depend on the model parameterisation and the precise reform being considered. In particular, comparing a symmetric reduction in both price and wage mark-ups against the same reduction in either one or the other, referred to as product and labour market reforms respectively, there is a clear advantage in carrying out product market reforms. In fact, labour market reforms create almost no increase in the long run deficit-to-GDP ratio, but still necessitate a short run fiscal stimulus. This is because while the reform increases employment at the new steady state, it also reduces wages, and the net effect on the government's tax revenues is negligible. Of course, another way to interpret this result is that it is necessary to complement labour market reforms with simultaneous product market reforms so that the short run fiscal costs of the former can be justified by the long run gains of the latter.

The aim of the second chapter is to revisit the effects of government expenditure cuts and labor tax hikes on output, unemployment and welfare, when tax evasion and corruption are present. Although the recent fiscal crisis has sparked a considerable amount of research measuring the macroeconomic effects of fiscal consolidations, this literature has left aside these two crucial political economy aspects. This is surprising, given that they are important features in many of the countries adopting consolidation policies, as well as the growing evidence that tax evasion and corruption have increased in recent years.

Many authors have studied whether it is preferable to rely on spending cuts or tax hikes when consolidating the public deficit. Overall, the findings are not conclusive. Indeed, there is strong evidence that the effects of fiscal consolidations are not yet fully understood. Blanchard and Leigh (2013) find that forecasts of output growth systematically underestimate the size of fiscal multipliers. We show that this underestimation of fiscal multipliers is more pronounced in countries with a higher level of tax evasion and/or corruption, suggesting that these two features amplify the effects of fiscal consolidations. Furthermore, we incorporate a time series on informal employment in Italy in a VAR, and identify the effects of fiscal consolidations occurring through a fall in government consumption expenditure or an increase in direct taxes. We find that both types of shocks are contractionary, both reducing output and increasing unemployment. However, tax hikes significantly increase informal employment, while spending cuts reduce it.

To understand the mechanisms driving the results, we reassess the effects of fiscal consolidations in a model with price stickiness, search and matching frictions, endogenous labor force participation, tax evasion and corruption. We find that tax evasion and corruption imply that a larger increase in the tax rate is needed to reduce debt, and this amplifies the distortionary effects of the consolidation. Tax evasion further increases the output losses after a tax hike because workers and firms reallocate resources to the informal sector, increasing inefficiencies since this sector is less productive. On the other hand, government spending cuts create a positive wealth effect which increases consumption and investment and reduces labor force participation. Relative to standard models, tax evasion and corruption increase the size of this wealth effect, thereby increasing the crowding-in of private consumption, and reducing output losses. Agents reallocate their labor search towards the formal sector, first because it is more productive, and second because the formal labor market has a higher matching efficiency and a lower job destruction rate. Hence, the share of shadow employment in total employment is reduced. Labor tax hikes are costly in terms of welfare, but spending cuts typically involve welfare gains, since private consumption increases and labor supply decreases. The latter result is reversed, however, if government spending directly enters the utility of households, or if agents are liquidity constrained.

We use our model to compare the recent consolidation policies in Greece, Italy, Spain and Portugal, all countries that are characterized by both high corruption and tax evasion. Despite the fact that the consolidation plans rely heavily on spending cuts, the model predicts increasing levels of tax evasion in all countries, as well as

prolonged recessions. The largest output losses are observed in Portugal, due to the size of the tax hikes, and Greece, due to the severity of the austerity measures. There are also substantial welfare losses in all countries; the largest occurs in Portugal because of the significant tax hikes in the consolidation package. To quantitatively evaluate the welfare gains from fighting tax evasion and corruption, we perform a counterfactual analysis of the consolidation plans when we reduce the degree of corruption and tax evasion. We find that both battles are worth fighting as they significantly reduce the welfare losses from fiscal consolidation.

The third chapter examines the effects of alternative fiscal consolidation strategies to reduce the public wage bill, specifically comparing price-based measures and quantity-based measures, under different inflation environments. An important feature of the current economic conditions in the EU, which challenges the design and implementation of macroeconomic policy, is inflation uncertainty. With monetary policy constrained by the ZLB, inflation in the euro area has remained below the ECB's medium-run objective for some time. While some recent studies have looked at the impact of the ZLB on fiscal policy, research on the differential impact of inflation on different budgetary items is limited.

Low inflation is generally considered to make fiscal consolidation more difficult. From a theoretical point of view, low inflation reduces the growth in nominal GDP and, all else equal, raises deficit- and debt-to-GDP ratios. Debt dynamics would be left unchanged if nominal interest rates fall by the same magnitude as inflation, thus leaving real rates unchanged. Instead, when nominal rates have hit the ZLB, falling inflation leads to rising real interest rates, making it more difficult to reduce government debt-to-GDP ratios.

Moreover, much of the literature, both theoretical and empirical, has found that fiscal multipliers are higher when monetary policy is constrained. The converse of these arguments is that attempting to carry out fiscal consolidation in a liquidity trap can be very costly, and even self-defeating.

Another important way in which low inflation affects fiscal policy is the fact that inflation shocks can be expected to have a different impact, both in terms of size and timing, across different government revenue and expenditure categories. One dimension of this comparison which has been overlooked is that the effectiveness of consolidation packages that focus on quantity-based measures instead of price-based measures may be different depending on the inflation environment. In that context, reducing the wage bill via cutting wages (price-based measure) or reducing public employees (quantity-based measure) may have a different budgetary impact

depending on the inflation environment.

This chapter aims to uncover the potential effect of a low-inflation environment on these alternative consolidation strategies, with a particular focus on the public wage bill. Recent austerity packages implemented in many European countries, like Greece and Spain, have placed special emphasis on the reduction of the public wage bill. Since the beginning of the crisis in 2008, many countries have been trying to cut government wage bills, by freezing wages and hirings, and cutting or retrenching specific indemnities or benefits.

We develop a DSGE model through which we can study the differential effects of quantity-based and price-based consolidation measures. In particular, we consider a New-Keynesian model of a two-block monetary union, with nominal rigidities in the form of monopolistic retailers facing price-stickiness. In order to build a complete model of the labour market, we incorporate both search and matching frictions, leading to involuntary unemployment, and an endogenous labour force participation decision, leading to voluntary unemployment. Finally, to study the effects of the public wage bill, we allow the government to hire public employees to produce a public good that is used by private firms.

In our model, in normal times, a fiscal consolidation through a cut in public wages is able to reduce the public debt-to-GDP ratio faster than public vacancy costs, although both have similar positive effects on private output through an increase in private-sector hirings. In the case of public wage cuts the increase in private-sector employment dominates the fall in public employment, leading to a fall in the unemployment rate, while in the case of public vacancy cuts the unemployment rate rises. Hence, public wage cuts are a preferable consolidation strategy to public vacancy cuts in normal times.

In a low inflation environment, induced by a negative demand shock, the fall in demand leads to a fall in private output, which, along with the rise in the real interest rate, causes government debt-to-GDP to rise. Hence a much larger cut in the public wage bill is required to bring debt to the desired level, meaning that the consolidation in this environment has large negative effects. The differences between the two instruments appear less pronounced in a low inflation environment; yet, again, public wage cuts lead to a reduction in the long-run unemployment rate, while public vacancy cuts induce a persistent rise in unemployment.

Chapter 1

Structural Reforms under Constrained Monetary Policy: the Case for Fiscal Stimulus

Abstract

Given the weak economic performance of many European countries since the recent crisis, there is an increasing need for structural reforms aimed at promoting long run growth. Reforms entail short run output costs that must be offset by a demand expansion. When monetary policy is constrained and cannot carry out this short run expansion, there is a potential role for fiscal policy. In this case, reforms imply a fiscal cost in the short run, which can be justified if they improve public finances in the long run. The aim of this paper is to quantify the short run fiscal costs and long run benefits of reforms, and investigate how the design of reforms can affect this trade-off. Results show that short run output losses from reforms can be fully offset by allowing a modest fiscal stimulus. While for product market reforms this cost is fully justified by the long run gains, labour market reforms alone do not provide a sufficient boost to long run tax revenues. For major European countries, a modest reform in both product and labour markets is shown to entail between 0.04 – 0.12pp increase in the deficit-to-GDP ratio, and provide a 0.1pp reduction in this ratio in the long run.

1.1 Introduction

Since the recent economic crises, many European countries have continued to exhibit weak economic growth and high unemployment. This has been further exacerbated by both contractionary fiscal policy, as many countries are undergoing fiscal consolidation, and monetary policy that is constrained at the zero lower bound. These short run policy constraints have increased the importance of measures to boost growth in the long run. Particular focus has been on structural reforms aimed at either increasing competition in product markets or increasing the flexibility of labour markets. However, the short run costs associated with these reforms are also affected by these short run policy constraints. In particular, with monetary policy constrained, there is an increasing need for fiscal policy to offset short run output costs while reforms are being implemented. This paper looks at the relationship between reforms and fiscal policy in this context, quantifying both the short run fiscal costs of reforms, and the long run impact of reforms on public finances, with the aim of seeing the extent to which the latter justify the former.

The slow recovery of countries within the Euro-area since the Great Recession has been widely documented. As summarised in the IMF World Economic Outlook, 2015, the Euro-area is still facing increasing levels of public debt, and is struggling to maintain adequate growth levels, with some countries facing especially high levels of unemployment. In this climate, policy makers are turning to alternative policy measures to boost economic growth, with particular focus on structural reforms. Reducing structural rigidities can improve the efficiency of resource allocation, the competitiveness of countries within the single market and resilience to economic shocks.¹ The lack of competition and flexibility in countries such as Spain and Italy have been blamed for worsening the effects of the recent crisis and slowing their recovery. While structural reforms have been a key policy issue in these countries for many years, the crisis has renewed the momentum for their implementation. This can be seen, for example, with the Europe 2020 strategy, which, in contrast to the Lisbon Treaty, has induced active implementation of structural reforms in recent years.²

Despite the reforms which have already been legislated or implemented across Europe, a lot remains to be done. As well as uncertainty about their future benefits, and their redistributive effects, the main obstacles for carrying out structural reforms

¹See, for example, Griffith and Harisson (2004), Duval and Vogel (2008) and Gnocchi et al. (2015).

²See, for example, OECD (2013) and European Commission (2013, 2014) for analyses of the recent reforms implemented in southern Europe.

are the potential short run costs. While reforms are expected to increase activity in the long run, this comes at the expense of a short run contraction, which can be countered by short run policy measures to boost demand. On the one hand, papers such as Eggertsson et al. (2014) and Vogel (2014), which look at structural reforms as reductions in price and wage mark-ups, focus on the short run deflationary effect of reforms, which then require a demand expansion to stabilise inflation. On the other hand, Cacciatore et al. (2016) focus on the transitional costs of reforms by modeling slow or costly product and labour market adjustments. In their framework, reforms are not deflationary, but again the optimal policy response is to use a demand expansion to bring forward the long run gains from the reform.

In both cases, the expansionary policies to offset the short run costs of the reforms would typically be carried out by monetary policy. Therefore, in situations when monetary policy is constrained, reforms can be costly. This argument was made in the early days of the Euro-area, since common monetary policy would no longer respond to inflation in individual countries, and has recently become relevant again with monetary policy constrained by the zero lower bound. As in other contexts, policy makers have looked at the possibility of using fiscal policy to provide the necessary demand expansion, in order to mitigate the short run costs and so reduce the obstacles to reform.

Acknowledging the potential fiscal costs of reforms in a monetary union, the Stability and Growth Pact (SGP) has incorporated explicit exceptions for countries carrying out structural reforms. For example, proposals laid out in 2002 state that “A small temporary deterioration in the underlying budget position of a member state could be envisaged, if it derives from the introduction of a large structural reform” (European Commission 2002). More recently, the European Commission has released a report reiterating the flexibility within the SGP rules for countries carrying out structural reforms (European Commission 2015), and the head of the European Central Bank has repeatedly called for fiscal authorities to facilitate the implementation of structural reforms, stressing that “existing flexibility within the [SGP] rules allows the budgetary costs of major structural reforms to be addressed and demand to be supported” (see Draghi 2014a,b,c).

While a fiscal expansion can reduce the short run output or employment costs of reform, this can be costly in terms of public debt and deficit, and so requires sufficient fiscal space.³ The formulation of the flexibility in the SGP rules highlights the short run to long run trade-off in accommodating the fiscal costs of reform. The

³There can also be direct budgetary costs from some reforms, but these tend to have negligible impact on overall deficit.

short run fiscal expansion is desirable so long as the reform has a positive effect on public finances in the long run.⁴ This is particularly important at a time when fiscal consolidation itself is a key policy concern.

Whether future gains can repay the costs of reforms, and the horizon over which this effect can materialise, is ultimately a quantitative question. This paper studies this issue using the framework of Eggertsson et al. (2014), extended to include a richer fiscal block. Reforms are simulated as a transition to a new steady state in which the wage and price mark-ups are reduced.

In line with Eggertsson et al. (2014), the simulations show that while reforms in normal times boost output in every period, reforms implemented during the ZLB crisis entail output losses in the short run. These results are also extended along two dimensions. Firstly, the fiscal block in this model shows that the fall in output also leads to a rise in the deficit-to-GDP ratio during the reform, even absent any active fiscal stimulus. Secondly, these results hold true in the case where the monetary policy constraint is imposed exogenously and the nominal interest rate is fixed at its steady state. In this case, abstracting from the direct negative effects of the ZLB crisis, the reforms are again found to be contractionary in the short run.

To address the underlying question of this paper, an active fiscal stabilisation rule is introduced, which induces a fiscal stimulus that offsets the short run output costs of the reforms under constrained monetary policy. This will entail an additional rise in the deficit, which captures the short run fiscal costs of the reform. In the long run, the deficit will reach a lower post-reform steady state, this is the long run fiscal gains from the reform. With the parameterisation of Eggertsson et al. (2014), the baseline reform of a 1% reduction in both price and wage mark-ups implies a 0.15pp reduction in the steady state deficit-to-GDP ratio, and active fiscal policy induces a fiscal stimulus of 0.6% of the pre-reform GDP. This costs can be repaid in around 5 quarters at the new steady state.

The size of both the long run fiscal gains and the short run cost of the fiscal stimulus will depend on the model parameterisation and the precise reform being considered. In particular, comparing a symmetric reduction in both price and wage mark-ups against the same reduction in either one or the other, referred to as product and labour market reforms respectively, there is a clear advantage in carrying out product market reforms. In fact, labour market reforms create almost no increase

⁴Of course it should be noted that there are political issues at play here. See, for example, Beetsma and Debrun (2005) for a discussion of the politics of enforcing these ‘flexible’ SGP rules, and Beetsma and Debrun (2004) and Poplawski Ribeiro and Beetsma (2008) for a discussion of the political incentives to implement reforms when facing fiscal rules.

in the long run deficit-to-GDP ratio, but still necessitate a short run fiscal stimulus. This is because while the reform increases employment at the new steady state, it also reduces wages, and the net effect on the government's tax revenues is negligible. Of course, another way to interpret this result is that it is necessary to complement labour market reforms with simultaneous product market reforms so that the short run fiscal costs of the former can be justified by the long run gains of the latter.

To illustrate the short run costs and long run benefits of reforms for relevant parameterisations, the model is re-calibrated for France, Italy and Spain. In the case of France, the baseline reform entails a short run fiscal stimulus of 0.3% of the pre-reform GDP over 2 years, and a long run gain of 0.13pp in the deficit-to-GDP ratio. For Italy and Spain, the short run costs are smaller, at 0.2% and 0.1% respectively, while the long run gains are around the same size, at 0.11pp for both countries. This implies that for Italy and Spain the reforms are much more self-financing in the long run. Furthermore, in the framework of the SGP, this stimulus would require a relatively small deviation from the 3% deficit-to-GDP target, at its peak around 0.12pp, 0.08pp and 0.04pp for the three countries respectively.

The rest of the paper is organised as follows. The next section will lay out the model. Section 1.3 shows comparative statics for different levels of structural rigidities, dynamic simulations of reform episodes, and quantitative comparisons of the size of the fiscal costs and benefits of reform for different parameterisations of the model. Building on these quantitative comparisons, in Section 1.4 compares the effects of different reform packages in France, Italy and Spain. Section 1.5 concludes.

1.2 The Model

The model closely follows that of Eggertsson et al. (2014), henceforth EFR. The economy consists of a two-block monetary union. Each block produces tradable and non-tradable goods using sector-specific labour, which is aggregated from the differentiated labour supplied by households. In each sector, there exist competitive firms using labour to produce intermediate goods, monopolistically competitive firms which use the intermediate goods to produce differentiated goods, and competitive retailers which aggregate these goods into the final goods. Households receive utility from a final consumption good, which is aggregated from non-tradables and both domestically-produced and foreign-produced tradables, as well as disutility from labour. Households save through domestic government bonds and an internationally traded risk-free bond. As well as issuing debt, the government collects taxes to

finance wasteful consumption expenditures.

The following is an exposition of the ‘Home’ block of the union. The ‘Foreign’ block follows the same structure.

1.2.1 Household

There is a continuum of households of mass σ , indexed by j . Each household derives utility from consumption, $c_t(j)$, and disutility from labour, $n_t(j)$. The expected value of the infinite stream of utility is given by:

$$E_0 \sum_{t=0}^{\infty} \beta \mathfrak{B}_t U(c_t(j), n_t(j)) = E_0 \sum_{t=0}^{\infty} \beta \mathfrak{B}_t \left[\frac{c_t(j)^{1-\eta}}{1-\eta} - \frac{n_t(j)^{1+\varphi}}{1+\varphi} \right] \quad (1.1)$$

where β is the discount factor and \mathfrak{B}_t is an exogenous demand shock. In the utility function, η is the inverse of the intertemporal elasticity of substitution and φ is the inverse of the Frisch elasticity of labour supply.

The final consumption good is an aggregate of the tradable and non-tradable goods, given by:

$$c_t(j) = \left[(1-\theta)^{\frac{1}{\xi}} c_{Tt}(j)^{\frac{\xi-1}{\xi}} + \theta^{\frac{1}{\xi}} c_{Nt}(j)^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}}$$

where the tradable consumption good is itself aggregated from domestic and foreign produced goods:

$$c_{Tt}(j) = \left[(1-\alpha)^{\frac{1}{\phi}} c_{Ht}(j)^{\frac{\phi-1}{\phi}} + \alpha^{\frac{1}{\phi}} c_{Ft}(j)^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}}$$

where α captures the openness of the country (the inverse of the home-bias), and ϕ is the elasticity of substitution between domestic and foreign goods.

The intertemporal budget constraint is given by:

$$c_t(j) + b_{Gt+1}(j) + b_{Ft+1}(j) \leq (1-\tau^n)w_t(j)n_t(j) + \frac{R_{Ht-1}}{\pi_t} b_{Gt}(j) + \frac{R_{Ft-1}}{\pi_t} b_{Ft}(j) + \Pi_t(j) + T_t \quad (1.2)$$

where $b_{Gt}(j)$ is the real holdings of domestic government bonds, $b_{Ft}(j)$ is the real holdings of foreign bonds, R_{Ht} and R_{Ft} are the gross nominal interest rates on domestic and foreign bonds respectively, π_t is the gross inflation rate of the CPI, defined below, $w_t(j)$ is the real wage of household j , $\Pi_t(j)$ are the profits from the monop-

olistically competitive firms, which will be discussed below, τ^n represents taxes on labour income, and T_t is a lump-sum transfer from the government.

The household delegates the labour supply decision to a labour union, which will be discussed below, and so takes $n_t(j)$ as given. Thus the household chooses $c_t(j)$, $b_{Gt+1}(j)$ and $b_{Ft+1}(j)$ so as to maximise lifetime utility (1.1), subject to the budget constraint (1.2). Letting $\lambda_t(j)$ denote the multiplier on this constraint, the first order conditions for the households are:

$$c_t(j)^{-\eta} = \lambda_t(j) \tag{1.3}$$

$$\mathbb{B}_t \lambda_t(j) = \beta E_t \mathbb{B}_{t+1} \lambda_{t+1}(j) \frac{R_{Ht}}{\pi_{t+1}} \tag{1.4}$$

$$\mathbb{B}_t \lambda_t(j) = \beta E_t \mathbb{B}_{t+1} \lambda_{t+1}(j) \frac{R_{Ft}}{\pi_{t+1}} \tag{1.5}$$

Note that equations (1.4) and (1.5) imply that in equilibrium $R_{Ht} = R_{Ft}$.

For the optimal level of the final consumption good $c_t(j)$, the households choose the components, $c_{Nt}(j)$, $c_{Ht}(j)$ and $c_{Ft}(j)$ to minimise their expenditure, given the respective prices P_{Nt} , P_{Tt} and P_{Tt}^* . Firstly, for a given $c_{Tt}(j)$, the cost minimisation yields the following demand functions for home- and foreign-produced tradable goods:

$$c_{Ht}(j) = (1 - \alpha) \left(\frac{P_{Tt}}{\mathcal{P}_{Tt}} \right)^{-\phi} c_{Tt}(j) \quad \text{and} \quad c_{Ft}(j) = \alpha \left(\frac{P_{Tt}^*}{\mathcal{P}_{Tt}} \right)^{-\phi} c_{Tt}(j)$$

where \mathcal{P}_{Tt} is the aggregate price of the tradable consumption bundle, defined as:

$$\mathcal{P}_{Tt} = [(1 - \alpha)P_{Tt}^{1-\phi} + \alpha(P_{Tt}^*)^{1-\phi}]^{\frac{1}{1-\phi}}$$

Then, similarly, the composition of tradable and non-tradable consumption satisfies the following demand functions:

$$c_{Nt}(j) = (1 - \theta) \left(\frac{P_{Nt}}{P_t} \right)^{-\xi} c_t(j) \quad \text{and} \quad c_{Tt}(j) = \theta \left(\frac{\mathcal{P}_{Tt}}{P_t} \right)^{-\xi} c_t(j)$$

where P_t is the aggregate price of the final consumption bundle, the CPI, defined as:

$$P_t = [(1 - \theta)P_{Nt}^{1-\xi} + \theta\mathcal{P}_{Tt}^{1-\xi}]^{\frac{1}{1-\xi}}$$

1.2.2 Production

In each sector, labour inputs are used to produce intermediate goods. These goods are sold to a continuum of monopolistic firms which turn them into differentiated goods. Finally, a retailer buys all varieties of these good and produces a final good. For simplicity, the exposition of these steps will be carried out in reverse order, for the sector $k = T, N$, with $\theta_T \equiv \theta$ and $\theta_N \equiv (1 - \theta)$ denoting the size of each sector.

Retailers A competitive retailer aggregates a continuum of differentiated goods, indexed by $i \in [0, 1]$, as follows:

$$y_{kt} = \left[\left(\frac{1}{\theta_k} \right)^{\frac{1}{\epsilon_k}} \int_0^{\theta_k} y_{kt}(i)^{\frac{\epsilon_k - 1}{\epsilon_k}} di \right]^{\frac{\epsilon_k}{\epsilon_k - 1}}$$

where ϵ_k is the elasticity of substitution between the different varieties.

Letting P_{kt} denote the price at which the retailer sells the final good y_{kt} , and $P_{kt}(i)$ denote the price at which they buy each good $y_{kt}(i)$, the profit of the retailer can be written as:

$$P_{kt} y_{kt} - \int_0^{\theta_k} P_{kt}(i) y_{kt}(i) di$$

Note that for $k = T$, this equation assumes that the law of one price holds. The zero-profit condition therefore defines the aggregate price as:

$$P_{kt} = \left(\frac{1}{\theta_k} \int_0^{\theta_k} P_{kt}(i)^{1 - \epsilon_k} di \right)^{\frac{1}{1 - \epsilon_k}}$$

The cost minimisation of this transaction yields the following demand schedule for each differentiated good:

$$y_{kt}(i) = \frac{1}{\theta_k} \left(\frac{P_{kt}(i)}{P_{kt}} \right)^{-\epsilon_k} y_{kt} \quad (1.6)$$

Monopolistic Firms There is a measure of mass θ_k of monopolistic firms producing differentiated goods in each sector. These firms buy intermediate goods at unit price MC_{kt} , and differentiate them with a technology that transforms one unit of intermediate goods into one unit of differentiated goods.

Following Calvo (1983), in any given period each firm can reset their price with a fixed probability $(1 - \chi_p)$. A firm, i , that is able to reset their price chooses the

optimal price level, $\tilde{P}_{kt}(i)$, so as to maximize expected profits given by:

$$E_t \sum_{s=0}^{\infty} \chi_p^s \Lambda_{t,t+s} \left(\tilde{P}_{kt}(i) - MC_{kt+s} \right) y_{kt+s}(i)$$

subject to the demand schedule, (1.6), where $\Lambda_{t,t+s}$ is a stochastic discount factor and $y_{kt+s}(i)$ is the output of firm i .

Since all firms are ex-ante identical, all optimising firms will choose the same optimal price, that is $\tilde{P}_{kt}(i) = \tilde{P}_{kt}$. The resulting expression for \tilde{P}_{kt} , is:

$$\tilde{P}_{kt} = \frac{\epsilon_k}{\epsilon_k - 1} \frac{E_t \sum_{s=0}^{\infty} \chi_p^s \Lambda_{t,t+s} MC_{kt+s} y_{kt+s} (P_{kt+s})^{\epsilon_k}}{E_t \sum_{s=0}^{\infty} \chi_p^s \Lambda_{t,t+s} y_{kt+s} (P_{kt+s})^{\epsilon_k - 1}} \quad (1.7)$$

Intermediate Goods Firms Intermediate goods, x_{kt} , are produced with the following technology:

$$x_{kt} = z_{kt} n_{kt}$$

where z_{kt} is an exogenous productivity factor, and n_{kt} is the aggregate labour input. For a given aggregate nominal wage, W_{kt} , the firm's profit maximisation yields the standard first order condition:

$$W_{kt} = MC_{kt} z_{kt}$$

The labour input is aggregated from the differentiated labour supply according to:

$$n_{kt} = \left[\left(\frac{1}{\theta_k \sigma} \right)^{\frac{1}{\gamma_k}} \int_0^{\theta_k \sigma} n_t(j)^{\frac{\gamma_k - 1}{\gamma_k}} dj \right]^{\frac{\gamma_k}{\gamma_k - 1}}$$

where γ_k denotes the elasticity of substitution between different labour types, and $\theta_k \sigma$ is the mass of households working in sector k in the Home economy. Since this aggregation is costless, the aggregate wage index must satisfy

$$W_{kt} n_{kt} = \int_0^{\theta_k \sigma} W_t(j) n_t(j) dj$$

and is therefore given by:

$$W_{kt} = \left(\frac{1}{\theta_k \sigma} \int_0^{\theta_k \sigma} W_t(j)^{1-\gamma_k} dj \right)^{\frac{1}{1-\gamma_k}}$$

The cost-minimisation problem of the firm gives the following demand schedule for each type of labour:

$$n_t(j) = \frac{1}{\theta_k \sigma} \left(\frac{W_t(j)}{W_{kt}} \right)^{-\gamma_k} n_{kt} \quad \text{for } j \in k$$

1.2.3 Labour Union

The households delegate the labour supply decision to a labour union. As with price-setting, in any given period the union can reset the wage of each household with a fixed probability $(1 - \chi_w)$. When they are able to reset wages, the labour union chooses the optimal wage so as to maximise household utility, subject to the intermediate firm's demand for each labour type.⁵ Hence, the problem of the labour union is:

$$\max_{\tilde{W}_t(j)} E_t \sum_{s=0}^{\infty} (\beta \chi_w)^s \mathbb{B}_{t+s} \left(\frac{c_{t+s}(j)^{1-\eta}}{1-\eta} - \frac{n_{t+s}(j)^{1+\varphi}}{1+\varphi} \right)$$

subject to:

$$\begin{aligned} c_{t+s}(j) &= (1 - \tau^n) \frac{\tilde{W}_t(j)}{P_{t+s}} n_{t+s}(j) + \mathbf{X} \\ n_{t+s}(j) &= \frac{1}{\theta_k \sigma} \left(\frac{\tilde{W}_t(j)}{W_{kt+s}} \right)^{-\gamma_k} n_{kt+s} \end{aligned}$$

where the first constraint is the household's budget constraint, with irrelevant terms subsumed in \mathbf{X} .

As with prices, with ex-post symmetry, this gives the following forward-looking expression for optimal wages:

$$\tilde{W}_{kt}^{(1+\gamma_k \varphi)} = \frac{\gamma_k}{\gamma_k - 1} \frac{E_t \sum_{s=0}^{\infty} (\beta \chi_w)^s \mathbb{B}_{t+s} W_{kt+s}^{\gamma_k(1+\varphi)} \left(\frac{n_{kt+s}}{\theta_k \sigma} \right)^{1+\varphi}}{E_t \sum_{s=0}^{\infty} (\beta \chi_w)^s \mathbb{B}_{t+s} \lambda_{t+s} (1 - \tau^n) w_{kt+s} W_{kt+s}^{(\gamma_k-1)} (n_{kt+s}/\theta_k \sigma)} \quad (1.8)$$

⁵Since the union maximises the household's utility, this is equivalent to the formulation in EFR, and is still optimal from the perspective of the household.

1.2.4 Government

The government's expenditures consist of purchases of domestic non-tradable goods, g_t , and lump-sum transfers, T_t , while revenues come from labour income taxes. The government deficit, net of transfers, is therefore given by:

$$d_t = \frac{P_{Nt}}{P_t} g_t - \tau^n (w_{Tt} n_{Tt} + w_{Nt} n_{Nt})$$

The budget constraint is defined by:

$$\frac{R_{Ht-1}}{\pi_t} b_{Gt} + d_t + \sigma T_t = b_{Gt+1}$$

To ensure stationarity of government debt, transfers respond to deviations of debt from its steady state value, according to the rule:⁶

$$T_t = T_{t-1}^{\rho_T} \left[T \left(\frac{b_{Gt}}{b_G} \right)^{\rho_B} \right]^{(1-\rho_T)}$$

Government consumption expenditures, as a ratio to GDP, react to deviations of output from its steady state according to:⁷

$$\frac{g_t}{y_t} = \left(\frac{g_{t-1}}{y_{t-1}} \right)^{\rho_g} \left[\left(\frac{g}{y} \right) \left(\frac{y_t}{y} \right)^{\rho_y} \right]^{(1-\rho_g)}$$

1.2.5 Equilibrium

Risk-Sharing Notice that idiosyncratic shocks exist due to staggered wage-setting. The existence of contingent assets that allow perfect risk-sharing between domestic households is implicitly assumed, such that all consumption and savings decisions are the same. This implies that the j index can be dropped from the household's first order conditions. Furthermore, each household holds a diversified portfolio of shares in all domestic monopolistic firms. Therefore, the stochastic discount factor of these firms, $\Lambda_{t,t+s}$, can be defined as the generic household's price of transferring one unit of consumption between time t to $t + s$, and is given by:

$$\Lambda_{t,t+s} \equiv \beta^s E_t \frac{\beta_{t+s} \lambda_{t+s}}{\beta_t \lambda_t}$$

⁶Variables without time subscripts denote the steady state values.

⁷In order to differentiate the impact of this fiscal stabilisation rule from the debt-targeting transfers rule, in the remainder of the paper the deficit will be defined net of the deviations of transfers from its steady state.

Goods Market Clearing - Intermediate Goods Recall that the monopolistic firms use one unit of the intermediate good to produce one unit of their differentiated goods, such that:

$$x_{kt} = \int_0^{\theta_k} y_{kt}(i) di \quad (1.9)$$

This gives a simple expression for the aggregate nominal profits of the monopolistic firms:

$$\Pi_{kt} = P_{kt}y_{kt} - MC_{kt}x_{kt}$$

Plugging the demand schedule, (1.6), into equation (1.9) yields:

$$x_{kt} = y_{kt}\Delta_{kt}$$

where the index of price dispersion is defined as:

$$\Delta_{kt} \equiv \int_0^{\theta_k} \left(\frac{P_{kt}(i)}{P_{kt}} \right)^{-\epsilon_k} di$$

Under the Calvo-pricing assumption, the price index can be written as:

$$P_{kt} = \left[(1 - \chi_p)(\tilde{P}_{kt})^{1-\epsilon_k} + \chi_p(P_{kt-1})^{1-\epsilon_k} \right]^{\frac{1}{1-\epsilon_k}}$$

and this equation can be used to derive the law of motion of the price dispersion index:

$$\Delta_{kt} = \chi_p \pi_{kt}^{\epsilon_k} \Delta_{kt-1} + (1 - \chi_p) \tilde{P}_{kt}^{\epsilon_k}$$

where $\pi_{kt} \equiv P_{kt}/P_{kt-1}$ is the inflation rate in sector k .

Goods Market Clearing - Final Goods Using the perfect risk-sharing assumption to aggregate over households, the market clearing conditions in the tradable and non-tradable sectors are given by:

$$y_{Tt} = \sigma c_{Ht} + \sigma^* c_{Ht}^*$$

$$y_{Nt} = \sigma c_{Nt} + g_t$$

Aggregate GDP is defined as:

$$y_t = (P_{Nt}y_{Nt} + P_{Tt}y_{Tt})/P_t$$

Asset Markets To ensure stationarity, the interest rate on foreign bond holdings is assumed to be a function of the level of bond holdings. That is:

$$R_{Ft} = R_t \exp \left\{ \psi \sigma \frac{b_{Ft+1}}{y_t} \right\}$$

where R_t is the union's common nominal risk free rate.

The aggregate household budget constraint, the budget constraint of the government, the zero-profit condition of the intermediate goods producers and the final good producers, yield the following law of motion for the foreign asset holdings

$$\sigma b_{Ft+1} = R_{Ft-1} \sigma b_{Ft} + P_{Tt} \sigma^* c_{Ht}^* - P_{Tt}^* \sigma c_{Ft}$$

where variables with an asterisk denote the Foreign counterparts. Market clearing in the asset markets requires $\sigma b_{Ft} + \sigma^* b_{Ft}^* = 0$.

1.2.6 Union-level Variables

The structure of the Foreign block is symmetric to that of Home block. The population of the union is normalised to 1, so that $\sigma^* = (1 - \sigma)$. Union-wide GDP and inflation rate are thus defined as

$$y_t^U = (y_t)^\sigma (y_t^*)^{1-\sigma}$$

$$\pi_t^U = (\pi_t)^\sigma (\pi_t^*)^{1-\sigma}$$

Monetary Policy There is an independent monetary authority which follows a Taylor rule targeting union-wide inflation, subject to a lower bound, R^{lb} . In particular, they set the interest rate according to:

$$R_t = \max\{R^{lb}, R(\pi_t^U)^{\rho_\pi}\}$$

1.2.7 Structural Reform

This framework gives rise to steady state prices that are a mark-up over marginal costs, and steady state wages that are a mark-up over the household's marginal

rate of substitution between labour and consumption, as seen from the steady state versions of the optimal price- and wage-setting equations, (1.7) and (1.8).

$$P_k = \frac{\epsilon_k}{\epsilon_k - 1} P_k^x$$

$$w_k = \frac{\gamma_k}{\gamma_k - 1} \frac{(n_k/\theta_k\sigma)^\varphi}{(1 - \tau^n)\lambda_t}$$

The size of these mark-ups is determined by the rates of substitution between intermediate goods, ϵ_k , and differentiated labour inputs, γ_k , respectively. These mark-ups are interpreted as structural rigidities arising from excessive regulation.

EFR assume symmetry across the two blocks in the elasticities of substitution, and induce excess rigidities in the non-tradable sector of the Home economy by adding distortionary taxes on wages and prices in this sector. The structural reform is then simulated as a reduction in these tax rates. Instead, in this paper, the asymmetries in regulation are embedded into different elasticities of substitution, and reform is simulated as a direct increase in these elasticities.

Although it may seem more natural to consider tax rates as policy instruments, rather than deep parameters such as the elasticities of substitution, there are two main considerations which lead to the alternative formulation in this paper. Firstly, this formulation differentiates the effects of fiscal instruments, such as tax rates and public expenditures, from the effects of excessive government regulation which gives rise to structural rigidities. While this distinction was not important in the original EFR paper, it becomes particularly important here since the focus is predominantly on the interaction between these two types of macroeconomic policy.

Secondly, in micro-founded models that underlie this setup, government regulations affect the mark-up by augmenting the elasticity of substitution. On the labour side, in models such as Gnocchi (2009), where labour market rigidities are explicitly modelled by centralisation of wage-setting, the degree of centralisation augments the elasticity perceived by the non-atomistic labour union, which determines the mark-up. Similarly, on the product market side, Bilbiie et al. (2012) build a framework with endogenous firm entry in which, depending on the functional form of household preferences, the elasticity of demand for differentiated goods can depend on the number of firms in the market, which in turn depends on the barriers to firm entry.⁸

⁸Lewis and Stevens (2015) use full-information methods to estimate this model, and find that the effect of firm entry on price mark-ups plays a non-negligible role on inflation dynamics. Griffith and Harisson (2004) also find empirical evidence of a reduction in price mark-ups following a reduction in product market regulation.

Hence, familiar structural reforms such as a reduction in the centralisation of wage-setting, or the barriers to firm entry, induce a change in the mark-up which can be mapped directly into a change in the relevant elasticities of substitution. This has no implication for the steady state, since the elasticities only enter the steady state equations through the mark-up. However, it could in principle have some impact on the dynamics, particularly of inflation rates, since they enter the dynamic price-setting equations outside of the mark-up term. Numerically, these differences are negligible for the reforms considered here. Furthermore, allowing time-varying elasticities of substitution could be problematic for the forward-looking price- and wage-setting rules. However, for unanticipated changes, the forward-looking rules are not affected dynamically.

1.3 Results

1.3.1 Calibration

For the purpose of this section, the model is calibrated as in EFR. For the fiscal variables, values common in the literature are used. Table 1.1 shows some of the key values used. Unless otherwise stated, parameters have the same value in the Home and Foreign blocks, which are calibrated as the Periphery and Core of the Euro-area respectively.

Table 1.2 summarises the baseline calibration of the structural rigidities. Wage and price mark-ups are assumed to be equal in a given sector. The tradable sector mark-up in both blocks is set to 15%, and the non-tradable sector mark-up in the Core (Foreign) block to 33%. The non-tradable sector of the Periphery (Home) block is assumed to face “excess” rigidities, here the initial elasticities are set to target a mark-up of 50%.

1.3.2 Examining the Effects of Reform

Figure 1.1 shows the steady states of different variables for values of the non-tradable mark-up ranging from 0 to 100%.

Panel a) shows the effect on relative prices. Increasing the non-tradable sector mark-up increases the price of non-tradable goods both relative to the CPI, and relative to the price of tradable goods. The upward pressure on prices means that the real exchange rate, defined as P^*/P , falls. This implies that, despite the fall in domestic tradable sector prices relative to the CPI, the terms of trade, defined as

Parameter	Description	Value
Preferences		
β	Discount Factor	0.99
η	Inverse Elasticity of Intertemporal Substitution	2
φ	Inverse Frisch Elasticity of Labor Supply	2
ξ	Elasticity of Substitution Tradable/Non-tradable	0.5
θ	Share of Non-tradables	0.6
ϕ	Elasticity of Substitution Home/Foreign	1.5
α	Share of Imported Goods	0.4
Price and Wage Rigidities		
χ_p	Price Stickiness	0.66
χ_w	Wage Stickiness	0.66
Fiscal Policy		
τ^n	Labor Income Tax Rate	30%
g/y	Government Expenditure-to-GDP Ratio	10%
d/y	Government Deficit-to-GDP Ratio	3%
Union-level		
σ	Relative Block Size	0.5
ρ_π	Taylor rule parameter	10

Table 1.1: Parameter Values - Overview

p_T^*/p_T , falls slightly.⁹

Increasing the wage mark-up and increasing the price mark-up will have two opposing effects on the non-tradable sector wage, pushing it up and down respectively. Panel b) of Figure 1.1 shows that when increasing both mark-ups simultaneously, the latter effect dominates and the wage falls. The combination of lower non-tradable wages and a lower price in the tradable sector, lowers the tradable sector wage. This wage falls as much as the non-tradable sector, meaning that the relative wage remains effectively constant.

Panel c) shows the effect of this price- and wage-setting on employment, and hence output. As expected, employment in the non-tradable sector falls as the mark-up rises. Employment in the tradable sector also falls slightly, meaning that the share of employment in the non-tradable sector falls slightly, and total output falls. With a 50% mark-up, total output is almost 15% below the steady state with no mark-up.

⁹The terms of trade and the real exchange rate are both equal to 1 when there is symmetry across the countries, namely when the Periphery non-tradable sector mark-up is equal to 33% as in the Core.

Target Description	Target Value	Parameter
Tradeable Sector Mark-up	1.15	$\epsilon_T = \gamma_T = 7.7$
Core Non-Tradeable Sector Mark-up	1.33	$\epsilon_N^* = \gamma_N^* = 4$
Periphery Non-Tradeable Sector Mark-up	1.50	$\epsilon_N = \gamma_N = 3$

Table 1.2: Parameter Values - Structural Rigidities

To show the effects of the mark-up on public finances, the steady state level of lump sum transfers, T , is calibrated such that the steady state deficit-to-GDP ratio at the baseline calibration with a 50% mark-up is equal to 3%. This level of T is then held constant, and government expenditure is fixed at 10% of GDP. This means that changing the mark-up affects the deficit-to-GDP through changes in tax revenues-to-GDP and through the denominator effect on T/y . Panel d) of Figure 1.1 shows that total tax revenue falls as a fraction of GDP, given the fall in both employment and wages, while transfers as a fraction of GDP rise, as GDP falls. This implies that the deficit-to-GDP ratio rises as the mark-up rises. In fact, for this calibration, mark-ups below around 30% would imply a steady state government surplus, while higher mark-ups can push the ratio up to around 7%.

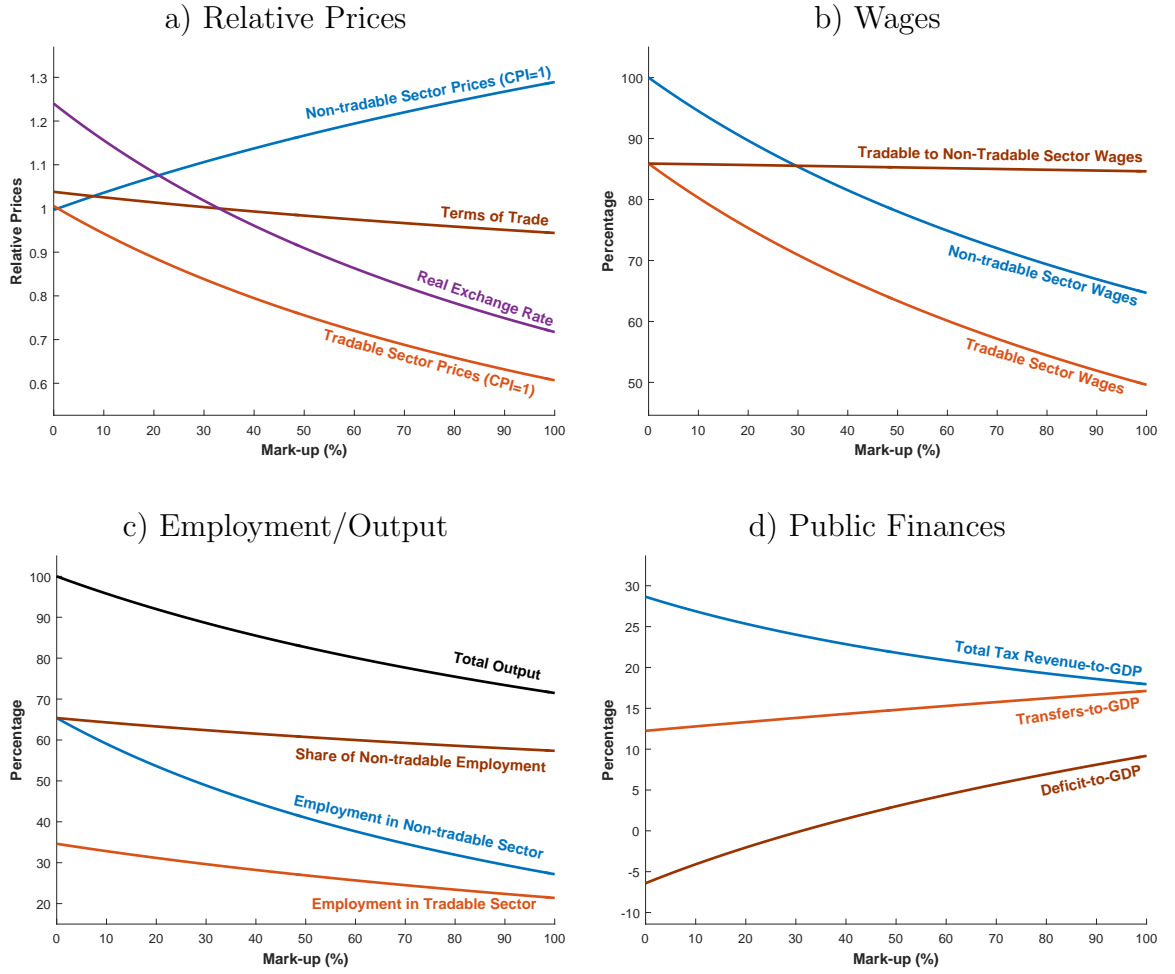
Notice, also, that these effects are not linear: the same increase in the mark-up when it is already very high is smaller than when it is low. In particular, the non-linearity of the effects on wages and non-tradable employment feed into the tax revenues-to-GDP, and hence the deficit-to-GDP rises less steeply as the mark-up increases.

1.3.3 Comparison of Policy Scenarios

This section looks at the short run dynamics following a reform that reduces both price and wage mark-ups in the non-tradable sector of the Periphery block by 1%. The simulation is a deterministic transition from the initial pre-reform steady state towards the new steady state with the lower mark-up.¹⁰

The reform is simulated under different assumptions regarding monetary and fiscal policy. The purpose is to illustrate that a monetary expansion following a reform is necessary for the reform to be expansionary in the short run; without this, reforms reduce output for a few periods. Furthermore, when monetary policy is constrained, active fiscal stabilisation can be used to mitigate the output losses.

¹⁰The transition is based on the fully non-linear solution to the model, and is implemented in Dynare. The simulations are run for 200 periods.



Note: Total Output, as well as Employment and Wages in each sector, are normalised with respect to their level when mark-ups are zero. Tradable Wages in Panel b) and both Tradable and Non-tradable Employment in Panel c) are then shifted down such that the intercept is equal to their ratio with Non-tradable Wages and Total Output respectively.

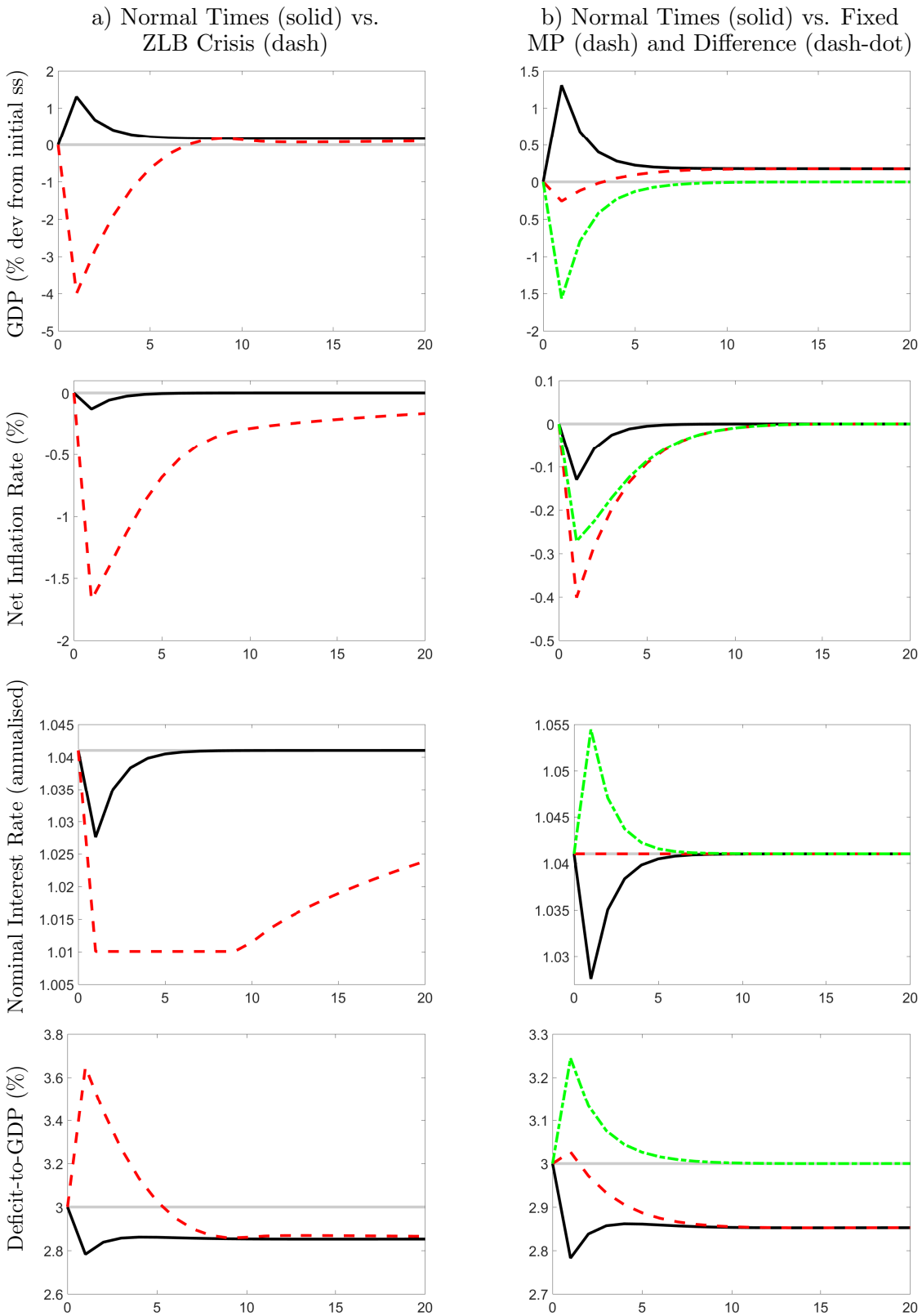
Figure 1.1: Comparative Statics

1.3.3.1 Structural Reforms under Constrained Monetary Policy

To start with, government spending is fixed at its steady state by setting $\rho_y = 0$, and only monetary policy acts to stabilise the economy during the reform.

In order to replicate the results of EFR for the reform at the ZLB, a shock to β_t is assumed to increase the stochastic discount factor and so push the interest rate to $R^{lb} = 1.0025$. Column a) of Figure 1.2 shows the results of these simulations for four key variables: Union-wide output and inflation, the common nominal interest rate and the deficit-to-GDP ratio of the Periphery block.

The solid lines show the effects of reforms in normal times. The reform creates deflationary pressure, which induces a monetary expansion, but the effect on output is positive in every period. On the other hand, as seen in the dashed lines, reforms



All responses are to a 1% reduction in mark-ups. Solid lines in both columns show the reform in normal times. Dashed lines in the first column show the case where the nominal interest rate hits its lower bound, and, in the second column, the case where the nominal interest rate is fixed at steady state. Dash-dotted lines show the difference between the dashed and solid lines, and, for the interest rate and the deficit ratio, are shifted up by the steady state value for ease of viewing. Y-axes show quarters.

Figure 1.2: Alternative Monetary Policy Scenarios

implemented in the ZLB crisis are contractionary in the short run. While the short run contraction in output is predominantly a result of the discount factor shock, rather than the reform directly, this exercise highlights the fact that reforms implemented when monetary policy cannot provide a demand expansion do not provide the same boost to output in the short run. In other words, there is an interaction between the reform and the ZLB shock, and a “naïve” expectation that the effect of the two together is the sum of the two effects is incorrect.

To further illustrate this point, the Column b) of Figure 1.2 shows the effect of the reform under monetary policy which is exogenously fixed at its steady state for a fixed length of time.¹¹ The purpose of this exercise is to abstract from the direct negative demand effects of the ZLB shock, at the same time neutralising the effect of monetary policy, keeping it fixed without any additional expansionary or contractionary effects. Importantly, in this exercise, all responses are directly due to the reform: removing the reform would make all of these responses flat, which is not the case for the simulations with the ZLB shock. The dashed lines show that even without the direct effects of the discount factor shock, the reform is contractionary in the short run when monetary policy is fixed. The dash-dotted lines show the difference between the fixed and active monetary policy, showing the net effect of fixed monetary policy.

The bottom row of each Column of Figure 1.2 shows the response of government deficit-to-GDP ratios for the Periphery block. As shown in the previous section, the reform reduces this ratio in the long run. Without any monetary policy constraint, the ratio falls immediately after the reform. However, the ZLB crisis raises the deficit in the short run, even absent a response of the fiscal instrument. This is partly due to a shrinking of the tax base, but is predominantly a denominator effect from the fall in output. Looking at the case with a fixed nominal interest rate, the deficit ratio rises slightly on impact and falls to the new lower level more gradually. The net effect of fixed monetary policy during the reform, shown in the dash-dotted lines, is to raise the deficit-to-GDP ratio for almost 10 quarters.

1.3.3.2 Structural Reforms with Active Fiscal Policy

This section repeats the same reform simulations, this time allowing government spending to respond by setting $\rho_y < 0$.¹²

¹¹In particular, the monetary policy rule is specified as $R_t = \varepsilon^{MP}R + (1 - \varepsilon^{MP})R(\pi_t^U)^{\rho_\pi}$ and ε^{MP} , a white noise zero-mean process, is set equal to 1 for 10 periods.

¹²In particular, $\rho_y = -200$. This is a very large number but serves only to excentuate the differences in the plots for ease of viewing.

The two Columns of Figure 1.3 again show the two cases of constrained monetary policy, comparing the cases with and without active fiscal policy.¹³ Column a) shows that the fall in output during the ZLB crisis induces a fiscal expansion, which can mitigate the deflationary pressures and thus mitigate the output losses in the short run, as well as speeding up the recovery towards the new, higher level of output. However, this comes at the cost of a larger and more persistent increase in the deficit-to-GDP ratio. In fact, this remains above its pre-reform level even after 20 quarters.

Column b) shows the alternative exercise in which the nominal interest rate is fixed at its steady state. Abstracting from the direct negative effects of the ZLB shock, active fiscal policy can fully eliminate the short run output losses. In this case, output is above the initial steady state in every period following the reform.

Again, the dash-dotted lines show the difference between the cases with and without active fiscal policy, and hence capture the effect of the reform under constrained monetary policy that is attributable to active fiscal stabilisation. In particular, active fiscal policy implies the deficit-to-GDP ratio remains above the pre-reform steady state for around 1 year after the reform, and above the baseline of no active policy for almost 3 years before reaching the new lower steady state.

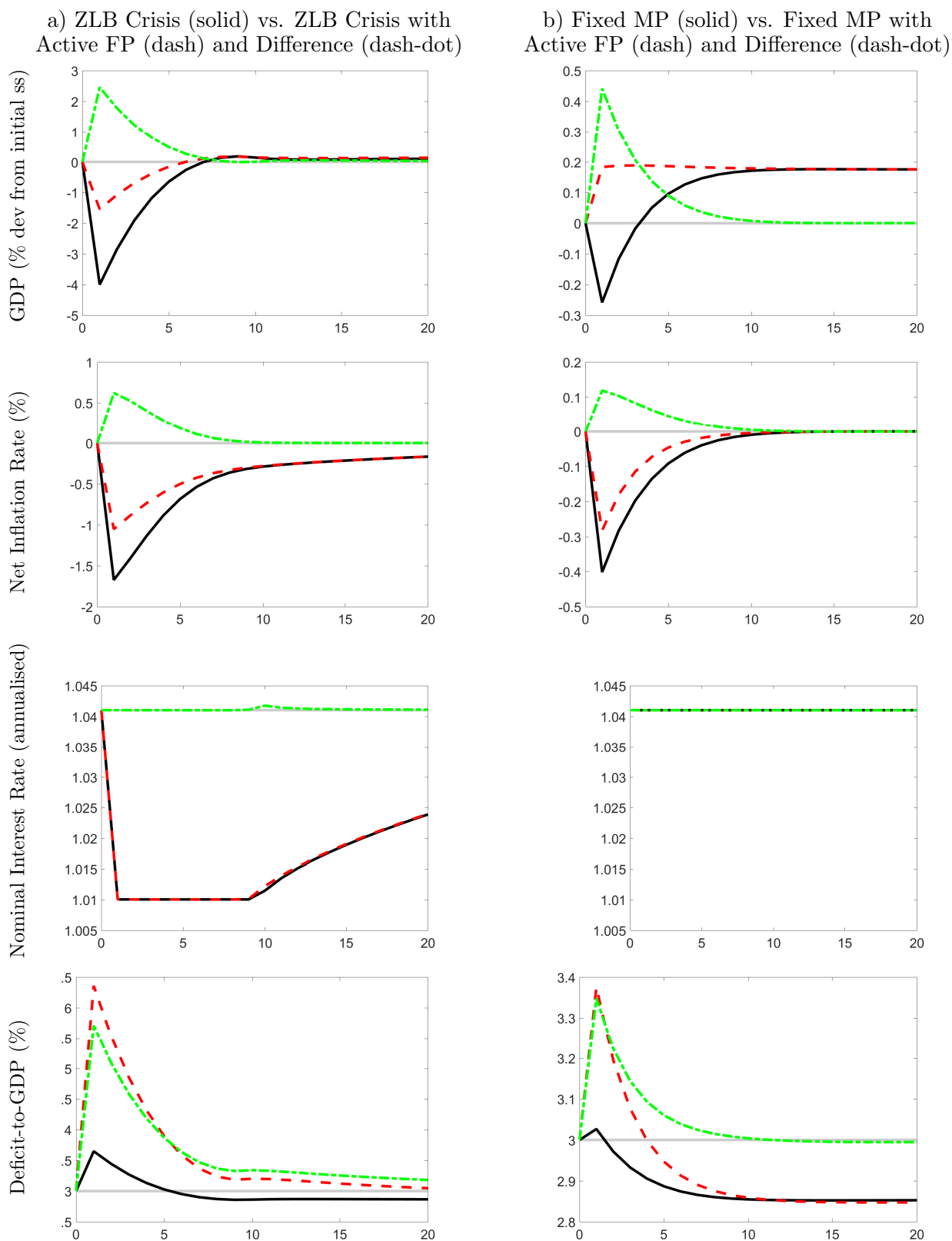
1.3.4 Quantitative Comparisons

The above analysis illustrated, somewhat qualitatively, the contractionary effects of reforms implemented when monetary policy is constrained, and the potential for active fiscal policy to offset the short run costs of reform. This section returns to the underlying question of how large the fiscal costs and benefits of reforms are, and to what extent the latter justify the former.

In this analysis, the value of ρ_y becomes important. In each simulation discussed below, this parameter is set as the smallest integer, in absolute value, such that Home output is above the initial steady state in every period following the reform. This gives the “smallest” fiscal stimulus which fully offsets the output losses of the reform.

To measure the size of this fiscal stimulus, referred to as the short run fiscal cost of the reforms, it is necessary to abstract from the direct effects of the ZLB shock, and isolate the additional effect of the active fiscal response. This means focusing on the difference between the response of deficit-to-GDP under exogenously fixed

¹³There is effectively a form of “monetary dominance” and fiscal policy is not considered to be active during normal times.



All lines show a 1% reduction in mark-ups. The first column shows the case where the nominal interest rate hits its lower bound, and the second column the case where the nominal interest rate is fixed at steady state. Solid lines replicate the dashed lines in Figure 1.2 and dashed lines show the case where government spending responds to deviations of output from steady state. Dash-dotted lines show the difference between the dash and solid lines, and are shifted up by the steady state for the interest rate and deficit. Y-axes show quarters.

Figure 1.3: Alternative Fiscal Policy Scenarios

monetary policy with and without active fiscal policy. In other words, focusing on the dash-dotted lines in the second column of Figure 1.3, which will be referred to as the “excess deficit”. Two summary statistics are extracted from this:

- 1. Cumulative excess deficit in transition** This is the sum of the excess deficit in each period that it is positive. This statistic is expressed as a ratio to the pre-reform GDP, and captures the total size of the short run fiscal stimulus following the reform.
- 2. Peak deficit-to-GDP deviation** This is the largest value of the excess deficit-to-GDP. This statistic captures the amount of fiscal space required to carry out the stimulus, and will be useful for comparison against the provisions in the SGP for deviations from imposed deficit targets.

The long run benefit to public finances is measured by comparing the pre- and post-reform steady states of the model, looking in particular at:

- 3. Fall in steady state deficit-to-GDP** This is the percentage point fall in deficit-to-GDP at the post-reform steady state relative to the initial steady state.

Finally, the extent to which the long run improvement in steady state deficit-to-GDP can justify the short run fiscal costs is quantified as:

- 4. Years to repay** This is the number of years required at the new steady state, such that the ‘excess surplus’, i.e. the lower deficit, adds up to the cumulative excess deficit in transition, as defined above.

Excess Deficit in Transition	Peak Deficit-to-GDP Deviation	Fall in steady state deficit-to-GDP	Years to Repay
0.67%	0.23pp	0.15pp	1.22

Table 1.3: Summary Statistics Under Baseline Calibration

The values of these summary statistics under the baseline calibration are given in Table 1.3. The long run gain from the reform is a 0.15pp improvement in the long run deficit-to-GDP ratio. These numbers correspond to the lines in Figure 1.3, except that here $\rho_y = -10$, which results in a fiscal stimulus with a total cost of 0.67% of the pre-reform GDP. The peak deviation of deficit-to-GDP from the baseline is 0.23pp on impact. At the new lower steady state deficit-to-GDP, this cost can be repaid in just over 1 year.

Clearly, under the baseline reform scenario, the short run costs of carrying out a fiscal expansion are not particularly large and are outweighed by the long run gains. However, the precise numbers depend on the parameterisation of the model and the reforms. This is investigated by looking at the sensitivity of these statistics along two dimensions: firstly how they depend on the calibration of certain model parameters, and secondly how they depend on the reform that is being simulated.

1.3.4.1 Sensitivity to Parameterisation

The summary statistics are computed for different values for the relative size of the Home block, the initial level of the non-tradable sector mark-up, and the size of the government, as captured by the government spending-to-GDP ratio. Table 1.4 shows the different summary statistics.

	Excess Deficit in Transition	Peak Deficit-to- GDP Deviation	Fall in Steady State Deficit	Years to Repay
Relative size of Home block				
20%	0.20%	0.08pp	0.15pp	0.36
30%	0.53%	0.19pp	0.15pp	0.95
50%	0.67%	0.23pp	0.15pp	1.22
Initial Mark-up				
33%	0.62%	0.21pp	0.18pp	0.91
50%	0.67%	0.23pp	0.15pp	1.22
60%	0.67%	0.23pp	0.13pp	1.37
Government Size				
5%	0.61%	0.21pp	0.16pp	1.01
10%	0.67%	0.23pp	0.15pp	1.22
30%	0.88%	0.30pp	0.09pp	2.71

Table 1.4: Sensitivity of Summary Statistics to Parameterisation

Relative Country Size The first panel shows that for smaller countries, the short run fiscal costs are lower. In fact, the value of ρ_y for the different country sizes is -4 , -8 and -10 respectively: the output costs of the reforms are smaller in each case, such that a weaker fiscal response is needed to offset these costs. Since the long run gains are equal, significantly less time to repay the short run costs. The fiscal space required for a smaller country to carry out the reform, in terms of deviation from the SGP objectives, is also much smaller.

Initial Mark-up The second panel shows the results from varying the initial level of mark-ups in the Periphery Non-tradable sector. These results show that both the peak and the the cumulative deficit cost of the reform is slightly lower when the initial level of rigidities are lower. Since the long run gain in deficit-to-GDP is also higher, echoing the non-linearity observed in Figure 1.1, overall the trade-off is larger when markets are initially more rigid, and the costs take longer to repay.

Size of Government The last panel shows the effect of different steady state levels of government spending-to-GDP. In this case, when the government is larger, the fiscal costs of the reform are higher and the long run gains are smaller. This implies considerably longer time to repay: almost 3 years in the case of 30% steady state government spending-to-GDP.

1.3.4.2 Reform Design

The final step of the analysis is to compare different reform scenarios, looking in particular at the size of the reform and whether the reform is in price or wage mark-ups, labelled product market reforms (PMR) and labour market reforms (LMR) respectively. Table 1.5 shows the different summary statistics for these different reforms.

	Excess Deficit in Transition	Peak Deficit-to- GDP Deviation	Fall in Steady State Deficit	Years to Repay
Size of Reform				
1%	0.67%	0.23pp	0.15pp	1.22
5%	3.13%	1.07pp	0.75pp	1.10
10%	5.70%	1.99pp	1.53pp	0.96
Type of Reform				
LMR	0.13%	0.03pp	0.03pp	1.54
50-50	0.67%	0.23pp	0.15pp	1.22
PMR	0.62%	0.24pp	0.12pp	1.33

Table 1.5: Sensitivity of Summary Statistics to Reform Design

Reform Size The first panel shows the results from varying the size of the reform, comparing the baseline scenario of 1% to 5% and 10% mark-up reductions. The effects here are almost precisely linear, although the overall years to repay does fall slightly. On the other hand, the larger reforms do imply larger deviations of deficit

from steady state, with the 10% reform requiring a 2pp deviation of deficit-to-GDP. However this is clearly justified by the equally larger long run gains.

Reform Type Finally, the second panel explores the possibility of carrying out asymmetric reforms in product and labour markets. In particular, the symmetric 1% reduction in both price and wage mark-ups is compared against a 1% reduction in either price or wage mark-ups. These results show that product market reforms are much more costly than labour market reforms. However, a pure labour market reform, while implying only negligible deviation from the steady state deficit-to-GDP, also implies a very small gain in long run deficit-to-GDP. This is because while the reform increases employment, it also reduces wages, and this has a negative effect on the tax base. Accordingly, the trade-off between consolidation and reform is higher for labour market reforms.

1.4 Cross-Country Comparisons

Having seen the qualitative effects of reforms under alternative monetary and fiscal policy scenarios, and investigated quantitatively how these effects depend on the model parameterisation, this section now uses this to inform a comparison of reform scenarios for different countries. Specifically, the model is re-calibrated to represent different countries in the Euro-area and look at the size of fiscal costs and benefits from different reform scenarios.

1.4.1 Calibration

The entire economy is taken to be made up of the four largest Euro-area economies: France, Germany, Italy and Spain. In accordance with the comparisons carried out above, for each of France, Italy and Spain, the relative size of the Home country, the steady state government deficit-to-GDP and expenditure-to-GDP ratios, and the initial mark-up in both the tradable and non-tradable sector are re-calibrated. In each case, the Foreign block is then calibrated to be the weighted average of the remaining three countries. Table 1.6 summarises the values used; all other parameters are kept at their baseline values.¹⁴

¹⁴The openness parameter, α , is altered in each case to remain just below the relative size of the country. This is necessary to ensure a feasible steady state is found.

Country	Country size, σ	Deficit-to-GDP, d/y	Government size, g/y	Tradable Mark-up	Non-tradable Mark-up
France	30%	4%	25%	12%	26%
Germany	35%	-1.7%	20%	13%	25%
Italy	20%	3.5%	20%	15%	38%
Spain	15%	5%	20%	14%	40%

Note: Country size based on relative GDP. Government size given by final consumption expenditure of general government. All data come from Eurostat and refer to averages 2004-2013, except the estimates of mark-ups, which are taken from Hoj et al. (2007). For Spain, for which data is unavailable, the OECD's Product Market Regulation Index is used, and mark-ups are set at a slightly higher mark-up level than Italy. Hoj et al. (2007) show that their estimates are significantly correlated with this index.

Table 1.6: Calibration for Different Countries

1.4.2 Baseline Dynamics

Figure 1.4 shows the dynamics of output and deficit-to-GDP following the baseline 1% reform in both price and wage mark-ups.

The reform implemented in France entails the largest fall in output in the short run, as well as the largest gains in the long run. Accordingly, the gain from a fiscal expansion during the reform are also larger. The costs of active fiscal policy are slightly larger than the other two countries: at the peak, there is just over 0.1pp deviation from the baseline deficit-to-GDP ratio, and the excess deficit-to-GDP takes around 2 years to disappear. The gain in the deficit ratio in the long run is also just over 0.1pp.

The reform in Italy has smaller negative effects in the short run, since it is a smaller country, and accordingly a smaller fiscal stimulus is needed, while the long-run gain in deficit-to-GDP is only slightly lower than in France. Finally, in Spain, the smallest country in this group, the reform has negligible and very short lived output costs, and so the necessary fiscal stimulus is much smaller, and disappears slightly faster, with the deficit-to-GDP ratio reaching the new steady state, which is again just over 0.1pp lower, after around 6 quarters.

1.4.3 Alternative Reforms

Finally, the summary statistics, introduced above, are shown for each country for different reform scenarios. In particular, the baseline reform is compared to a larger reform of a 5% reduction in price and wage mark-ups, and to 1% reductions in the price and wage mark-up separately.

The results are shown in Table 1.7, which also shows the long run gain in output

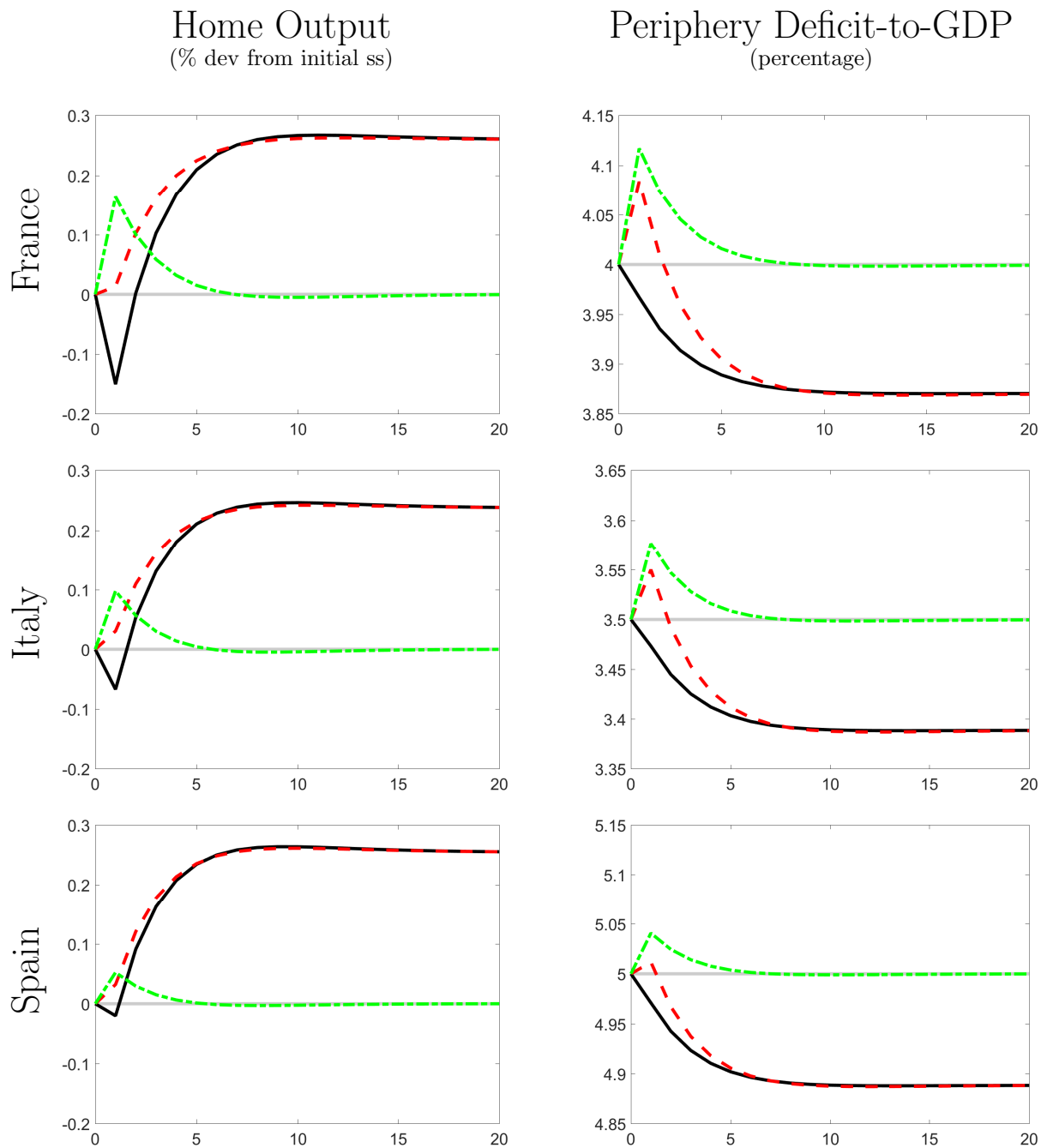


Figure 1.4: Baseline Reforms in Different Countries

for each reform, as a percentage of the pre-reform steady state. The output gains from reform in Italy and Spain are not much larger than France, although they start at higher mark-up levels. The long run gain from PMR and LMR are identical in each case, and, despite potential interaction effects through price- and wage-setting, the effect of the baseline reform in both markets is the sum of the two effects. The output effects of the larger reform scenario are, again, broadly linear.

	Gain in Steady State Output	Excess Deficit	Peak Deficit-to-GDP Deviation	Fall in Steady State Deficit	Years to Repay
France					
Baseline Reform	0.26%	0.31%	0.12pp	0.13pp	0.65
Larger Reform	1.31%	1.49%	0.57pp	0.66pp	0.60
LMR Only	0.13%	0.15%	0.03pp	0.01pp	36.77
PMR Only	0.13%	0.18%	0.09pp	0.12pp	0.37
Italy					
Baseline Reform	0.24%	0.19%	0.08pp	0.11pp	0.46
Larger Reform	1.20%	0.93%	0.38pp	0.57pp	0.44
LMR Only	0.12%	0.18%	0.04pp	0.01pp	7.77
PMR Only	0.12%	0.06%	0.04pp	0.10pp	0.16
Spain					
Baseline Reform	0.25%	0.10%	0.04pp	0.11pp	0.24
Larger Reform	1.29%	0.48%	0.20pp	0.57pp	0.24
LMR Only	0.13%	0.11%	0.02pp	0.01pp	4.37
PMR Only	0.13%	0.00%	0.00pp	0.10pp	0.00

Table 1.7: Alternative Reform Design in Different Countries

In terms of fiscal costs, in the case of France the baseline reform entails a short run fiscal cost of 0.31% of the pre-reform GDP, and a long run gain of 0.13pp in the deficit-to-GDP ratio. At its peak, the fiscal stimulus requires a 0.12pp increase in the deficit-to-GDP ratio. The costs of this reform can be repaid in just over 2 quarters at the new steady state. As before, increasing the size of the reform increases the short run costs and long run benefits in a linear fashion, and so the time to repay the costs is about the same. The peak deficit-to-GDP deviation remains modest at 0.66pp. Again the labour market reforms entail almost no increase in the long run deficit-to-GDP ratio, and so the short run costs are unfeasible to repay. On the other hand, while the pure product market reform has a slightly larger fiscal cost than the labour market reform, it achieves a sizeable long run gain in the deficit-to-GDP ratio, close to the gain from the baseline reform. Hence this reform is much more self-financing, and the costs can be repaid in just over one quarter.

There is a similar picture for Italy. Here the short run costs of all reform scenarios

are smaller, because of the smaller size of the country, while the long run gains are a similar size. Hence the costs can be repaid even faster than the case of France. Again, increasing the size of the reform does not affect this time to repay, but still does not require a larger deviation in deficit-to-GDP, with a peak value of 0.57pp. Once again, labour market reforms are unfeasible as they effectively do not improve the long run deficit-to-GDP level, while pure product market reforms are much less costly and can be repaid, in this case in well below 1 quarter.

Last but not least, the case of Spain again shows a similar pattern with respect to the different reform scenarios. What is particularly interesting here is that the pure product market reform actually does not require any fiscal stimulus: even with constrained monetary policy, the country is sufficiently small that the reform is not contractionary in the short run.

1.5 Summary and Concluding Remarks

In the current climate with constrained monetary policy in the Euro-area, policy makers have been discussing the role of fiscal policy in offsetting the short run costs of structural reforms. In order to understand whether a government should invest time and public expenditure on the costs of structural reforms, it is important to compare the potential short run costs to the effects of those reforms on public finances in the long run. In particular, reforms which boost economic growth can improve the fiscal balance in the long run, and so be self-financing.

This paper used the framework of Eggertsson et al. (2014) to show that that reforms implemented when monetary policy is constrained are contractionary in the short run. Furthermore, the fall in output also leads to a rise in the deficit-to-GDP ratio during the reform, even absent any active fiscal stabilisation, before this ratio reaches a lower post-reform steady state. An active fiscal stimulus can offset the short run output costs of reform, but will lead to an additional rise in the deficit, which captures the fiscal cost of the reform under constrained monetary policy.

The costs and benefits from the reforms depend on the size of the block implementing the reform, with a larger size implying both higher costs and higher benefits, such that the tradeoff is relatively stable. Countries with a higher initial level of non-tradable mark-up, or a higher steady state level of government spending-to-GDP, can expect lower long run gains from implementing the same reform, such that the short run costs are harder to justify. The long run gains are obtained predominantly from the reduction in price mark-ups, while labour market reforms aimed

at reducing wage mark-ups entail negligible long run gains in deficit-to-GDP. This can either be interpreted to mean that the short run fiscal costs of labour market reforms are not justified by their long run gains, or that labour market reforms need to be complemented with product market reforms.

The analysis in this paper focused on the primary deficit as the measure of public finances. However, some of the countries facing the highest need for reforms also faced particularly high borrowing costs throughout the crisis, increasing the costs of fiscal stimulus. Indeed, while this paper considered the SGP as the main fiscal constraint facing Euro-area countries, country risk premia can be considered as market-imposed fiscal constraints, and can be looked at in analogous way. In particular, during a fiscal crisis when spreads are high, not only are borrowing costs high, the market may react negatively to any sign of a lack of fiscal restraint. On the other hand, if fiscal stimulus is accompanied by structural reforms, fiscal expansion should not be considered as a sign of unsustainable debt in the long run.

Two further potentially interesting extensions present themselves. Firstly, considering alternative fiscal instruments could produce very different effects. This is true for both the debt-targeting fiscal rule and the fiscal stabilisation rule. As the former rule is not of interest in itself in this paper, and is only used to ensure determinacy of public debt, lump-sum transfers are the natural policy instrument to keep this neutral. However, considering alternative instruments for this rule is non-trivial in this setting, firstly because it acts as a destabilising rule. Hence if government consumption expenditures are used here, this would interfere with the fiscal stabilisation. At the same time, if distortionary taxes were used, for either of the fiscal rules, this would interfere with the reform process. Both labour income and consumption taxes are effectively a part of the wage and price mark-ups, respectively. Hence raising or reducing these tax rates during a reform would act like reducing or amplifying the reform itself. In terms of stabilisation, while a tax-based stimulus could offset the effects of the reform, the reduction in the tax rates would imply a further reduction in the mark-up, which could amplify the effects of the reform.

Finally, it would be interesting to introduce capital into the model. On the one hand, the existence capital can change the effects of the discount factor shock on the macro-economy: an increased desire to save can be channeled towards investment, thereby boosting aggregate demand. Structural reforms will also have a similar effect in the presence of capital, as the expectation of higher future productivity will increase investment and mitigate the short run contractionary effects of the reform. On the other hand, this would rely on a functioning financial intermediation sector.

In the presence of financial frictions, this could increase the desirability of targeted fiscal spending to alleviate credit constraints and so bring forward the long run effects of the reform. These extensions are left for future research.

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Chapter 2

Fiscal Consolidation with Tax Evasion and Corruption

This is joint work with Evi Pappa and Eugenia Vella, and is published as:
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Abstract

Cross-country evidence highlights the importance of tax evasion and corruption in determining the size of fiscal multipliers. We introduce these two features in a New Keynesian model and revisit the effects of fiscal consolidations. VAR evidence for Italy suggests that spending cuts reduce tax evasion, while tax hikes increase it. In the model, spending cuts induce a reallocation of production towards the formal sector, thus reducing tax evasion. Tax hikes increase the incentives to produce in the less productive shadow sector, implying higher output and unemployment losses. Corruption further amplifies these losses by requiring larger hikes in taxes to reduce debt. We use the model to assess the recent fiscal consolidation plans in Greece, Italy, Portugal and Spain. Our results corroborate the evidence of increasing levels of tax evasion during these consolidations and point to significant output and welfare losses, which could be reduced substantially by combating tax evasion and corruption.

2.1 Introduction

When there is an income tax, the just man will pay more and the unjust less on the same amount of income. Plato, *The Republic*, Book I, 343-D

The recent fiscal crisis has sparked a considerable amount of research measuring the macroeconomic effects of fiscal consolidations.¹ This literature, however, has left aside two crucial political economy aspects, namely the presence of tax evasion and corruption. This is surprising, given that they are important features in many of the countries adopting consolidation policies, as seen in Figure 2.1. In addition, there is growing evidence that tax evasion and corruption have increased in recent years. For example, a recent report by the technical staff of the Spanish Finance Ministry (Gestha, 2014) indicates that the shadow economy in Spain increased by 6.8 percentage points between 2008 and 2012, reaching 24.6% of GDP. At the same time, a special Greek police task force reported in 2013 that the number of cases of public corruption increased by 33% between 2011 and 2012.² The aim of this paper is to revisit the effects of government expenditure cuts and labor tax hikes on output, unemployment and welfare, when tax evasion and corruption are present.

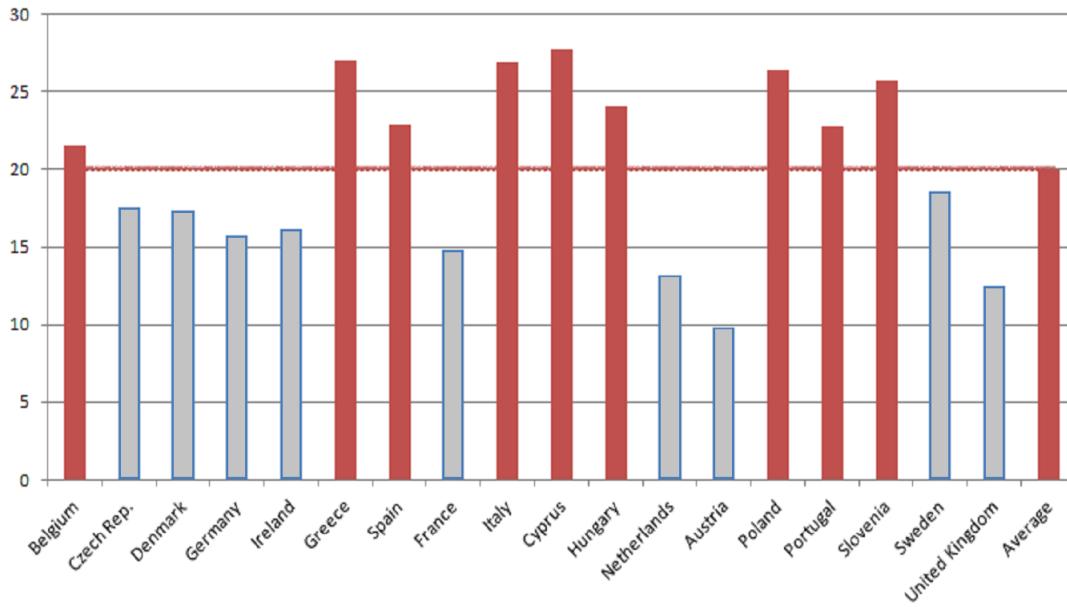
We treat tax evasion as synonymous with the shadow economy, which, according to Buehn and Schneider (2012, p.175-176), comprises “all market-based, lawful production or trade of goods and services deliberately concealed from public authorities in order to evade either payment of income, value added or other taxes, or social security contributions”. Fiscal policy has an impact on the size of the shadow economy since it affects the incentives to tax evade both directly, through the tax burden, and indirectly, through its effects on the formal economy. Thus, a fiscal consolidation can have important secondary effects if it generates a reallocation of resources between the formal and informal sectors.³ Corruption, in our paper, refers to the embezzlement of public funds. The presence of corruption can hamper the ability of the government to raise revenue, and thus distort the effects of fiscal consolidations. Tax evasion and corruption often coexist and possibly interact. For instance, Buehn and Schneider (2012) indicate that there is a positive correlation between the two.

¹The implementation of the Maastricht Treaty in the mid 1990s initiated a wave of research on the effects of consolidations. For examples, see the survey in Perotti (1996).

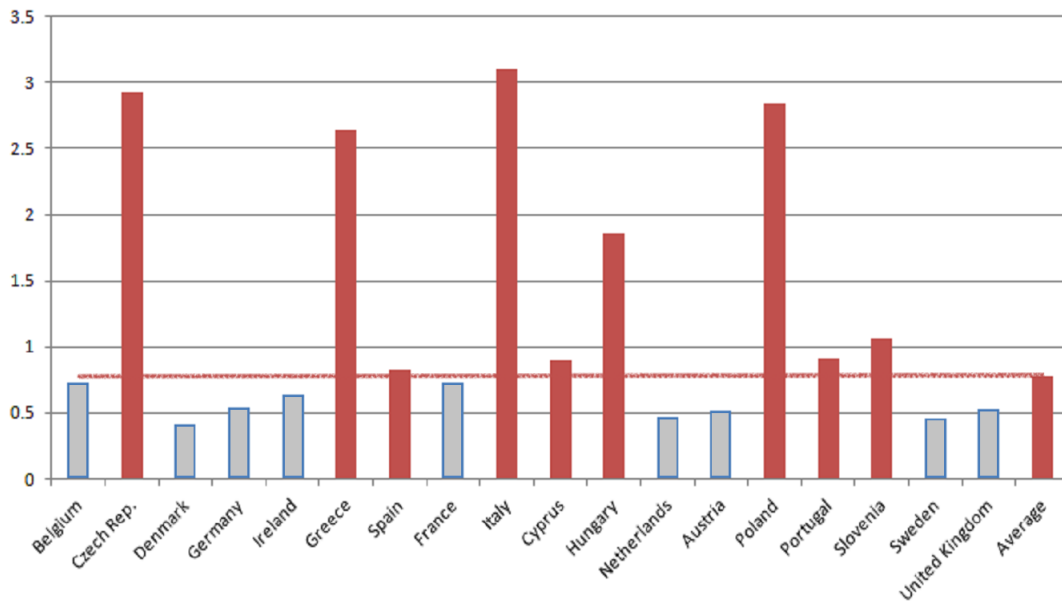
²See <http://greece.greekreporter.com/2013/04/02/greek-police-public-worker-corruption-soars/>

³For example, using a model calibrated to firm-level data for Greece, Pappadà and Zylberberg (2014) show that the increase in tax evasion can explain three quarters of the revenue leakages following the 2010 VAT hikes, when only half of the expected increase in revenue was realized. Colombo et al. (2014) also show empirical evidence of a rise in the shadow economy in recent years, although their focus is on the role of the banking crisis.

Figure 2.1: Shadow Economy and Corruption in European Countries



Shadow Economy (% GDP), Average over 1999-2010
Source: Schneider and Buehn (2012).



Control of Corruption Index, Average over 1998-2010
Source: World Bank Global Governance Indicators.

Note: The dotted line indicates the average for the countries considered.

Many authors have studied whether it is preferable to rely on spending cuts or tax hikes when consolidating the public deficit. Overall, the findings are not conclusive. Using multi-year fiscal consolidation data for 17 OECD countries over the period 1980-2005, Alesina et al. (2013) show that expenditure-based adjustments are typically associated with mild and short-lived recessions, and in some cases with no recession at all, while tax-based corrections are followed by deep and prolonged recessions. On the other hand, Erceg and Lindé (2013) reach a different conclusion. Using a two-country Dynamic Stochastic General Equilibrium (DSGE) model of a currency union, they show that, in the short run, a spending cut depresses output by more than a labor tax hike, because of the limited accommodation by the central bank and the fixed exchange rate. However, this is reversed in the long run as real interest and exchange rates adjust towards their flexible price levels.

Indeed, there is strong evidence that the effects of fiscal consolidations are not yet fully understood. Blanchard and Leigh (2013) examine the impact of the recent fiscal consolidations in 26 OECD countries. They regress the forecast errors of output growth between 2010-2011 on the planned consolidation of public deficit, and find that the forecasts underestimate the size of fiscal multipliers. As shown in the next section, the underestimation of fiscal multipliers is more pronounced in countries with a higher level of tax evasion and/or corruption, suggesting that these two features amplify the effects of fiscal consolidations.

Reliable time series data on tax evasion is typically hard to get. Luckily, the Italian National Institute of Statistics (ISTAT) has created and regularly updated a time series of informal employment in Italy, which is consistent with international standards and, in particular, with the 1993 System of National Accounts. Apart from data availability, Italy is a fitting case for studying tax evasion and corruption. Firstly, there is abundant evidence of a large shadow economy, with estimates varying between 15% and 30% of GDP (see e.g. Ardizzi et al., 2012, Orsi et al., 2014, and Schneider and Buehn, 2012). Secondly, Busato and Chiarini (2004) have shown that incorporating the shadow economy in an RBC model for Italy considerably improves the fit to the data. Thirdly, Italy scores poorly in international rankings of institutional quality: it is currently ranked 72nd among 176 countries with a score of 42/100 in Transparency International's Corruption Perception Index and 25th among the 27 EU members in the index for the 'Quality of Government' (see Charron et al., 2012).⁴

⁴The Corruption Perception Index is based on a cross-country survey assessing the degree of transparency in public administration. The 'Quality of Government' index accounts for other pillars, such as protection of the rule of law, government effectiveness and accountability, in addition to

In the first part of this paper, we incorporate the ISTAT series on informal employment in a VAR, and identify the effects of fiscal consolidations occurring through a fall in government consumption expenditure or an increase in direct taxes. We find that both types of shocks are contractionary, both reducing output and increasing unemployment. However, tax hikes significantly increase informal employment, while spending cuts reduce it.

To understand the mechanisms driving the results, we reassess the effects of fiscal consolidations in a model with price stickiness, search and matching frictions, endogenous labor force participation, tax evasion and corruption. The economy features a regular and an informal sector, and the transactions in the latter sector are not recorded by the government. Firms can hire informal labor to hide part of their production and evade payroll taxes. Households may also evade personal income taxation by reallocating their labor to the informal sector. In each period, there is a positive probability that irregular employment is detected, in which case the worker loses the job and the firm pays a fine. Corruption implies that a fraction of tax revenues is embezzled. Following Erceg and Lindé (2013), either labor tax rates or government consumption expenditures react to the deviation of the debt-to-GDP ratio from a target value. Fiscal consolidation occurs when this target is hit by a negative shock.

We find that the presence of tax evasion and corruption amplifies the negative effects of labor tax hikes on output and unemployment, while it mitigates those of expenditure cuts. Tax evasion and corruption imply that a larger increase in the tax rate is needed to reduce debt, and this amplifies the distortionary effects of the consolidation. Tax evasion further increases the output losses after a tax hike because workers and firms reallocate resources to the informal sector, increasing inefficiencies since this sector is less productive.

On the other hand, government spending cuts reduce tax evasion. The spending cut creates a positive wealth effect which increases consumption and investment and reduces labor force participation. Agents reallocate their labor search towards the formal sector, first because it is more productive, and second because the formal labor market has a higher matching efficiency and a lower job destruction rate. Hence, the share of shadow employment in total employment is reduced. Relative to standard models, tax evasion and corruption increase the size of this wealth effect, thereby increasing the crowding-in of private consumption, and reducing output losses.

Labor tax hikes are costly in terms of welfare, but spending cuts typically involve

corruption.

welfare gains, since private consumption increases and labor supply decreases. The latter result is reversed, however, if government spending directly enters the utility of households, or if agents are liquidity constrained.

We use our model to compare the recent consolidation policies in Greece, Italy, Spain and Portugal, all countries that are characterized by both high corruption and tax evasion. Despite the fact that the consolidation plans rely heavily on spending cuts, the model predicts increasing levels of tax evasion in all countries, as well as prolonged recessions. The largest output losses are observed in Portugal, due to the size of the tax hikes, and Greece, due to the severity of the austerity measures. There are also substantial welfare losses in all countries; the largest occurs in Portugal because of the significant tax hikes in the consolidation package.

There have been considerable discussions in the policy arena about combating both tax evasion and corruption. For example, members of the European Parliament organized an event focusing on corruption and tax evasion in Ljubljana in May 2013. The issue of reducing tax evasion also dominated the 2013 meeting of G8 leaders. To quantitatively evaluate the welfare gains from fighting tax evasion and corruption, we perform a counterfactual analysis of the consolidation plans when we reduce the degree of corruption and tax evasion. We find that both battles are worth fighting as they significantly reduce the welfare losses from fiscal consolidation.

The remainder of the paper is organized as follows. In the next section we present empirical evidence to motivate our work. In Section 2.3 we develop the model and its calibration. Section 2.4 discusses the main theoretical results. Section 2.5 presents the policy comparisons and Section 2.6 concludes.

2.2 Empirical Evidence

This section is divided into two parts. We first present evidence highlighting the importance of corruption and tax evasion in determining the size of fiscal multipliers. Here, we extend the cross-country regressions of Blanchard and Leigh (2013), henceforth BL (2013), controlling for tax evasion and public corruption, and we check the robustness of our conclusions by considering the output effects of narrative consolidation shocks. We then use the ISTAT data on shadow employment to run VAR regressions examining the effects of spending cuts and tax hikes on output, unemployment and shadow employment in Italy.

2.2.1 Do Tax Evasion and Corruption Matter?

To motivate our study, we replicate the BL (2013) regressions, controlling for tax evasion and public corruption. As a proxy for tax evasion we use the estimates of the share of shadow output to total GDP provided by Elgin and Öztunalı (2012), while for corruption we use the Corruption Perception Index. We group the 26 European countries considered by BL (2013) into either high and low tax evasion, or high and low corruption.⁵ We then add to the BL (2013) regressions a dummy which is equal to one for the high corruption or tax evasion group. We also run the same regression using a dummy for both high corruption and tax evasion; in this case we drop three countries which do not fall into the same group across the two indices.⁶

The results are shown in Table 2.1. The first column replicates the findings of BL (2013). The planned fiscal consolidation variable is significant at 1% and has a coefficient of -1.095, implying that “for every additional percentage point of fiscal consolidation as a percentage of GDP, output was 1 percent lower than forecast” (BL, 2013, p.8). Thus, fiscal multipliers are underestimated. Columns 2 to 4 show the results when we include the interaction of the planned fiscal consolidation variable with our dummies for high tax evasion and corruption. While the coefficient is still significant at 5% when the dummy variables are included, it is lower in absolute value. On the other hand, the interaction term is always significant, showing that there is a significant difference in the coefficients between the two groups. Our estimates imply that the coefficient on the planned fiscal consolidation is -1.431 for the high tax evasion group, -1.540 for the high corruption group, and -1.518 for the high tax evasion and corruption group. In all cases, they are larger, in absolute value, than the baseline results of BL (2013), indicating that the implicit underestimation of fiscal multipliers is more pronounced in countries with higher tax evasion and/or corruption. In other words, these two features amplify the effects of

⁵We use a two-mean clustering algorithm to endogenously group the countries. The resulting ‘high tax evasion’ group comprises Belgium, Bulgaria, Cyprus, Greece, Hungary, Italy, Malta, Poland, Portugal, Romania, Slovenia and Spain, while the ‘low tax evasion’ group includes Austria, Czech Republic, Denmark, Finland, France, Germany, Iceland, Ireland, Netherlands, Norway, Sweden, Switzerland, Slovakia and the UK. The ‘high corruption’ group comprises Bulgaria, Cyprus, Czech Republic, Greece, Hungary, Italy, Malta, Poland, Portugal, Romania, Slovakia, Slovenia and Spain, while the ‘low corruption’ group includes Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Netherlands, Norway, Sweden, Switzerland, and the UK.

⁶An alternative way of carrying out this analysis would be to include the indices as controls in the regression. We have chosen to use the dummy variable approach because, although we have robust groupings of countries in terms of high and low tax evasion and corruption, there is not enough cross-sectional variation in either index to add them directly in the regression, and also to avoid issues of generated regressor bias, since both measures are estimates of the underlying variables of interest.

fiscal consolidations.

The BL (2013) methodology has been criticized in a number of ways. Of particular importance for our study is the fact that the regression may not truly capture the effect of fiscal multipliers on forecast errors. Given that the forecasts are conditional not only on fiscal shocks but on the full set of information used by the forecaster, forecast errors may depend on factors other than underestimated fiscal multipliers.

In order to check whether the results we obtain are due to the particular methodology of BL (2013), we perform a different exercise using the narrative fiscal consolidation episodes identified by Devries et al. (2011) for a group of OECD countries. As above, we separate the sample of countries into high and low tax evasion and high and low corruption groups.⁷ We then calculate the output responses to both expenditure-based and tax-based consolidations for each group by estimating an empirical model similar to Alesina et al. (2013). The results are shown in Figure 2.2. Tax evasion and corruption do not appear to significantly affect the response of output to expenditure-based consolidations, although the high tax evasion group has slightly lower output losses in the long run. In the case of tax-based consolidations, the output effects for high tax evasion and corruption countries are lower on impact, but significantly larger and more prolonged in the medium and long run. Hence, even with this alternative methodology, we find that tax evasion and corruption affect the size of fiscal multipliers, and amplify the output losses from tax adjustments in particular.

There is an important caveat to the exercises we have shown above, specifically that we could be omitting other factors which are common across the groups. In other words, the effects which we capture could be driven by other country characteristics that are correlated with tax evasion and corruption. To address this issue, we have attempted to control for several of the potential omitted factors. Columns 5 to 9 of Table 2.1 show the results of the BL (2013) regressions controlling for: i) sophistication of financial systems, ii) degree of slack in the economy, iii) size of the fiscal consolidation, iv) level of sovereign debt and v) level of sovereign risk.⁸ We see that none of these controls can explain the results we had previously found. We have also carried out the same robustness checks for the second exercise shown above

⁷In this case, the ‘high tax evasion’ group consists of Belgium, Ireland, Italy, Portugal and Spain, whilst the ‘low tax evasion’ group consists of Australia, Austria, France, the UK and the US. The ‘high corruption’ group consists of France, Italy, Japan, Portugal and Spain, and the ‘low corruption’ group consists of Australia, Austria, Denmark, Finland and Sweden.

⁸These are measured by i) the household debt-to-income ratio, ii) the unemployment rate, iii) the reduction in the structural deficit, where, following Alesina and Ardagna (2010), a consolidation is large if the deficit was reduced by more than 1.5% GDP, iv) the government debt-to-GDP level and v) the sovereign credit default swap spread, respectively.

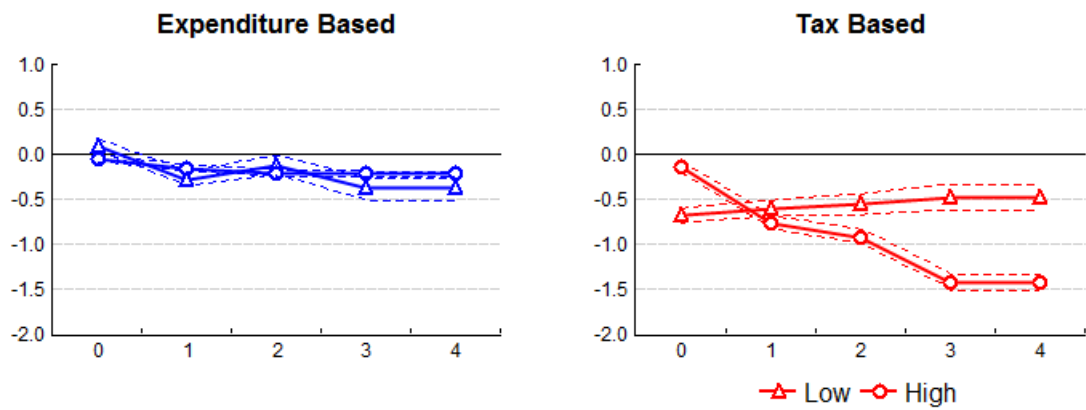
Table 2.1: Blanchard and Leigh (2013) Regressions with Additional Controls, Dependent Variable: Forecast Error of GDP growth

REGRESSORS	1 (Baseline)	2	3	4	5	6	7	8	9
Planned Fiscal Consolidation	-1.095*** (0.255)	-0.670** (0.268)	-0.550** (0.259)	-0.618** (0.268)	-1.326*** (0.152)	-1.003** (0.349)	-1.095*** (0.261)	-1.400** (0.562)	-0.924*** (0.301)
<u>Interaction with:</u>									
High Tax Evasion		-0.761** (0.351)							
High Corruption			-0.990*** (0.333)						
High Tax Evasion and Corruption				-0.900** (0.351)					
Poorly Functioning Financial System					0.511 (0.419)				
High Slack in Economy						-0.181 (0.517)			
Large Fiscal Consolidation							-0.064 (0.570)		
High Sovereign Debt								0.385 (0.614)	
High Sovereign Debt Risk									-0.253 (0.445)
Constant	0.775* (0.383)	0.918** (0.414)	0.964** (0.415)	0.925* (0.450)	0.727* (0.383)	0.820* (0.416)	0.777* (0.404)	0.781* (0.400)	0.828* (0.401)
Observations	26	26	26	23	26	26	26	26	26
R-squared	0.496	0.557	0.600	0.607	0.525	0.499	0.496	0.507	0.501

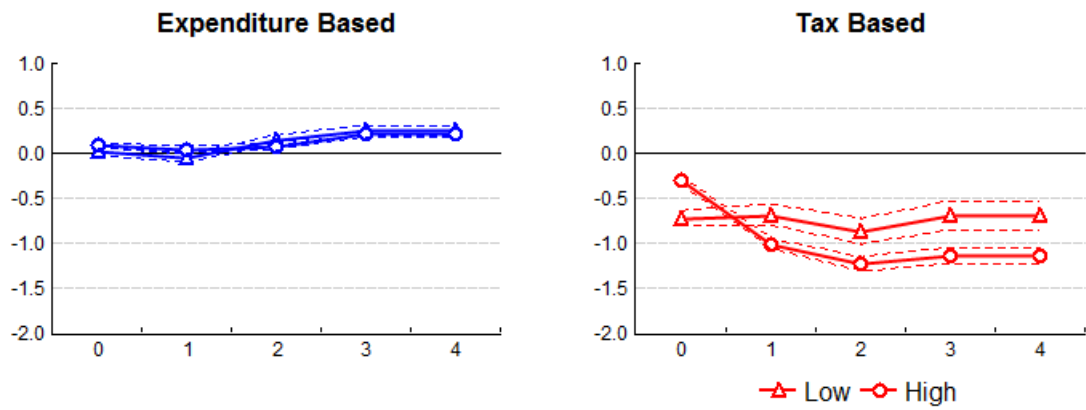
Robust standard errors in parentheses

*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Figure 2.2: Output Responses to Narrative Consolidation Episodes



(a) High and Low Tax Evasion Groups



(b) High and Low Corruption Groups

using the narrative fiscal consolidation episodes, and again we do not find that any of these controls can account for the differences we observe between countries with high and low tax evasion and corruption.⁹ Whilst we cannot make causal statements from these results, we can clearly see that countries with high tax evasion or corruption have higher fiscal multipliers, and that this is not driven by five of the most likely potential omitted factors.

We also run regressions for the components of GDP, and for unemployment, to understand which variables are more significantly affected by the presence of these two features. The results are shown in the online appendix.¹⁰ We find that the presence of corruption and tax evasion is particularly important for the effects of consolidations on the unemployment rate and investment, but not for consumption, exports or imports.

2.2.2 Do Fiscal Consolidations Affect Tax Evasion?

The Italian statistical office provides estimates of the number of employees working in the informal sector using the discrepancies between reported employment from household surveys and firm surveys (see ISTAT, 2010). We use the share of informal workers in total workers as a measure of the size of the shadow economy, and enter this variable into a VAR to ascertain the effect of fiscal consolidations using different instruments.

To identify the effects of unexpected spending cuts, we run a VAR with GDP (or the unemployment rate), government final consumption expenditures, government debt and the share of informal workers in total workers as endogenous variables, and tax revenues as an exogenous variable. We use sign restrictions to identify a negative shock to government expenditure which lasts for 3 periods, and reduces debt with a lag. To identify the effects of unexpected labor tax hikes, we run a similar VAR which includes direct tax revenues as an endogenous variable and government expenditures as an exogenous control. We again use sign restrictions to identify a positive shock to tax revenues, lasting 3 periods, which reduces debt with a lag. The responses of all other variables are left unrestricted. The sign restrictions used are summarized in Table 2.2.

We use annual data from 1980-2006. Except for the ISTAT series, all data is taken from the AMECO database of the European Commission.¹¹ All fiscal variables are

⁹These results are available from the authors upon request.

¹⁰The online appendix is available at: <http://www.eui.eu/Personal/Pappa/>

¹¹The ISTAT data is available from <http://www.istat.it/it/archivio/39522>.

Table 2.2: Baseline Sign Restrictions

	Variable:	Govt Expenditure	Tax Revenue	Debt
Shock:		$t = 0, 1, 2$	$t = 0, 1, 2$	$t = 1, 2, 3$
Spending Cut		–	n/a	–
Tax Hike		n/a	+	–

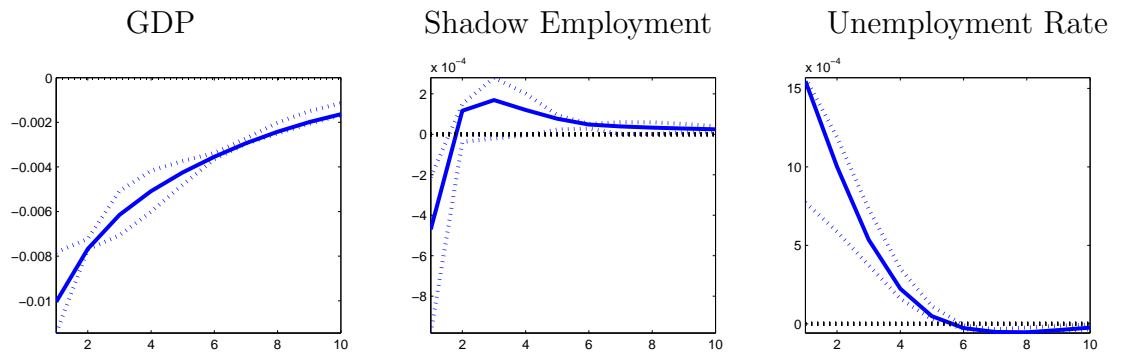
expressed as a ratio to GDP, and we include time trends and dummies for the start of the European Monetary Union, and for the mid-90s since there is a break in the debt series. We include one lag in the VAR, and also include interest rates as an exogenous variable in order to control for the effects of monetary policy. Given the small sample size, we estimate the VAR with Bayesian methods and present 68% posterior confidence bands.

The first panel of Figure 2.3 shows the resulting IRFs for the spending shocks, and Figure 2.4 shows the results for the tax shock.¹² After an expenditure cut, output decreases significantly at all horizons, while shadow employment falls significantly on impact. Following a tax hike, output does not fall on impact but the response is significantly negative in the medium run, and there is a significant rise in shadow employment on impact. When the unemployment rate is used instead of output, we see that it rises significantly after both types of consolidation.

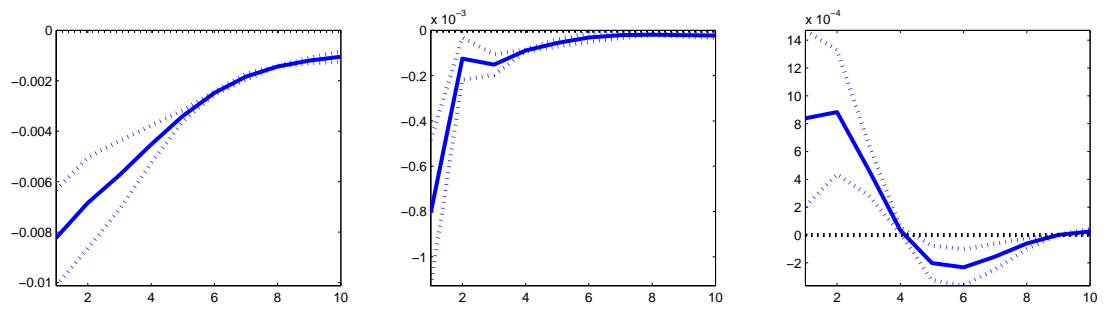
The correct identification of fiscal shocks is highly contested in the literature, and there are justifiable concerns regarding the robustness of VAR results to different identification schemes. To demonstrate the robustness of our qualitative results, we examine their sensitivity to alternative identification schemes. The second panel of Figures 2.3 and 2.4 present responses when we use an alternative set of sign restrictions in which we jointly identify spending cuts and tax hikes in the same VAR regression, by assuming that they are uncorrelated. The final panel presents results when we use a simple Cholesky decomposition to identify the shocks, ordering government spending and tax revenues first in the system. Whilst the precise pattern of the responses can differ, the result broadly remains that consolidations are contractionary, and that spending-based consolidations reduce tax evasion whilst tax-based consolidations increase it. Since the zero restrictions imposed in both the alternative sign restrictions and the Cholesky are unlikely to hold in annual data, and we are

¹²For ease of exposition we show only the responses of the unrestricted variables in each case, and show only the shadow employment response in the VAR specification with GDP; the other responses are in line with the sign restrictions imposed, and the response of shadow employment is similar in all cases. The full results are presented in the online appendix.

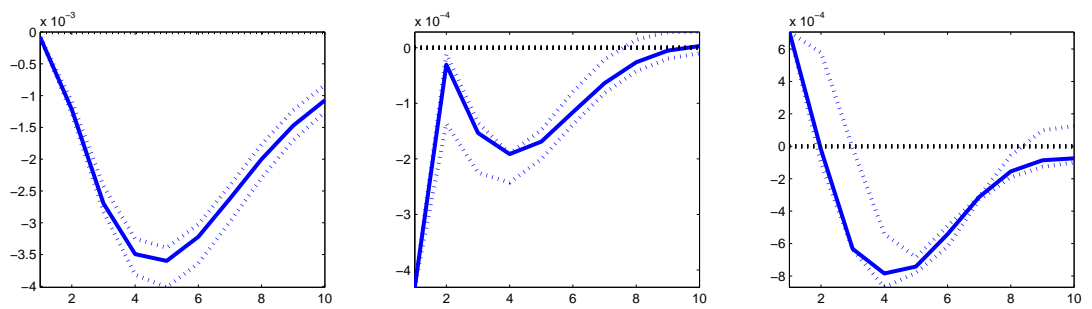
Figure 2.3: Empirical IRFs - Expenditure Shock



(a) Baseline Sign Restrictions

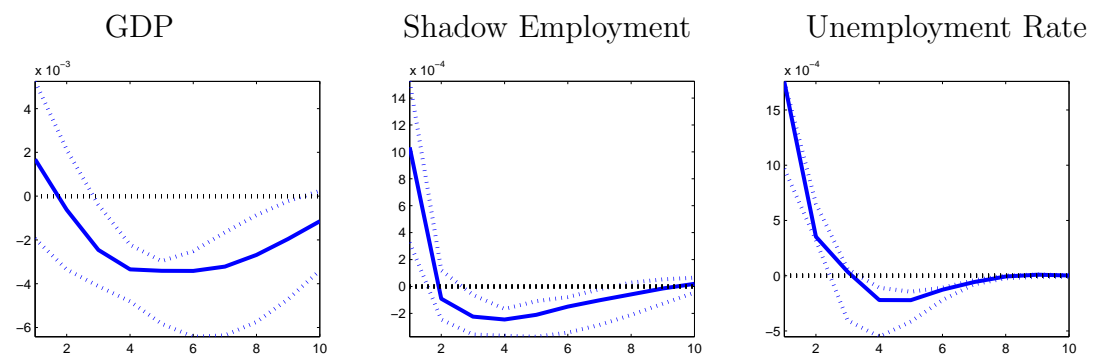


(b) Alternative Sign Restrictions

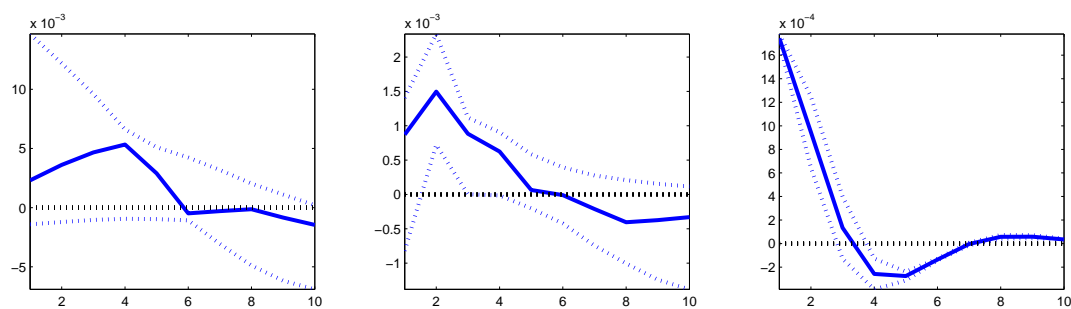


(c) Cholesky Decomposition

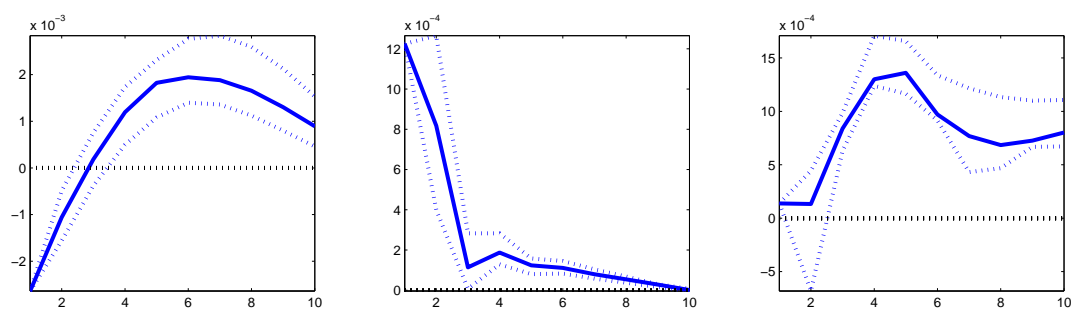
Figure 2.4: Empirical IRFs - Tax Shock



(a) Baseline Sign Restrictions



(b) Alternative Sign Restrictions



(c) Cholesky Decomposition

Table 2.3: Anticipated Shocks

Dependent Variable: VAR Expenditure Shocks		
REGRESSOR	1	2
‘Raw’ Professional Forecast Errors	0.006 (0.005)	
‘Purified’ Professional Forecast Errors		-.001 (0.005)
Constant	0.001 (0.005)	0.002 (0.004)
R-squared	0.091	0.002

Robust standard errors in parentheses
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

restricted to using annual data due to the availability of data on shadow employment, we feel that our baseline sign restrictions are the most valid choice.¹³

Another potential problem with the SVAR methodology is whether the shocks we have identified can be anticipated. Dealing comprehensively with this issue is not straightforward, and is beyond the scope of this paper. As a first pass at ascertaining whether the shocks we have identified are truly unanticipated, we follow Perotti (2005) and regress the spending shocks, identified in our baseline sign restrictions, on forecast errors from professional forecasts of government expenditure, taken from the ECB’s survey of professional forecasts. The first column of Table 2.3 shows the results from regressions using the “raw” forecast errors, and the second column shows the results using the residuals after regressing the forecast errors on the lag of the 4 variables in the VAR. We see that in both cases, the forecast errors are uncorrelated to our shocks, suggesting that our shocks are not predictable.

Thus the data robustly suggests that fiscal consolidation through expenditure cuts leads to a fall in shadow employment, while a consolidation through tax hikes increases shadow employment, and that both types of consolidations are contractionary. In the next section we develop a model with tax evasion and corruption to replicate these findings and understand how these frictions affect the propagation of

¹³We have also used the narrative fiscal consolidation episodes identified by Devries et al. (2011), however, given that they provide very few episodes for Italy alone, we do not find significant responses. Further details of all these exercises are provided in the online appendix.

fiscal shocks.

2.3 The Model

We construct a DSGE model featuring search and matching frictions, endogenous labor decisions, and sticky prices in the short run. Since, in Section 2.2, we found that corruption and tax evasion are not important for the effects of fiscal consolidation on exports or imports, we consider a closed economy. There are two types of firms in the economy: (i) competitive firms that produce intermediate goods in either the formal or informal sector, and (ii) monopolistic retailers that use all intermediate varieties to produce differentiated retail goods, which are then costlessly aggregated into a final consumption good. Price rigidities arise at the retail level, while labor market frictions occur in the production of intermediate goods. Intermediate firms can choose to produce in the informal sector in order to evade the payroll taxes paid on formal employment. In each period, they face a probability of being inspected by the fiscal authorities and convicted of tax evasion, in which case they pay a penalty, and the employment match is terminated. There is a representative household consisting of formal and informal employees, unemployed jobseekers and labor force non-participants. Jobseekers can choose to search in the informal sector in order to evade income taxes. The household rents out its private capital to the intermediate firms, and purchases the final consumption good. The government collects taxes from the regular sector, embezzles a fraction of the revenues, and uses the remainder to finance public expenditures and the provision of unemployment benefits.

2.3.1 Labor markets

We account for the imperfections and transaction costs in the labor market by assuming that jobs are created through a matching function. For $j = F, I$ denoting the formal and informal sectors, let v_t^j be the number of vacancies and u_t^j the number of jobseekers in each sector. We assume matching functions of the form:

$$m_t^j = \mu_1^j (v_t^j)^{\mu_2} (u_t^j)^{1-\mu_2} \quad (2.1)$$

where we allow for differences in the efficiency of the matching process, μ_1^j , in the two sectors. In each sector we can define the probability of a jobseeker being hired,

ψ_t^{hj} , and of a vacancy being filled, ψ_t^{fj} , as follows:

$$\psi_t^{hj} \equiv \frac{m_t^j}{u_t^j}, \quad \psi_t^{fj} \equiv \frac{m_t^j}{v_t^j}$$

In each period, jobs in the formal sector are destroyed at a constant fraction, σ^F , and m_t^F new matches are formed. The law of motion of formal employment, n_t^F , is thus given by:

$$n_{t+1}^F = (1 - \sigma^F)n_t^F + m_t^F \quad (2.2)$$

In the informal sector there is an exogenous fraction of jobs destroyed in each period, σ^I , as well as a probability, ρ , that an informal employee loses their job due to an audit. The law of motion of informal employment, n_t^I , is given by:

$$n_{t+1}^I = (1 - \rho - \sigma^I)n_t^I + m_t^I \quad (2.3)$$

2.3.2 Households

The representative household consists of a continuum of infinitely lived agents. The members of the household derive utility from leisure, which corresponds to the fraction of members that are out of the labor force, l_t , and a consumption bundle, cc_t , defined as:

$$cc_t = [\alpha_1(c_t)^{\alpha_2} + (1 - \alpha_1)(g_t)^{\alpha_2}]^{\frac{1}{\alpha_2}}$$

where g_t denotes public consumption, taken as exogenous by the household, and c_t is private consumption. The elasticity of substitution between the private and public goods is given by $\frac{1}{1-\alpha_2}$.¹⁴ The instantaneous utility function is given by:

$$U(cc_t, l_t) = \frac{cc_t^{1-\eta}}{1-\eta} + \Phi \frac{l_t^{1-\varphi}}{1-\varphi}$$

where η is the inverse of the intertemporal elasticity of substitution, $\Phi > 0$ is the relative preference for leisure, and φ is the inverse of the Frisch elasticity of labor supply.

At any point in time, a fraction n_t^F (n_t^I) of the household members are formal

¹⁴When α_2 approaches one, c_t and g_t are perfect substitutes. They are instead perfect complements if α_2 tends to minus infinity. $\alpha_2 = 0$ nests the Cobb-Douglas specification.

(informal) employees. Campolmi and Gnocchi (2014), Brückner and Pappa (2012) and Bermperoglou et al. (2014) have added a labor force participation choice in New Keynesian models of equilibrium unemployment. Following Ravn (2008), the participation choice is modelled as a trade-off between the cost of giving up leisure and the prospect of finding a job. In particular, the household chooses the fraction of the unemployed actively searching for a job, u_t , and the fraction which are out of the labor force and enjoying leisure, l_t , so that:

$$n_t^F + n_t^I + u_t + l_t = 1 \quad (2.4)$$

The household chooses the fraction of jobseekers searching in each sector: a share s_t of jobseekers look for a job in the informal sector, while the remainder, $(1 - s_t)$, seek employment in the formal sector. That is, $u_t^I \equiv s_t u_t$ and $u_t^F \equiv (1 - s_t)u_t$.

The household owns the capital stock, which evolves over time according to:

$$k_{t+1} = i_t + (1 - \delta)k_t - \frac{\omega}{2} \left(\frac{k_{t+1}}{k_t} - 1 \right)^2 k_t \quad (2.5)$$

where i_t is investment, δ is a constant depreciation rate and $\frac{\omega}{2} \left(\frac{k_{t+1}}{k_t} - 1 \right)^2 k_t$ are adjustment costs.

The intertemporal budget constraint is given by:

$$(1 + \tau_t^c)c_t + i_t + \frac{B_{t+1}\pi_{t+1}}{R_t} \leq r_t k_t + (1 - \tau_t^n)w_t^F n_t^F + w_t^I n_t^I + \varpi u_t^F + B_t + \Pi_t^p - T_t \quad (2.6)$$

where $\pi_t \equiv p_t/p_{t-1}$ is the gross inflation rate, w_t^j , $j = F, I$, are the real wages in the two sectors, r_t is the real return on capital, ϖ denotes unemployment benefits, available only to formal jobseekers (see e.g. Boeri and Garibaldi, 2007), B_t is the real government bond holdings, R_t is the gross nominal interest rate, Π_t^p are the profits of the monopolistic retailers, discussed below, and τ_t^c , τ_t^n and T_t represent taxes on private consumption, labor income and lump-sum taxes respectively.

The household maximizes expected lifetime utility subject to (2.1) for each j , (2.2), (2.3), (2.4), (2.5), and (2.6). Taking as given n_t^j , they choose u_t , s_t (which together determine l_t) and n_{t+1}^j , as well as c_t , k_{t+1} and B_{t+1} .

It is convenient to define the marginal value to the household of having an additional member employed in each sector, as follows:

$$V_{n_{n^F t}^h} = \lambda_{ct} w_t^F (1 - \tau_t^n) - \Phi l_t^{-\varphi} + (1 - \sigma^F) \lambda_{n^F t} \quad (2.7)$$

$$V_{n^I t}^h = \lambda_{ct} w_t^I - \Phi l_t^{-\varphi} + (1 - \rho - \sigma^I) \lambda_{n^I t} \quad (2.8)$$

where $\lambda_{n^F t}$, $\lambda_{n^I t}$ and λ_{ct} are the multipliers in front of (2.2), (2.3) and (2.6) respectively.¹⁵

2.3.3 Production

2.3.3.1 Intermediate goods firms

Intermediate goods are produced with two different technologies:

$$x_t^F = (A_t^F n_t^F)^{1-\alpha^F} (k_t)^{\alpha^F}$$

$$x_t^I = (A_t^I n_t^I)^{1-\alpha^I}$$

where A_t^j denotes total factor productivity in sector j . Following the literature, we assume that the informal production technology uses labor inputs only (see e.g. Busato and Chiarini, 2004).

Firms maximize the discounted value of future profits, subject to (2.2) and (2.3). That is, they take the number of workers currently employed in each sector, n_t^j , as given and choose the number of vacancies posted in each sector, v_t^j , so as to employ the desired number of workers next period, n_{t+1}^j . Here, firms adjust employment by varying the number of workers (extensive margin) rather than the number of hours per worker (intensive margin). According to Hansen (1985), most of the employment fluctuations arise from movements in this margin. Firms also decide the amount of private capital, k_t , needed for production. They face a probability, ρ , of being inspected by the fiscal authorities, convicted of tax evasion and forced to pay a penalty, which is a fraction, γ , of their total revenues. We assume that, once they are produced, there is no differentiation between intermediate goods from the different sectors. In other words, we assume that formal and informal goods are perfect substitutes, so that they are sold at the same price, p_t^x (see e.g. Orsi et al., 2014). Hence the problem of an intermediate firm is summarized by the following Bellman equation:

$$Q(n_t^F, n_t^I) = \max_{k_t, v_t^F, v_t^I} \left\{ (1 - \rho\gamma) p_t^x (x_t^F + x_t^I) - (1 + \tau_t^s) w_t^F n_t^F - w_t^I n_t^I - r_t k_t \right. \\ \left. - \kappa^F v_t^F - \kappa^I v_t^I + E_t [\Lambda_{t,t+1} Q(n_{t+1}^F, n_{t+1}^I)] \right\}$$

¹⁵The first order conditions of the household's problem and the derivations of equations (2.7) and (2.8) are presented in the online appendix.

where τ_t^s is a payroll tax, κ_t^j is the cost of posting a new vacancy in sector j , and $\Lambda_{t,t+1} \equiv \beta \frac{U_{cc,t+1}}{U_{cc,t}} = \beta \left(\frac{cc_{t+1}}{cc_t} \right)^{-\eta}$ is a discount factor. The first-order conditions are:

$$r_t = (1 - \rho\gamma) p_t^x \left(\frac{\alpha^F x_t^F}{k_t} \right) \quad (2.9)$$

$$\frac{\kappa_t^F}{\psi_t^{fF}} = E_t \Lambda_{t,t+1} \left[(1 - \rho\gamma) p_{t+1}^x (1 - \alpha^F) \frac{x_{t+1}^F}{n_{t+1}^F} - (1 + \tau_{t+1}^s) w_{t+1}^F + \frac{(1 - \sigma^F) \kappa_{t+1}^F}{\psi_{t+1}^{fF}} \right] \quad (2.10)$$

$$\frac{\kappa_t^I}{\psi_t^{fI}} = E_t \Lambda_{t,t+1} \left[(1 - \rho\gamma) p_{t+1}^x (1 - \alpha^I) \frac{x_{t+1}^I}{n_{t+1}^I} - w_{t+1}^I + \frac{(1 - \rho - \sigma^I) \kappa_{t+1}^I}{\psi_{t+1}^{fI}} \right] \quad (2.11)$$

According to (2.9)-(2.11), the net value of the marginal product of private capital should equal the real rental rate and the expected marginal cost of hiring a worker in each sector j should equal the expected marginal benefit. The latter includes the net value of the marginal product of labor minus the wage, augmented by the payroll tax in the formal sector, plus the continuation value.

For convenience, we define the value of the marginal formal and informal job for the intermediate firm:

$$V_{n_{t+1}^F}^f = (1 - \rho\gamma) p_t^x (1 - \alpha^F) \frac{x_t^F}{n_t^F} - (1 + \tau_t^s) w_t^F + \frac{(1 - \sigma^F) \kappa_t^F}{\psi_t^{fF}} \quad (2.12)$$

$$V_{n_{t+1}^I}^f = (1 - \rho\gamma) p_t^x (1 - \alpha^I) \frac{x_t^I}{n_t^I} - w_t^I + \frac{(1 - \rho - \sigma^I) \kappa_t^I}{\psi_t^{fI}} \quad (2.13)$$

2.3.3.2 Retailers

There is a continuum of monopolistically competitive retailers indexed by i on the unit interval. Retailers buy intermediate goods and differentiate them with a technology that transforms one unit of intermediate goods into one unit of retail goods, and thus the relative price of intermediate goods, p_t^x , coincides with the real marginal cost faced by the retailers. Let y_{it} be the quantity of output sold by retailer i . The final consumption good can be expressed as:

$$y_t = \left[\int_0^1 (y_{it})^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}$$

where $\epsilon > 1$ is the constant elasticity of demand for retail goods. The final good is sold at a price $p_t = \left[\int_0^1 p_{it}^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}}$. The demand for each intermediate good depends

on its relative price and on aggregate demand:

$$y_{it} = \left(\frac{p_{it}}{p_t} \right)^{-\epsilon} y_t$$

Following Calvo (1983), we assume that in any given period each retailer can reset its price with a fixed probability $(1 - \chi)$. Hence, the price index is given by:

$$p_t = [(1 - \chi)(p_t^*)^{1-\epsilon} + \chi(p_{t-1})^{1-\epsilon}]^{\frac{1}{1-\epsilon}} \quad (2.14)$$

Firms that are able to reset their price choose p_{it}^* so as to maximize expected profits given by:

$$E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t,t+s} (p_{it}^* - p_{t+s}^x) y_{it+s}$$

The resulting expression for p_{it}^* is:

$$p_{it}^* = \frac{\epsilon}{\epsilon - 1} \frac{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t,t+s} p_{t+s}^x y_{it+s}}{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t,t+s} y_{it+s}} \quad (2.15)$$

2.3.4 Government

Government expenditure consists of consumption purchases and unemployment benefits, while revenues come from the collected fines and the payroll, consumption, and labor income taxes, as well as the lump-sum taxes. The government deficit is therefore defined by:

$$DF_t = g_t + \varpi u_t^F - (1 - \xi^{TR}) TR_t - \rho \gamma p_t^x (x_t^F + x_t^I)$$

where $TR_t \equiv (\tau_t^n + \tau_t^s) w_t^F n_t^F + \tau_t^c c_t + T_t$ denotes tax revenues and $\xi^{TR} \in [0, 1)$ denotes the embezzlement rate in the presence of corruption in the economy.

The government budget constraint is given by:

$$B_t + DF_t = R_t^{-1} B_{t+1} \pi_{t+1}$$

We assume that T_t , τ_t^s , and τ_t^c are constant and fixed at their steady state levels, and we do not consider them as active instruments for fiscal consolidation. In our model, the effects of payroll taxes are very similar to labor income taxes. Consumption taxes can have different effects, but they generally constitute a relatively small

source of tax revenues. Thus, in line with Erceg and Lindé (2013), the government has two potential fiscal instruments, g and τ^n . We consider each instrument separately, assuming that if one is active, the other remains fixed at its steady state value. For $\Psi \in \{g, \tau^n\}$, we assume fiscal rules of the form:

$$\Psi_t = \Psi^{(1-\beta_{\Psi 0})} \Psi_{t-1}^{\beta_{\Psi 0}} \exp\{(1 - \beta_{\Psi 0})[\beta_{\Psi 1}(b_t - b_t^*) + \beta_{\Psi 2}(\Delta b_{t+1} - \Delta b_{t+1}^*)]\}$$

where $b_t = \frac{B_t}{y_t}$ is the debt-to-GDP ratio, and b_t^* is the target value for this ratio, given by the AR(2) process:

$$\log b_{t+1}^* - \log b_t^* = \mu_b + \rho_1(\log b_t^* - \log b_{t-1}^*) - \rho_2 \log b_t^* - \varepsilon_t^b$$

where ε_t^b is a white noise shock representing a fiscal consolidation.

2.3.5 Closing the model

Monetary Policy There is an independent monetary authority that sets the nominal interest rate as a function of current inflation according to the rule:

$$R_t = R \exp\{\zeta_\pi(\pi_t - 1)\}$$

where R is the steady state value of the nominal interest rate.

Goods Markets Total output must equal private and public demand. The aggregate resource constraint is thus given by:

$$y_t = c_t + i_t + g_t + \kappa^F v_t^F + \kappa^I v_t^I + \xi^{TR} T R_t$$

where the last term is the resource cost of corruption in the economy.¹⁶

The aggregate price index, p_t , is given by (2.14) and (2.15). The return on private capital, r_t , adjusts so that the capital demanded by the intermediate goods firm, given by (2.9), is equal to the stock held by the household.

Bargaining over wages Wages in both sectors are determined by ex-post (after matching) Nash bargaining. Workers and firms split rents and the part of the surplus they receive depends on their bargaining power. We denote by $\vartheta^j \in (0, 1)$ the firms' bargaining power in sector j . The Nash bargaining problem is to maximize the

¹⁶See the online appendix for full derivations.

weighted sum of log surpluses:

$$\max_{w_t^j} \left\{ (1 - \vartheta^j) \log V_{n^j t}^h + \vartheta^j \log V_{n^j t}^f \right\}$$

where $V_{n^j t}^h$ and $V_{n^j t}^f$ are defined in equations (2.7), (2.8), (2.12) and (2.13). As shown in the online appendix, wages are given by:

$$w_t^F = \frac{(1 - \vartheta^F)}{(1 + \tau_t^s)} \left((1 - \rho\gamma) p_t^x (1 - \alpha^F) \frac{x_t^F}{n_t^F} + \frac{(1 - \sigma^F) \kappa^F}{\psi_t^{fF}} \right) + \frac{\vartheta^F}{\lambda_{ct}(1 - \tau_t^n)} \left(\Phi l_t^{-\varphi} - (1 - \sigma^F) \lambda_{n^F t} \right)$$

$$w_t^I = (1 - \vartheta^I) \left((1 - \rho\gamma) p_t^x (1 - \alpha^I) \frac{x_t^I}{n_t^I} + \frac{(1 - \rho - \sigma^I) \kappa^I}{\psi_t^{fI}} \right) + \frac{\vartheta^I}{\lambda_{ct}} \left(\Phi l_t^{-\varphi} - (1 - \rho - \sigma^I) \lambda_{n^I t} \right)$$

2.3.6 Calibrating the Model

We calibrate the model using annual Italian data for the period 1982-2006.¹⁷ Table 2.4 displays the values used. We calibrate the labor force participation and unemployment rate in the formal sector to match the observed average values. Thus, we set official labor force participation, $lf \equiv n^F + u^F$, equal to 60% and the official unemployment rate to 10%. We fix the separation rate $\sigma^F = 0.07$. We set the probability of filling a vacancy in the formal sector $\psi^{fF} = 0.96$, and the matching elasticity with respect to vacancies $\mu_2 = 0.7$, which is close to the estimate obtained in Peracchi and Viviano (2004).

The capital depreciation rate, δ , is set equal to 0.088. Following the literature, we set the discount factor $\beta = 0.96$. The elasticity of demand for retail goods, ϵ , is set such that the gross steady state markup, $\frac{\epsilon}{\epsilon-1}$, is equal to 1.25, and the price of the final good is normalized to one. The TFP parameter in the formal sector, A^F , is normalized to one, and the capital share $\alpha^F = 0.36$. We set the vacancy costs in the formal sector $\kappa^F = 0.14$, and the payroll tax rate $\tau^s = 16\%$, close to the value used in Orsi et al. (2014).

In the informal sector, we assume that TFP is lower than the formal sector by setting $A^I = 0.6$. According to Restrepo-Echavarria (2014), the fact that the informal sector has restricted access to credit leads to fewer resources being devoted to research and development, or to absorbing technology spillovers, which in turn reduces productivity. Also, both Boeri and Garibaldi (2007) and Orsi et al. (2014) emphasize empirical evidence suggesting that the workers in the informal sector have

¹⁷Details of the calibration exercise are in the online appendix.

Table 2.4: Baseline Calibration Values

Parameter	Description	Value
β	Discount Factor	0.96
δ	Depreciation Rate	0.088
α_1	Share of Private Consumption in Utility	1
η	Inverse Elasticity of Intertemporal Substitution	2
φ	Inverse Frisch Elasticity of Labor Supply	2
Φ	Relative Utility from Leisure	0.7
lf	Official Labor Force Participation	0.6
$\frac{u^F}{lf}$	Official Unemployment Rate	0.1
$\frac{u}{1-l}$	Actual Unemployment Rate	0.09
s	Share of Informal Jobseekers to Total	0.10
$\frac{n^I}{n^F}$	Share of Informal Employment to Total	0.13
σ^F	Exogenous Job Destruction Rate - Formal Sector	0.07
σ^I	Exogenous Job Destruction Rate - Informal Sector	0.0545
ρ	Auditing Probability	0.02
μ_1^F	Matching Efficiency - Formal Sector	0.85
μ_1^I	Matching Efficiency - Informal Sector	0.12
μ_2	Elasticity of Matching to Vacancies	0.7
ψ^{fF}	Probability of Filling a Vacancy - Formal Sector	0.96
ψ^{fI}	Probability of Filling a Vacancy - Informal Sector	0.05
ψ^{hF}	Probability of Finding a Job - Formal Sector	0.63
ψ^{hI}	Probability of Finding a Job - Informal Sector	0.91
A^F	TFP - Formal Sector	1
A^I	TFP - Informal Sector	0.6
α^F	Capital Share - Formal Sector	0.36
α^I	Production Function Parameter - Informal Sector	0.4
$\frac{y^I}{y}$	Share of Underground Output in Total	0.16
κ^F	Vacancy Costs - Formal Sector	0.14
$\frac{\kappa^F}{w^F}$	Vacancy Costs/Wage	0.21
κ^I	Vacancy Costs - Informal Sector	0.13
ϵ	Price Elasticity of Demand	5
ϑ^F	Firm's Bargaining Power - Formal Sector	0.22
ϑ^I	Firm's Bargaining Power - Informal Sector	0.80
$\frac{w^I}{w^F}$	Formal/Informal Wage Differentials	0.98
$\frac{g}{y}$	Government Expenditure-to-GDP Ratio	0.11
$\frac{\varpi}{w^F}$	Replacement Rate	0.35
τ^n	Labor Income Tax Rate	0.4
τ^s	Payroll Tax Rate	0.16
τ^c	Consumption Tax Rate	0.18
γ	Proportional Fine in Case of Auditing	0.3
ξ^{TR}	Embezzlement Rate	0.2
$\frac{DF}{y}$	Deficit-to-GDP Ratio	-0.04
b	Debt-to-GDP Ratio	1.03
ρ_1, ρ_2	Debt-to-GDP Target Parameters	0.85, 0.0001
χ	Price Stickiness	0.25
ω	Capital Adjustment Costs	0.5
ζ_π	Taylor Rule Parameter	1.5

lower education levels.¹⁸

Using the ISTAT data, we set the share of informal employment to total employment equal to 0.13, and we set $\alpha^I = 0.4$, implying the share of shadow output to total output $\frac{y^I}{y} = 16\%$. We set the exogenous job destruction rate in the informal sector $\sigma^I = 0.0545$, the probability of filling a vacancy in the informal sector $\psi^{fI} = 0.05$, and the vacancy cost in the informal sector $\kappa^I = 0.13$. These values yield a relatively small wage premium for the formal sector, $\frac{w^I}{w^F} = 0.98$, in line with the literature. The probability of audit and the fraction of total revenues paid as a fine in the event of an audit are set as follows: $\rho = 0.02$, close to the value used in Boeri and Garibaldi (2007), and $\gamma = 0.3$. For the probability of tax audit, we also consider alternative values ($\rho = 0.04$ and $\rho = 0.01$) in the sensitivity analysis.

We set the replacement rate $\frac{\bar{w}}{w^F} = 0.35$, close to the estimates in Martin (1996), and used by Fugazza and Jacques (2004). Government spending as a share of GDP and the remaining tax rates are set as follows: $\frac{g}{y} = 11\%$, $\tau^n = 40\%$, in line with Orsi et al. (2014), and $\tau^c = 18\%$. The steady state debt-to-GDP ratio $b = 103\%$. Regarding the embezzlement parameter, we set $\xi^{TR} = 0.2$ and study the sensitivity of our results to different values of this parameter.

We begin by assuming purely wasteful government expenditure, setting $\alpha_1 = 1$, and will consider utility enhancing government spending as an extension. Regarding the inverse elasticity of intertemporal substitution, η , much of the literature cites the econometric estimates of Hansen and Singleton (1983), which place it “between 0 and 2”, and often choose a value greater than unity. In our calibration, we set $\eta = 2$ and we perform sensitivity analysis by considering η equal to 0.5 and 1. The inverse of the Frisch elasticity, φ , is set equal to 2 and we examine the sensitivity of our results to changes in this parameter. Finally, we set the inflation targeting parameter in the Taylor rule $\zeta_\pi = 1.5$, the capital adjustment costs $\omega = 0.5$ and the price-stickiness parameter $\chi = 0.25$.

2.4 Results

We present responses following a negative debt-target shock (following Erceg and Lindé, 2013). We compare the effects of a 5% reduction in the desired long run debt target, which is achieved after 10 years, either through a fall in government

¹⁸Orsi et al. (2014) also note the equivalence of assuming lower productivity in the informal sector to assuming a cost for concealing production.

consumption expenditure, or a hike in labor tax rates.¹⁹

2.4.1 Dynamics in a Model without Tax Evasion and Corruption

As a benchmark, we begin by analyzing the responses of a standard model where tax evasion and corruption are absent, shown in Figure 2.5.

A consolidation carried out through a fall in government spending has two effects. Firstly, there is a negative demand effect for firms, which leads, in the presence of nominal rigidities, to a fall in labor demand and hence in vacancies. Second, there is a positive wealth effect for the household, which increases consumption and investment and reduces labor force participation. Given the drop in both labor demand and supply, employment falls and the wage rate rises. Output falls in the short run, but increases in the medium and long run because investment, and hence the capital stock, increases. The unemployment rate reflects movements in the number of jobseekers: it falls on impact, but then increases as employment and wages adjust.

When the fiscal consolidation is carried out through a labor tax hike, there is a negative wealth effect for the household which makes consumption fall, and investment fall with a lag. However, as the return from employment falls, there is a substitution effect which outweighs the wealth effect, and leads to a decrease in labor force participation. The fall in private demand induces firms to contract their labor demand, again expressed through a drop in vacancies. Employment and output fall, and the responses are significantly larger and more persistent than in the case of spending cuts, due to the fall in investment.

Thus, our benchmark model seems to be consistent with the evidence of Alesina et al. (2013): spending cuts are accompanied by mild and short-lived recessions, while tax hikes lead to more prolonged and deep recessions.

2.4.2 Dynamics in a Model with Corruption

Next, we study how the responses change when we introduce embezzlement of public funds in our model, shown in Figure 2.6. In our baseline calibration we set the embezzlement rate $\xi^{TR} = 0.2$.

The introduction of corruption does not alter the responses of the economy qualitatively. In the case of government spending cuts, the effects are negligible. However,

¹⁹For comparison purposes, throughout this section we adjust the parameters of the policy rules for each case to ensure that the debt target is met after 10 years.

Figure 2.5: IRFs of Benchmark Model (without Tax Evasion and Corruption)

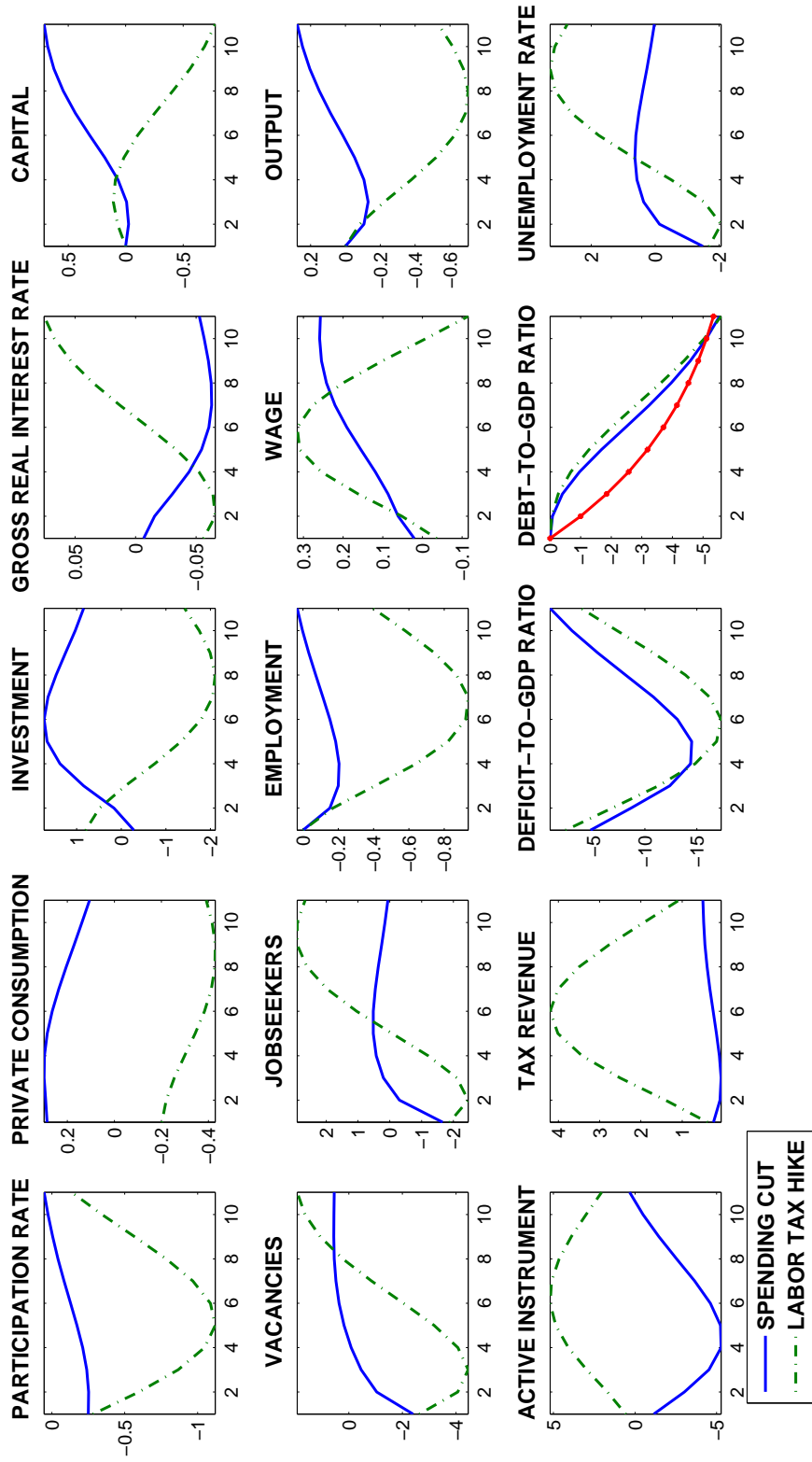
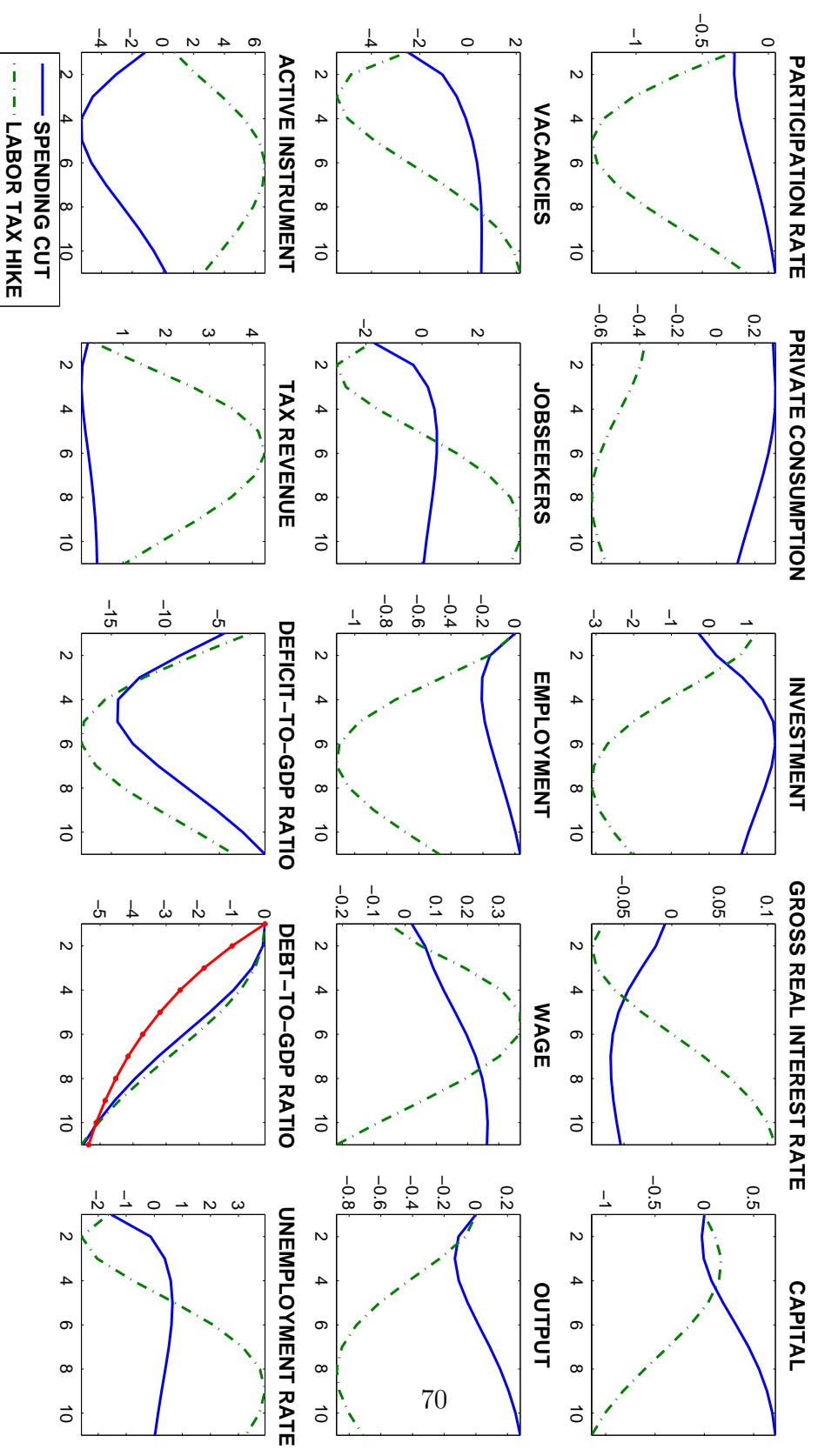


Figure 2.6: IRFs of Model with Corruption



in the case of labor tax rate hikes, there are notable quantitative differences. Given that a fraction of tax revenues are now lost through embezzlement, the change in the tax rates required to achieve debt consolidation is larger. This leads to an amplification of the effects observed in all variables.

We also check the sensitivity of this effect to the embezzlement rate. Informal accounts suggest that there are often large rents to be obtained in less developed economies, although precise estimates are difficult to obtain. Krueger (1974) estimates rents generated by import licenses alone to be in the range of 15% of GNP for Turkey in 1968; similarly large estimates are obtained by Gallagher (1991) for a sample of African countries from 1975 to 1987, ranging between 6% and 37% of GDP. Setting $\xi^{TR} = 0.2$ implies a value of embezzled tax revenues equal to 4.2% of GDP. Given the estimates for developing countries, we believe that a reasonable range of estimates of rent seeking as a percentage of GDP in Italy should be between 0.1% and 5%. This implies values for ξ^{TR} that vary between 0.05 and 0.25. Results for this sensitivity analysis, presented in the online appendix, show that with the higher the degree of corruption in the economy, the larger the tax hikes needed for consolidation and therefore the larger the amplification of the observed responses.

2.4.3 Dynamics in a Model with Tax Evasion

We now move to a model with tax evasion. Here, we incorporate the informal sector and set the corruption parameter again to zero. Figure 2.7 presents the responses of the formal sector and of fiscal variables, and Figure 2.8 shows the responses in the informal sector.

To start with, notice that the response of the formal sector is qualitatively similar to the benchmark model. However, there is an additional channel at play. For the case of tax hikes, unemployed jobseekers reallocate their labor supply and the intermediate firms reallocate their labor demand towards the informal sector. Tax hikes provide direct incentives for jobseekers to search in the informal sector because of the higher tax rates in the formal sector. At the same time, intermediate firms find it profitable to post vacancies in the informal sector because of the fall in the informal wage. The fall in investment, and hence the capital stock, lowers the productivity differential between the two sectors, and further provides incentives for agents to reallocate to the informal sector. As a result, shadow employment as a share of total employment increases.

For the case of expenditure cuts, the negative demand effect of the spending cut affects both formal and informal production, leading to a reduction in labor demand

Figure 2.7: IRFs of Model with Tax Evasion

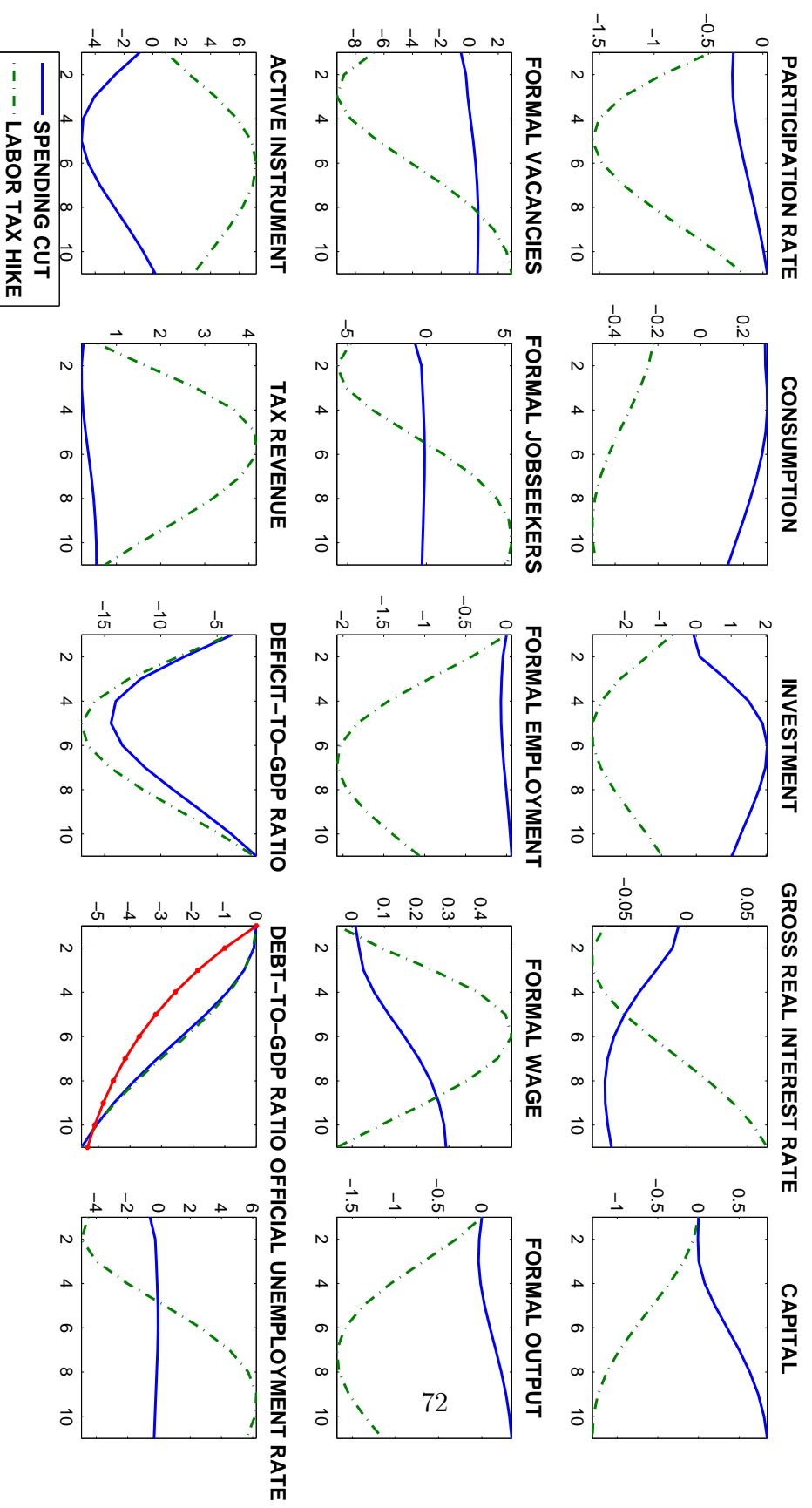
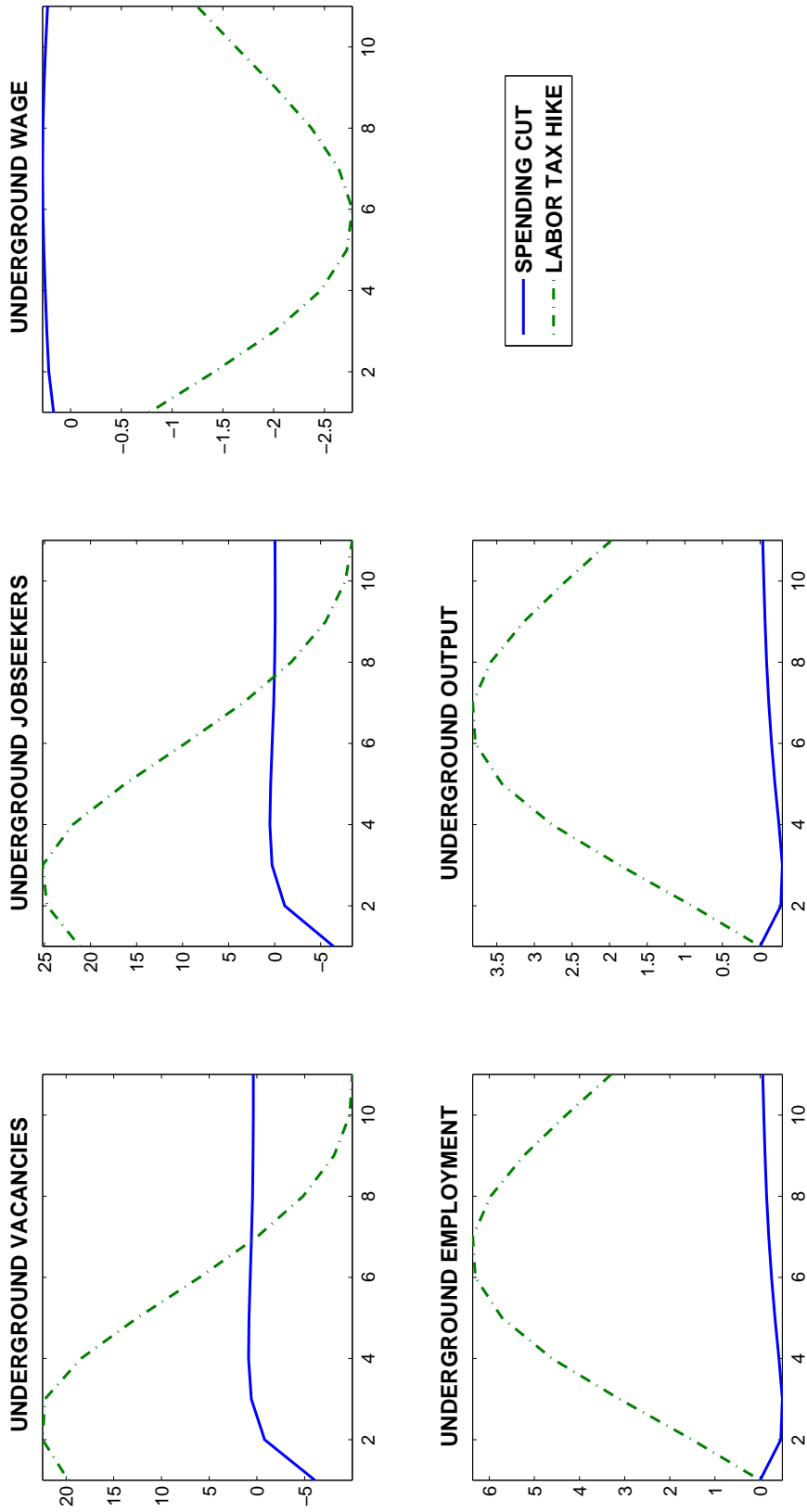


Figure 2.8: IRFs of Model with Tax Evasion - Informal Sector



in both sectors. Similarly, as labor force participation falls, there is a reduction in unemployed jobseekers in both sectors. This causes a contraction in total employment. Moreover, there is a reallocation of labor towards the formal sector; shadow employment as a share of total employment falls, consistent with the evidence we presented in Section 2.2. This happens for two reasons. Firstly, the formal labor market has a higher matching efficiency, and a lower job destruction rate. Secondly, in addition to having a higher TFP level, the rise in the capital stock further increases the productivity of the formal sector relative to the informal sector. In order to take advantage of these efficiency gains, and thus mitigate the negative effects of the fiscal contraction, agents optimally choose to reallocate towards the formal sector.

2.4.4 A Model with Tax Evasion and Corruption

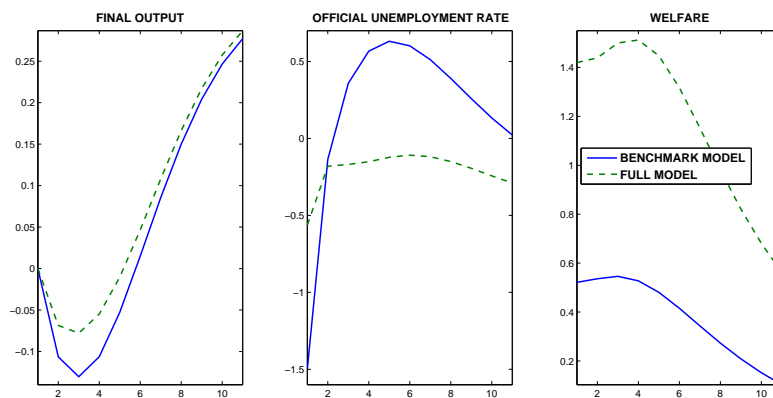
In this section we introduce both tax evasion and corruption and, in Figure 2.9, we compare the responses of output, the unemployment rate and welfare to the benchmark model.²⁰

For spending cuts, shown in the top panel, the presence of tax evasion and corruption generates smaller losses in output, a drop in the unemployment rate at all horizons, and larger welfare gains. With tax evasion and corruption, the tax adjustments required to achieve a given change in deficit are larger, and thus, following a spending cut, taxes in the future are expected to fall by more. In other words, there is an amplification of the positive wealth effect. Hence the rise in consumption and the fall in labor force participation are larger relative to the model without tax evasion and corruption, making welfare gains larger. The increased crowding-in of private consumption mitigates the negative demand effect for the firms, thereby mitigating output losses. The larger reduction in labor force participation implies a fall in the number of formal jobseekers, and hence in the official unemployment rate, at all horizons.

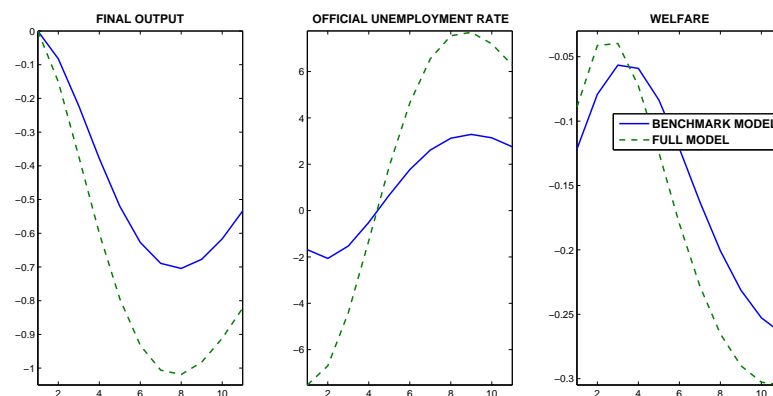
For tax hikes, shown in the middle panel, the presence of corruption and tax evasion amplifies the output losses, particularly in the long run. This is due to the loss of tax revenue from both corruption and tax evasion, implying that larger increases in tax rates are needed to reduce debt-to-GDP. This increases the distortionary effects of the consolidation, leading to a larger drop in labor force participation, private consumption and investment. In addition, the reallocation towards the informal sector increases the inefficiencies due to the lower productivity in this sector. Thus,

²⁰Welfare is computed as per-period steady state consumption equivalents. IRFs of all other variables are included in the online appendix.

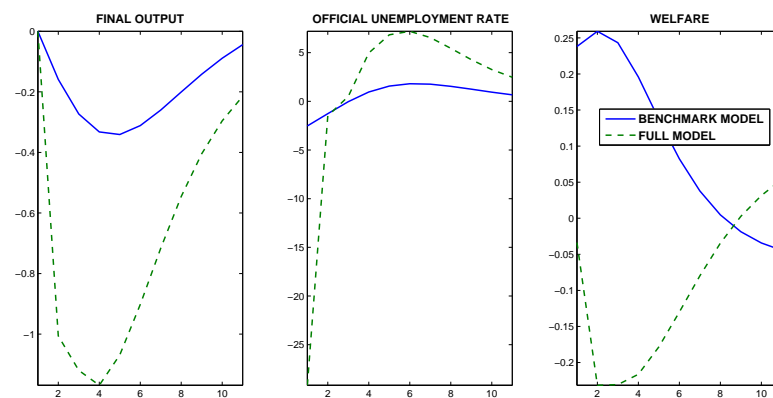
Figure 2.9: Comparison of Benchmark and Full Model



(a) Government Expenditure Cuts



(b) Labor Tax Hikes



(c) Mixed Consolidation

there is a larger contraction in the formal sector, which is also evident in the response of the official unemployment rate: the initial fall is amplified as jobseekers drop out of the formal sector, and the rise in the long run is higher as firms post fewer vacancies in this sector. Furthermore, tax hikes lead to welfare losses. Initially, these losses are lower with tax evasion and corruption, but in the medium and long run, as consumption falls increasingly, we obtain higher losses.

The bottom panel depicts the responses in the case of a mixed consolidation. Here, we allow both policy instruments, g and τ^n , to move simultaneously to reduce the deficit, which follows the debt-targeting rule. We fix the policy mix such that a fraction a of the reductions in deficit come from expenditure cuts and $(1 - a)$ from revenue enhancements, and set $a = 0.5$. In this case, the responses of consumption and investment are determined by the competing positive and negative wealth effects from the two instruments, and the presence of tax evasion and corruption plays an important role in determining this relative strength. In the benchmark model, the positive wealth effect of the expenditure cut is dominant and consumption rises for several periods. When there is tax evasion and corruption, this is no longer true and consumption and investment fall in all periods. Hence, as in the case of tax hikes, output and unemployment responses are amplified in the presence of tax evasion and corruption. This is in line with the evidence presented in Section 2.2. Moreover, the welfare gains obtained from mixed consolidation packages in the benchmark model turn into welfare losses in the model with tax evasion and corruption.

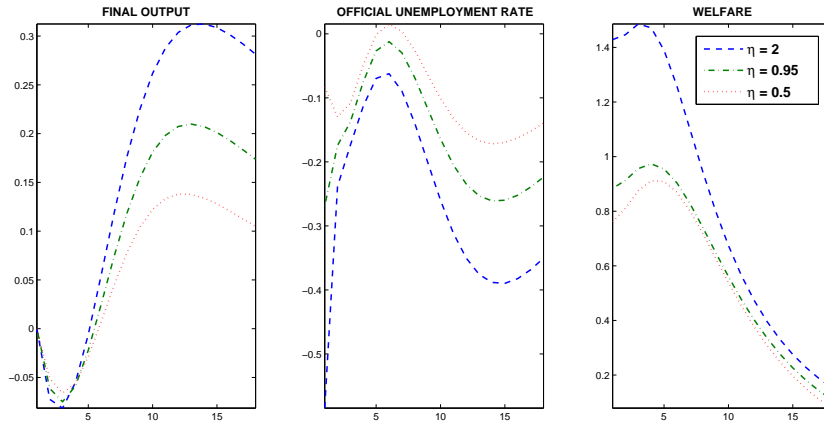
2.4.5 Sensitivity Analysis

Both the effects of labor tax hikes and expenditure cuts depend crucially on some modeling assumptions. In this section we present how the implications of fiscal consolidations change when we modify key assumptions or parameters of the model.

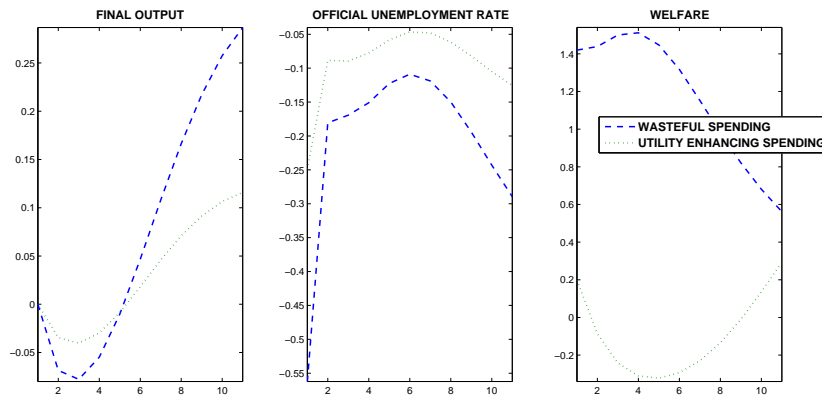
2.4.5.1 Spending Cuts

Elasticity of Intertemporal Substitution As we saw, the effects of the spending cuts depend crucially on the size of the wealth effect, which in turn depends on the elasticity of intertemporal substitution. As shown in the first panel of Figure 2.10, repeating the simulations using lower values for the inverse elasticity of intertemporal substitution, $\eta = 0.5$ and $\eta = 0.95$, yields qualitatively similar results. Quantitatively, for lower values of η , the risk aversion of agents is lower and after a spending cut we observe larger increases in consumption and smaller increases in

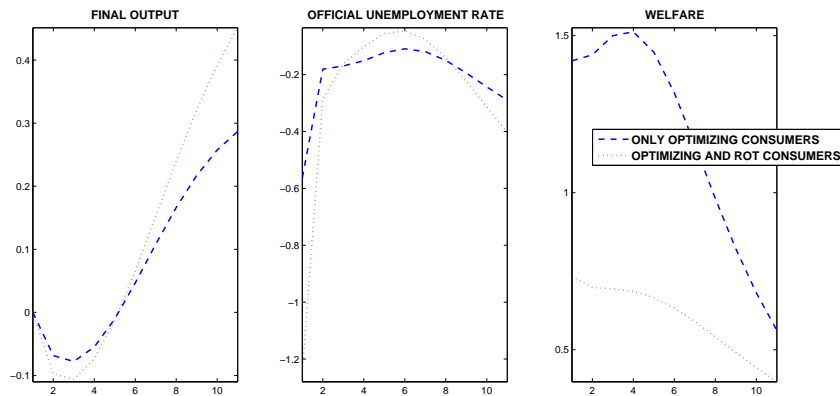
Figure 2.10: Sensitivity Analysis for Spending Cuts in the Full Model



(a) Intertemporal Elasticity of Substitution



(b) Utility Enhancing Government Spending



(c) Rule of Thumb (ROT) Consumers

investment, which dampens the long run expansion in output, as well as a larger drop in the labor force participation rate, which dampens the drop in the unemployment rate.

Utility-enhancing Government Spending Assuming that government expenditures provide a public good, which is consumed by households, can change the welfare implications of spending cuts. To illustrate this point, we set $\alpha_1 = 0.85$ and $\alpha_2 = -0.25$, so that private and public spending are weak complements. The top panel of Figure 2.10 compares the results of this case with those obtained with wasteful government spending. In the case of utility-enhancing expenditures, a spending cut directly reduces the consumption bundle, and households are forced to offset this fall by further increasing private consumption. Thus, we see a larger crowding-in of private consumption, which mitigates the output and unemployment effects of spending cuts. However, the welfare effects are reversed: the drop in the consumption bundle causes welfare to fall for several periods.

Liquidity Constrained Agents The presence of liquidity constrained consumers has been shown to play an important role in determining the response of private consumption to a government spending cut (see e.g. Galí et al., 2007). To explore how the presence of liquidity constrained consumers can affect our model, we assume a fraction of rule of thumb (ROT) household members, which we set equal to 44%, in line with the Italian household survey reported by Martin and Philippon (2014). As shown in the bottom panel of Figure 2.10, output and unemployment responses are amplified and welfare gains are mitigated following a spending cut. The presence of ROT agents reduces the positive wealth effect that the fiscal contraction generates, which implies a smaller increase in consumption and, hence, welfare, and a larger contraction in output.

2.4.5.2 Tax Hikes

The Elasticity of Taxable Income A large body of the literature, initiated by Feldstein (1999), has argued that the costs of labor taxes can be summarized by the elasticity of taxable income with respect to the net of tax share. The magnitude of this elasticity can therefore yield further insights about the effects of tax hikes in the presence of tax evasion and corruption. We compute the taxable income elasticity by dividing the cumulative response of taxable income by the cumulative response of the net tax share, up to the point that tax rates return to steady state. For the

benchmark model, the elasticity of taxable income equals 0.23, while incorporating tax evasion and corruption in the analysis almost doubles this elasticity to 0.42.²¹ This is not surprising, given that we are allowing workers to move out of taxable work, in the formal sector, not only by leaving the workforce but also by working in the informal sector. Data also suggests higher estimates of the taxable income elasticity in countries with more tax evasion and corruption. For example, Kleven and Schultz (2014) provide an estimate for Denmark equal to 0.09 for this elasticity and, using the same methodology, Arrazola et al. (2014) report a taxable income elasticity equal to 1.5 in Spain.

Of course many of our parameter choices affect the estimated value of the taxable income elasticity and so, in turn, our conclusions about the effects of tax hikes in a model with tax evasion and corruption. To investigate this, we first consider the inverse of the intertemporal elasticity of substitution, η . Smaller values of η imply higher values of the long run elasticity of taxable income: for $\eta = 0.95$ and 0.5 , the corresponding elasticities are 0.43 and 0.44, respectively. Accordingly, the higher values of the taxable income elasticity, implied by the lower η , are associated with higher output and welfare losses, as well as higher unemployment in the medium and long run, as seen in the top panel of Figure 2.11.

Next, we use alternative values for the inverse of the Frisch elasticity of labor supply, φ . The value of the labor supply elasticity determines the size of the substitution effect following a tax hike and this, in turn, affects the taxable income elasticity in our model. Higher values of the labor supply elasticity, meaning lower values of φ , are associated with higher values of the taxable income elasticity, equal to 0.56, 0.36 and 0.34 for $\varphi = 0.5, 5$ and 8 , respectively. Results presented in the second panel of Figure 2.11 indicate that output losses and medium and long run unemployment increase with the Frisch elasticity.²²

Finally, we consider the effects of a reduction in the ability of workers to reallocate between the two sectors, in particular by assuming a lower value for the matching efficiency parameter in the informal sector, $\mu_1^I = 0.05$ instead of 0.12 . This modification reduces the taxable income elasticity to 0.29, close to the value in the benchmark model, and we see from the third panel of Figure 2.11 that the model dynamics also resemble the dynamics of the benchmark model. This is because reallocation to the informal sector is now more difficult, implying that the reallocation channel plays a

²¹Our estimates are broadly in line with those presented in recent studies that place the value of this elasticity in the (0.2, 0.8) range. For a survey of the literature, see Saez et al. (2012).

²²Welfare comparisons are more difficult when we change η and φ because these parameters have a direct impact on the relative weight of consumption and leisure in the utility function.

smaller role in the dynamics.

The Detection Probability In our model, the incentives to tax evade are also affected by the probability of detection. We investigate the role of the detection probability in the last panel of Figure 2.11. A higher detection probability reduces the output, unemployment, and welfare losses after a consolidation through tax hikes, since the incentives to reallocate to the informal sector are reduced. However, this effect is mostly seen in the short and medium run; in the long run, the results are similar for the different values of ρ .²³

2.5 Policy Evaluation

Since the model qualitatively replicates the empirical evidence presented in Section 2.2, we employ it to evaluate the effects of consolidation packages implemented in southern European countries in recent years. We recalibrate the model for Greece, Portugal and Spain, three countries which are also characterized by high corruption and tax evasion, and analyze the effects of their recent consolidation packages.

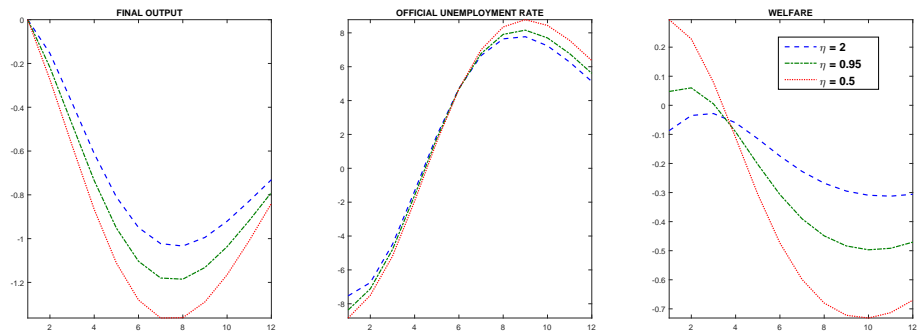
2.5.1 Calibration

Using the information in OECD (2012), we adjust the size of the consolidation in each country to match the reduction in the deficit-to-GDP ratio implemented in 2010 and also replicate the announced consolidation volumes in the long run. Table 2.5 reports the consolidation in 2010 for each country and the intended consolidation to be implemented by 2015. We see that Greece implemented the most severe austerity package. The consolidation package of Italy in 2010 was small, but larger consolidation volumes were announced for 2015. The consolidation packages in Spain and Portugal were similar in 2010, but Portugal announced a slightly larger long run consolidation volume. In order to replicate the actual consolidation packages, we allow both instruments to move simultaneously, again using OECD (2012) to fix the relative contribution of the two instruments for each country. Portugal used more tax hikes than expenditure cuts, while the other countries used predominantly expenditure-based measures.²⁴

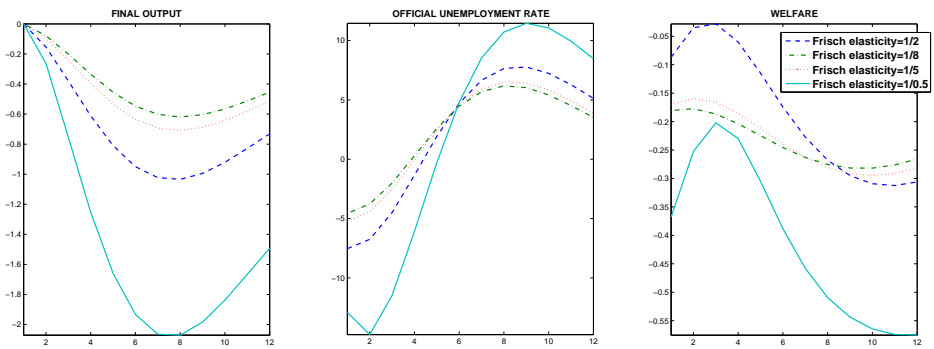
²³Since the auditing probability affects the reallocation of workers between sectors, it could also affect the consolidation through spending cuts. However, the results under the alternative values of ρ do not change substantially compared to the results of the baseline calibration.

²⁴See the tables on p.138, 166, 206, 226 of OECD (2012).

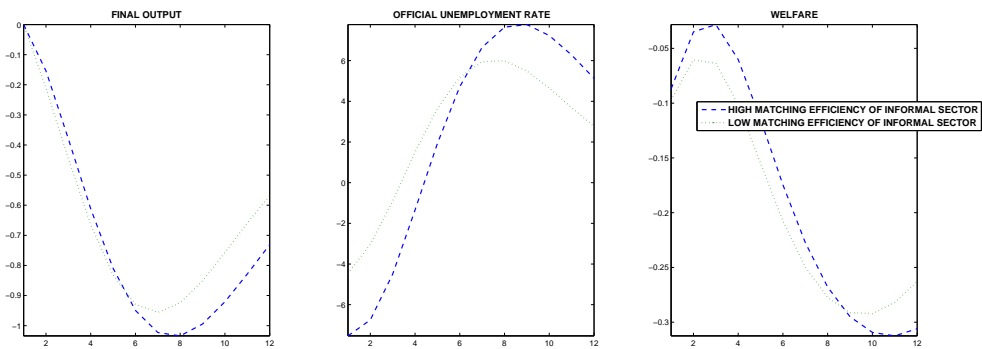
Figure 2.11: Sensitivity Analysis for Labor Tax Hikes in the Full Model



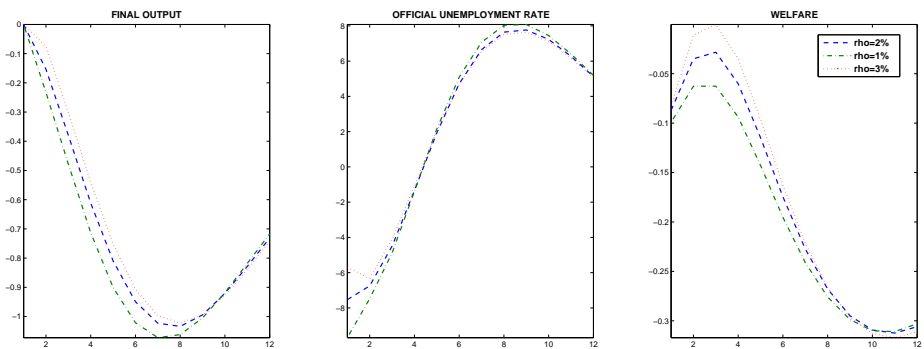
(a) Intertemporal Elasticity of Substitution



(b) Frisch Elasticity of Labor Supply



(c) Matching Efficiency of Informal Sector



(d) Detection Probability for Tax Evasion

Table 2.5: Policy Evaluation: Calibration Values

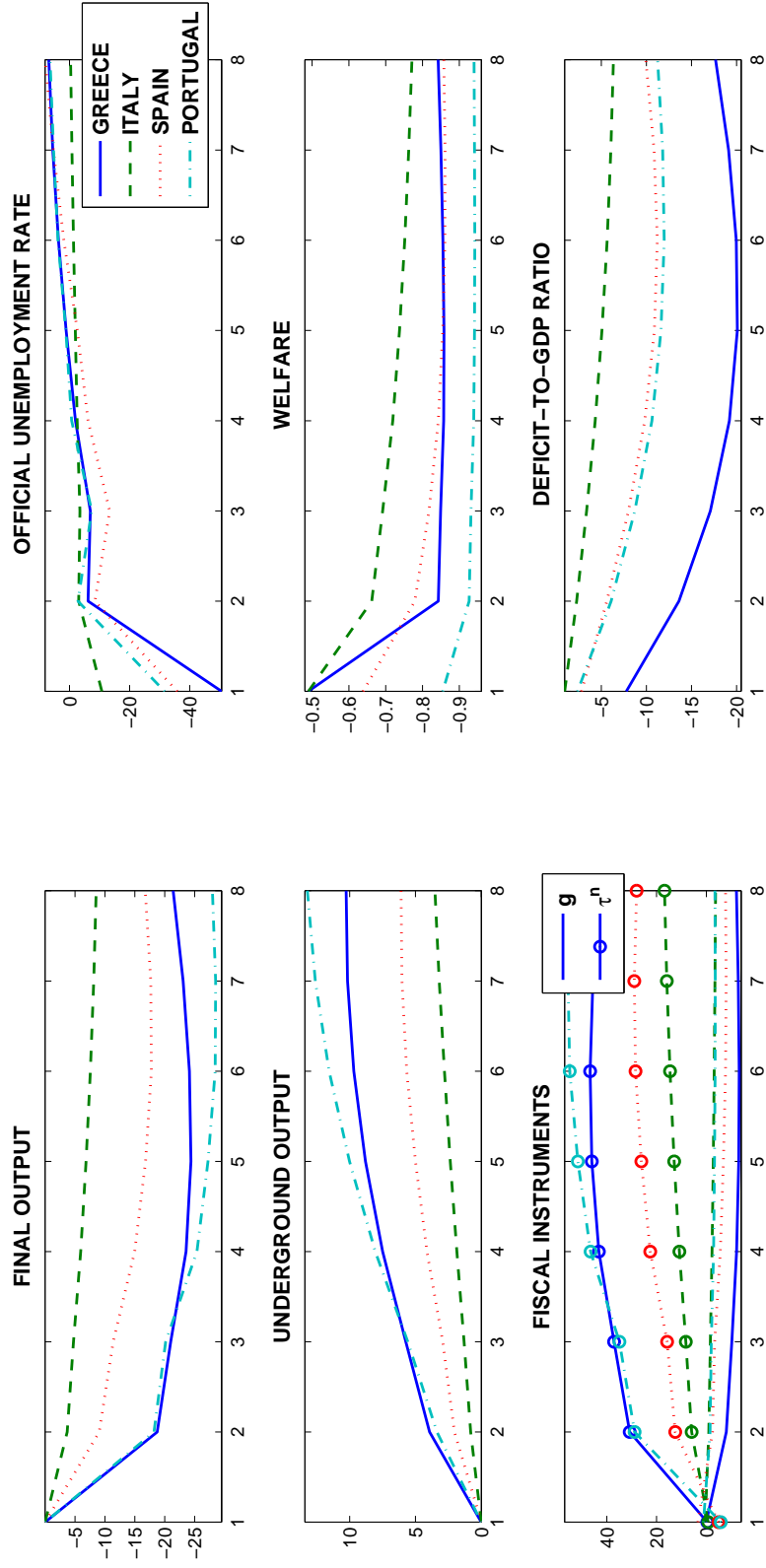
	Greece	Italy	Spain	Portugal
Consolidation Volume - 2010 (% GDP)	7.8	0.9	2.7	2.3
Consolidation Volume - 2015 (% GDP)	18.5	6.1	7.3	12.2
Expenditure Share in Policy Mix (%)	60	58	66	23
Informal Employment (% Total Employment)	14	13	12.5	12.5
Embezzlement Rate (%)	20	20	10	10
Unemployment Rate (%)	10	10	15	7
Labor Force Participation Rate (%)	64	60	65	70
Formal Firm's Bargaining Power (%)	22	20	27	32
Unemployment Benefit Replacement Rate (%)	35	35	45	45
Debt-to-GDP ratio (%)	145	120.1	61.2	93.3
Government Consumption Spending (% GDP)	5	11	6	5

Table 2.5 also summarizes the differences in the calibration for the various economies. We use the estimates of shadow output in Elgin and Öztunah (2012) to determine the relative share of shadow employment across countries, which gives comparable numbers, though slightly higher in Greece. Following the World Bank's Control of Corruption index, shown in Figure 2.1, we set the embezzlement rate in Greece and Italy higher than Spain and Portugal. According to the OECD statistics, Portugal has a notably healthier labor market, with the highest labor force participation rate and the lowest unemployment rate. According to the CEP-OECD database and the ICTWSS (Data Base on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts, 1960-2011) indices, Italy and Greece have higher unionisation and coordination of bargaining, reflected in our model by lower bargaining power for firms, compared to Spain and Portugal. Also, according to the CEP-OECD database and the estimates in Martin (1996), replacement rates are lower in Italy and Greece relative to Spain and Portugal. Accordingly in Table 2.5 we assume replacement rates of 35% for Italy and Greece and 45% for Portugal and Spain. Spain has the lowest debt-to-GDP ratio, while Greece and Italy both face debt well over 100% of GDP. Finally, the size of the government consumption expenditure as a percentage of GDP is higher in Italy than in the other countries.

2.5.2 Results

The simulation results are shown in Figure 2.12. Despite the substantial use of expenditure cuts, we see that tax evasion increases in all countries. With the use of tax hikes in the consolidation mix, the direct incentive to produce in the informal sector dominates the efficiency gains from producing in the formal sector, leading to

Figure 2.12: Cross-country Comparison of Fiscal Consolidation Plans



a reallocation towards the informal sector. The relative size of the increase across countries is determined by the relative size of the tax hikes. Note that Portugal experiences the largest long run increase in the informal economy because of the heavy use of tax hikes in their consolidation.

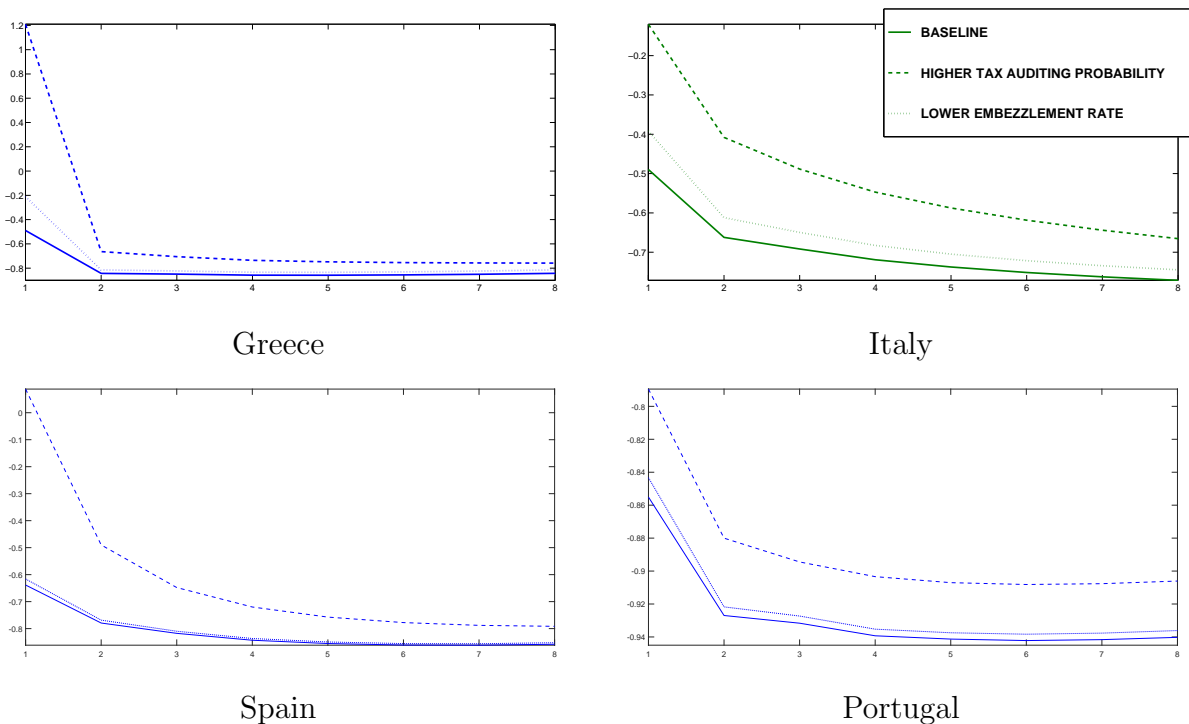
The model predicts sizeable and persistent output losses following all consolidation packages. The relative size of these losses across countries reflects the size of the consolidation: Greece exhibits large losses, while in Italy the relatively small adjustment implies smaller effect. As a result, the unemployment rate increases in the long run in Greece, while the effects are negligible in Italy. However, note that Portugal experiences the largest output drop in the long run, because of the large share of tax hikes in the consolidation mix. Accordingly, Spain experiences much smaller output losses, despite the similar size of the consolidation package. Nonetheless, given the higher efficiency of labor markets in Portugal, these two countries experience similar unemployment outcomes. Finally, the fiscal consolidations induce welfare losses in all countries. Both the size of the consolidation and the composition of the package determines the magnitude of the losses. In particular, Italy experiences the lowest welfare losses, given the small consolidation, whilst Portugal experiences higher welfare losses than Greece due to the large use of tax hikes.

2.5.3 Counterfactual Analysis

The austerity packages implemented in recent years have sparked a debate about the need to fight tax evasion and corruption. It is therefore interesting to ask whether reforms aimed at reducing tax evasion and corruption may change the effects of the current consolidation plans. To investigate the issue, we carry out two counterfactual experiments: we simulate the fiscal consolidation plans first assuming that the tax auditing probability is doubled, and then assuming that the embezzlement rate is reduced by half. Figure 2.13 reports the welfare responses in the baseline calibration, in the case when the auditing probability is higher, and in the case when the embezzlement rate is lower, for each country.

We find that welfare losses would be mitigated by the reforms. Reducing tax evasion and corruption implies that the deficit reductions are achieved with lower hikes in the tax rate. With the reduction in tax evasion, there is a sizeable reduction in welfare losses in Italy and Portugal, and short run welfare gains for Greece and Spain, which have relatively more expenditure-based consolidation policies. When corruption is reduced, welfare improves substantially in Italy, and in Greece on impact, since these two countries have a higher degree of corruption. In Spain and

Figure 2.13: Welfare Effects of Fiscal Consolidation Plans: Counterfactual Analysis



Portugal, where the level of corruption is lower, the gains from reducing corruption are small relative to fighting tax evasion.

2.6 Conclusions

Empirical evidence indicates that accounting for tax evasion and corruption is key for understanding the effects of fiscal consolidation. A New Keynesian DSGE model with involuntary unemployment, an informal sector and public corruption, demonstrates that these two features amplify the contractionary effects of labor tax hikes, while they mitigate the effects of expenditure cuts. It also shows that the instrument used to achieve fiscal consolidation affects the incentives of agents to produce in the informal sector. Consistent with VAR evidence obtained for Italian, spending cuts reduce the size of the informal economy, while tax hikes increase it.

Given the model's ability to reproduce the qualitative features of the data, we analyze how current fiscal consolidation plans in Greece, Italy, Portugal and Spain affect tax evasion, output, unemployment and welfare. The model predicts increasing levels of tax evasion during the consolidation in all countries, and prolonged output and welfare losses. Greece suffers heavy losses due to the severity of the austerity

package implemented; Portugal experiences the largest drops in output and welfare because of the heavy use of tax hikes in their consolidation package. Furthermore, the welfare costs of these consolidations would have been smaller if tax evasion and corruption had been reduced. Hence, reforms aimed at fighting public corruption and tax evasion should go hand-in-hand with austerity measures in order to mitigate the welfare costs of fiscal consolidations.

Our exercise is the first attempt to analyze the effects of fiscal consolidation in the presence of tax evasion and corruption. Since the model is stylized, it leaves out important aspects of reality that could affect our conclusions. For example, in our economy there is a representative household, and so we cannot assess the effects of tax evasion and corruption on income inequality. Also, we consider only cuts in government consumption expenditures and not in other items of the government budget. Furthermore, our model does not allow for evasion of consumption taxes, which is an important component of tax evasion in southern European countries. Finally, the model treats the degree of public corruption as a parameter, which does not allow it to respond to cyclical factors or to interact with tax evasion. We leave these extensions for future research.

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Chapter 3

Fiscal Consolidation in a Disinflationary Environment: Price- vs. Quantity-Based Measures

This is joint work with Evi Pappa and Eugenia Vella.

Abstract

An important feature of the current economic conditions in the EU, which challenges the design and implementation of macroeconomic policy, is inflation uncertainty. With monetary policy at the zero lower bound, and inflation well below its target, a key issue for policy makers is the effect this has on the transmission of fiscal policy. We aim to address this question, in particular comparing the effects of price-based and quantity-based fiscal instruments. In this paper we focus on the public wage bill, and consider a model of a monetary union in which the government can consolidate their debt through reductions in the public wage or public employment. We find that in both cases the low-inflation environment eliminates the expansionary effects of the reduction in the public wage bill for the private sector. The drag in economic activity is substantially amplified in the low inflation environment, with increased debt-to-GDP levels during the consolidation process.

3.1 Introduction

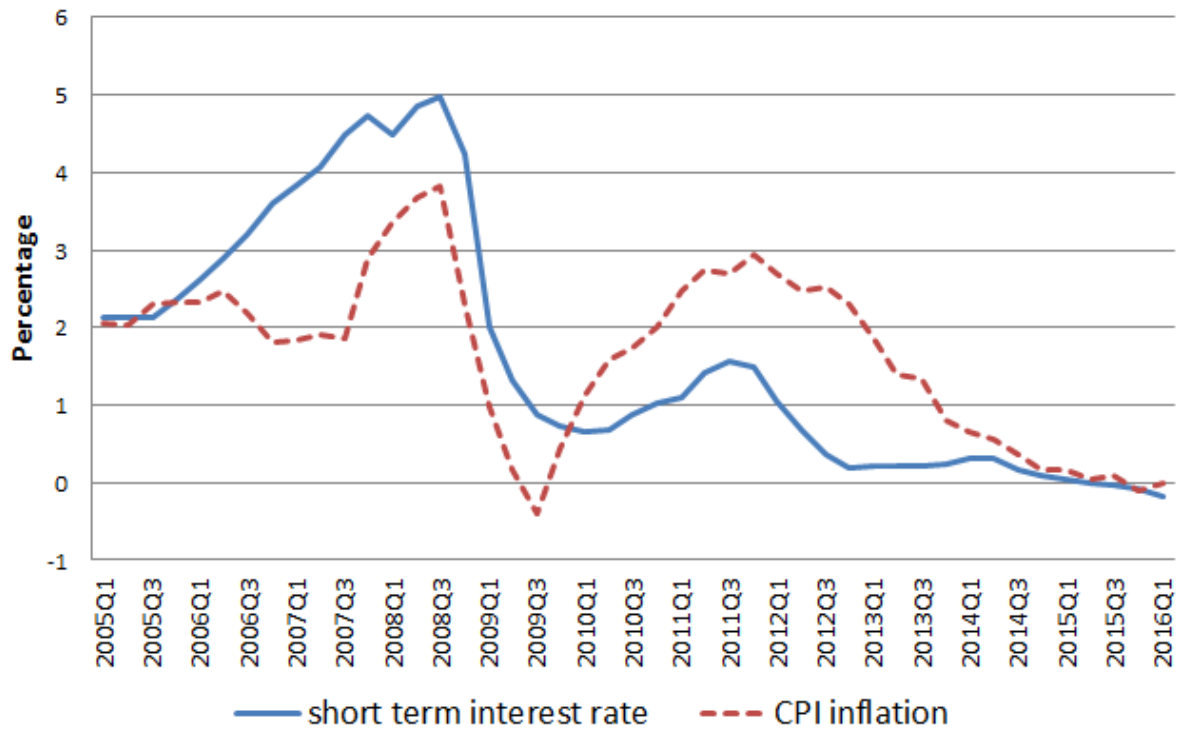
An important feature of the current economic conditions in the EU, which challenges the design and implementation of macroeconomic policy, is inflation uncertainty. With monetary policy constrained by the zero lower bound (ZLB henceforth), inflation in the euro area has remained below the ECB's medium-run objective for some time. While some recent studies have looked at the impact of the ZLB on fiscal policy, research on the differential impact of inflation on different budgetary items is limited. In this context, the aim of this paper is to examine the effects of alternative fiscal consolidation strategies to reduce the public wage bill, specifically comparing price-based measures and quantity-based measures, under different inflation environments.

As seen in Figure 3.1, since 2012, the inflation rate across the euro area has been trending downwards and still remains below the ECB's 2% target. At the same time, the scope for monetary policy easing has been limited, with nominal interest rates at the ZLB, and the effects of unconventional measures, such as the recent asset purchases, remaining uncertain.

This environment has important implications for fiscal policy. Firstly, low inflation is generally considered to make fiscal consolidation more difficult. Indeed, historically, periods of high inflation have been used to reduce debt-to-GDP ratios, for example in many western countries following both the First and Second World War (see Reinhart et al. 2015). From a theoretical point of view, low inflation reduces the growth in nominal GDP and, all else equal, raises deficit- and debt-to-GDP ratios. Debt dynamics would be left unchanged if nominal interest rates fall by the same magnitude as inflation, thus leaving real rates unchanged. Instead, when nominal rates have hit the ZLB, falling inflation leads to rising real interest rates, making it more difficult to reduce government debt-to-GDP ratios.

Moreover, much of the literature, both theoretical and empirical, has found that fiscal multipliers are higher when monetary policy is constrained. In particular, Eggertsson (2011) found that the government spending multiplier goes from below 0.5, to around 2.3 at the ZLB, and that tax multipliers even change sign and become negative at the ZLB. Similar results are found in the studies of Christiano et al. (2011), Coenen et al. (2012) and De Long and Summers (2012). Empirically, Ilzetzi et al. (2013) corroborate these results, finding that government spending multipliers are substantially higher in countries operating under fixed exchange rates, which is another form of constrained monetary policy. Nakamura and Steinsson (2014) draw similar conclusions regarding the multiplier of military spending, although their

Figure 3.1: Inflation and Interest Rates in the Euro Area *Source: Eurostat*



analysis is not a direct comparison of different monetary regimes. Based on these principles, several papers discuss the potential role of fiscal stimulus in alleviating a ZLB crisis: Correia et al. (2013) suggest an alternative stimulus strategy to the use of government spending, based on consumption taxation, and Rendahl (2015) focuses on amplification effects in the labour market due to the ZLB and how expansionary fiscal policy can best exploit these. The converse of these arguments is that attempting to carry out fiscal consolidation in a liquidity trap can be very costly, and even self-defeating.

Another important way in which low inflation affects fiscal policy is the fact that inflation shocks can be expected to have a different impact, both in terms of size and timing, across different government revenue and expenditure categories. In line with the research highlighted above, Jalil (2012) finds that the differences between the estimated multipliers of government spending and taxation can be explained by the differential response of monetary policy. Erceg and Linde (2013) find that the magnitude of the output contraction induced by spending-based consolidation is roughly three times larger when monetary policy is constrained by the ZLB than when it is unconstrained. They also find that, at the ZLB, a tax-based consolidation is less costly in the short-run than a spending-based consolidation, while the opposite

is true when monetary policy is unconstrained. McManus et al. (2014) find that the ZLB has different effects on different fiscal consolidation instruments, and should therefore be considered when designing austerity packages.

One dimension of this comparison which has been overlooked is that the effectiveness of consolidation packages that focus on quantity-based measures instead of price-based measures may be different depending on the inflation environment. In that context, reducing the wage bill via cutting wages (price-based measure) or reducing public employees (quantity-based measure) may have a different budgetary impact depending on the inflation environment. This paper aims to uncover the potential effect of a low-inflation environment on these alternative consolidation strategies, with a particular focus on the public wage bill.

Recent austerity packages implemented in many European countries, like Greece and Spain, have placed special emphasis on the reduction of the public wage bill. According to data reported by Holm-Hadulla et al. (2010), shown in Figure 3.2, the government wage bill before the crisis accounted, on average, for almost a quarter of total public spending and more than 10% of GDP in the euro area. On average, almost 15% of the labour force in the euro area was employed by the public sector. Since the beginning of the crisis in 2008, most of these countries have been trying to cut government wage bills, by freezing wages and hirings, and cutting or retrenching specific indemnities or benefits. A recent report by Gama et al. (2015) shows that even countries that showed more resilience in the aftermath of the crisis, such as the United Kingdom, Belgium, Denmark and the Netherlands, saw steep declines in public administration employment (see Figure 3.3). Cuts in public sector wages have been widely implemented in countries like Ireland, Cyprus, Portugal (see Figure 3.4).

In this paper, we develop a DSGE model through which we can study the differential effects of quantity-based and price-based consolidation measures. In particular, we consider a New-Keynesian model of a two-block monetary union, with nominal rigidities in the form of monopolistic retailers facing price-stickiness. In order to build a complete model of the labour market, we incorporate both search and matching frictions, leading to involuntary unemployment, and an endogenous labour force participation decision, leading to voluntary unemployment. Finally, to study the effects of the public wage bill, we allow the government to hire public employees to produce a public good that is used by private firms.

Following Erceg and Linde (2013) and Pappa et al. (2015), fiscal policy responds to the deviation of the debt-to-GDP ratio from a target value, and fiscal consolidation occurs when this target is hit by a negative shock. We focus attention on two fiscal

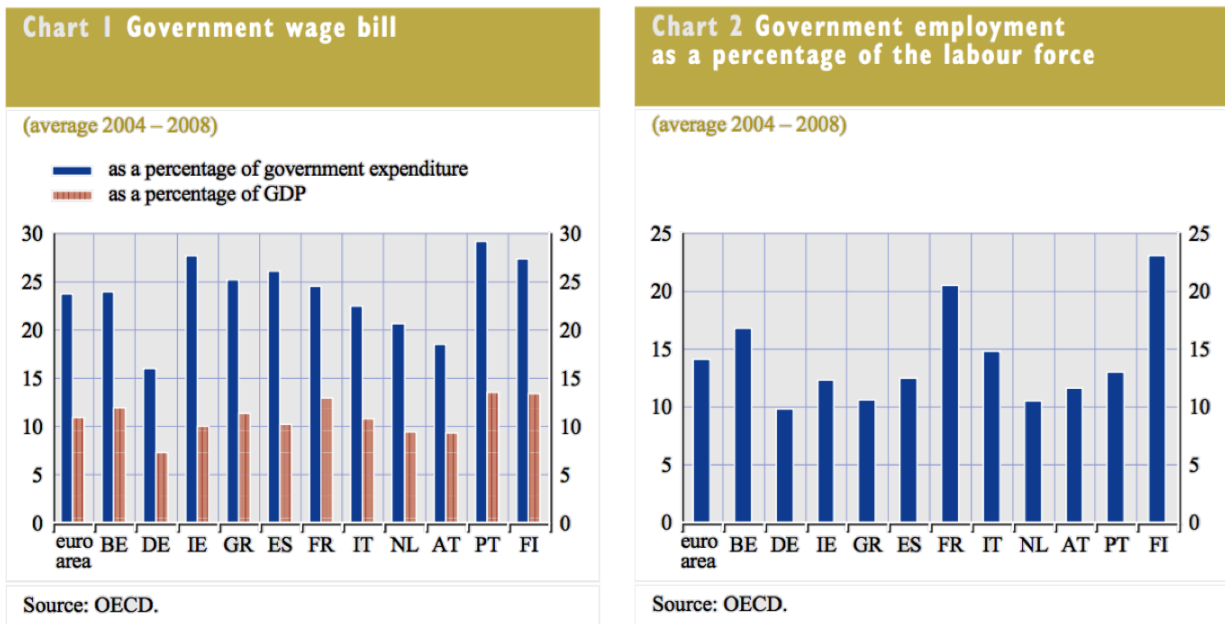
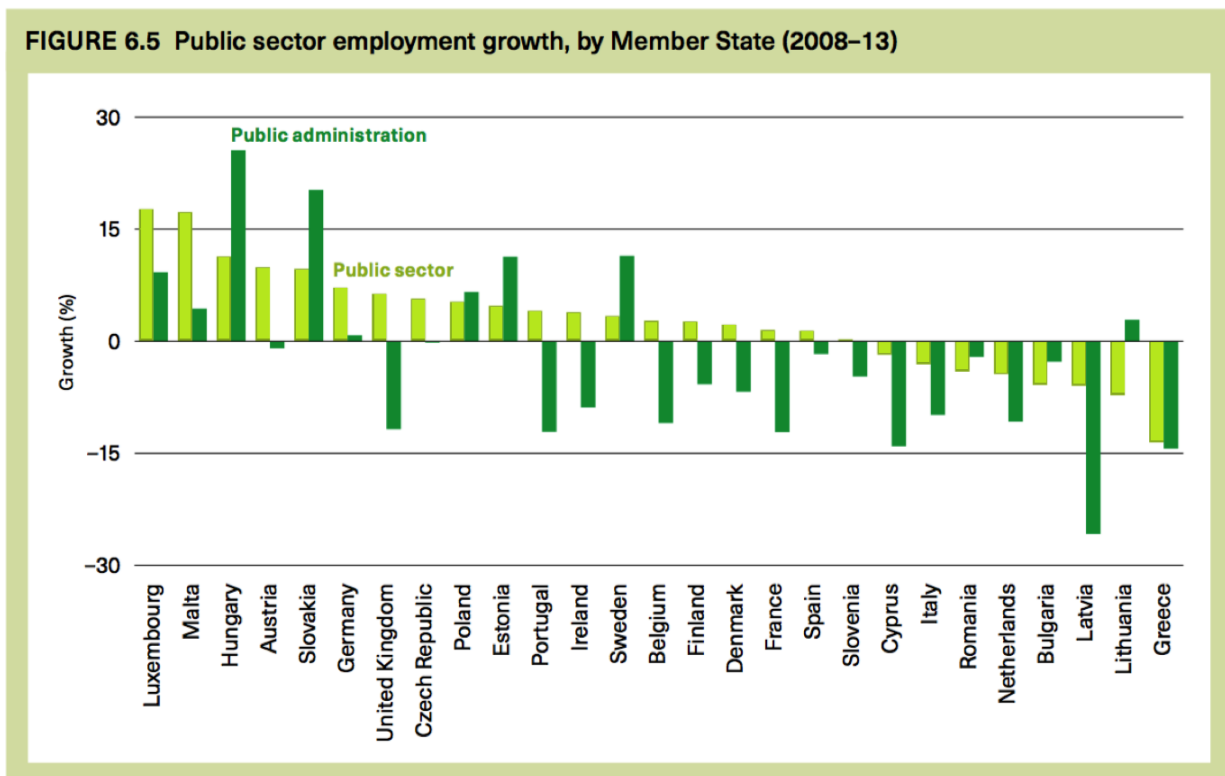


Figure 3.2: Public Wage Bill and Public Employment Before the Crisis *Source: Holm-Hadulla et al. (2010)*



Source: Eurostat [lfsa_egan2].

Figure 3.3: Changes in Public Sector Employment Following the Crisis *Source: Gama et al. (2015)*

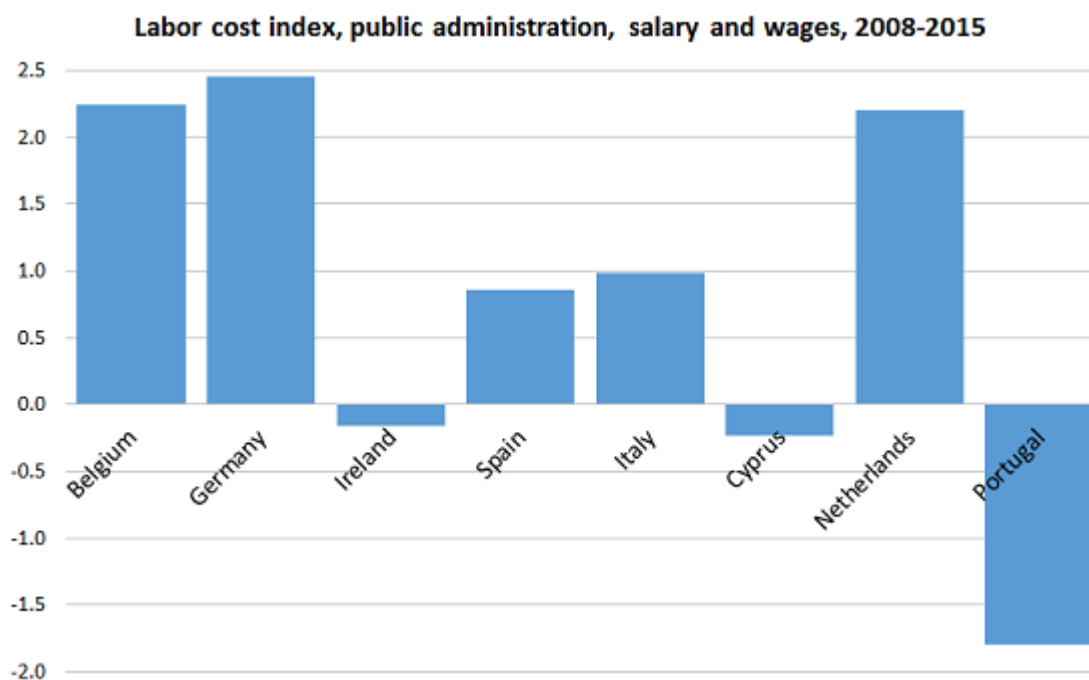


Figure 3.4: Changes in Public Sector Wages Following the Crisis *Source: Eurostat*

consolidation instruments on the part of the government: public wage cuts and public vacancy cuts. We consider each instrument separately, assuming that if one is active, the other remains fixed at its steady state value. We then repeat this experiment when the economy faces low inflation due to a liquidity trap. This setup allows us to compare, for a given consolidation volume, the effects of the alternative consolidation strategies in different environments.

There has been little work so far in explicitly modeling the interaction between the private and the public sector. The existing literature has largely focused on evaluating the impact of the public sector on the level or volatility of employment and wages (see e.g. Algan et al. (2002), Quadrini and Trigari 2007, Hörner et al. 2007, and Gomes 2015b). Ardagna (2007) has shown using a DSGE model with a unionized labour market (but without unemployment) that, in response to a debt-financed increase in public-sector employment and wages, unions demand higher wages, which leads to a fall in private-sector employment and capital stock, and a contraction in the economy. Michaillat (2014) makes an important contribution by finding that the “government multiplier”, defined as the additional number of workers hired in the private sector when one public job is created, is positive and countercyclical, suggesting that the public sector tends to stabilize labour market fluctuations. Bradley et al. (2015) are the first to estimate (using British data) a model with equilibrium

unemployment and a public sector. The authors also run simulations that attempt to mimic austerity measures implemented across Europe after the 2008 recession, namely a reduction in public sector hiring, an increase in public sector layoffs, and progressive and proportional cuts to the distribution of wages in the public sector. They find that all four policies increase hiring and turnover in the private sector, reduce public sector employment which is largely compensated by an increase in private sector employment, summing up to very moderate changes in aggregate unemployment; and finally, exert a very small impact on mean wages and in the aggregate economy. In an earlier contribution, Demekas and Kontolemis (2000) developed a simple two-sector model of the labour market with endogenous unemployment, but without explicit dynamics, showing that increases in government wages lead through worker flow dynamics to increases in private sector wages and, therefore, directly to higher unemployment. Increases in government employment do not have a significant impact on unemployment, and might even raise it. Using data for Greece, they found strong support for their theoretical predictions. On the empirical front, Cavallo (2005) found for the US that hours, output, and investment in the private sector decrease in response to an unanticipated increase in the government wage bill expenditure, in line with Finn (1998), but without distinguishing between public wage and employment policies.

In our model, in normal times, a fiscal consolidation through a cut in public wages is able to reduce the public debt-to-GDP ratio faster than public vacancy costs, although both have similar positive effects on private output through an increase in private-sector hirings. In the case of public wage cuts the increase in private-sector employment dominates the fall in public employment, leading to a fall in the unemployment rate, while in the case of public vacancy cuts the unemployment rate rises. Hence, public wage cuts are a preferable consolidation strategy to public vacancy cuts in normal times.

In a low inflation environment, induced by a negative demand shock, the fall in demand leads to a fall in private output, which, along with the high in the real interest rate, causes government debt-to-GDP to rise. Hence a much larger cut in the public wage bill is required to bring debt to the desired level, meaning that the consolidation in this environment has large negative effects. The differences between the two instruments appear less pronounced in a low inflation environment; yet, again, in the long run public wage cuts lead to a reduction in the long-run unemployment rate, while public vacancy cuts induce a persistent rise in unemployment.

The remainder of the paper is organised follows. In Section 3.2, we provide

the details of the model. Section 3.3 discusses the results of the different policy experiments and extensive sensitivity analysis. Section 3.4 concludes.

3.2 The Model

We consider a two-country DSGE model of a monetary union with search and matching frictions, endogenous labour force participation, and sticky prices in the short run. The two countries, labeled Home and Foreign, are of sizes n and $1 - n$, respectively. The following subsections describe the Home economy in more detail: the structure of the Foreign economy is analogous. All variables are in *per capita* terms. Where necessary, the conventional \star denotes foreign variables or parameters, and the subscripts h and f denotes goods produced in the Home and Foreign country and their respective prices.

There are four types of firms in each country: (i) a public firm that produces a good used in private production, (ii) private competitive firms that use labour, capital and the public good to produce a non-tradable intermediate good, (iii) monopolistic retailers that transform the intermediate good into a tradeable good, and (iv) competitive final goods producers that use domestic and foreign produced retail goods to produce a final, non-tradeable good which is used for investment and consumption. Price rigidities arise at the retail level, while labour market frictions occur in the intermediate goods sector. The representative household consists of private and public employees, unemployed, and labour force non-participants. The government collects taxes and uses revenues to finance the wages of public employees, the costs of opening new vacancies in the public sector and the provision of unemployment benefits.

3.2.1 Labour markets

We consider search and matching frictions in both the private and public labour markets. In each period, jobs in each sector, $j = p, g$, are destroyed at a constant fraction σ^j and a measure m^j of new matches are formed. The evolution of employment in each sector is thus given by:

$$n_{t+1}^j = (1 - \sigma^j)n_t^j + m_t^j \tag{3.1}$$

We assume that $\sigma^p > \sigma^g$ in order to capture the fact that, in general, public employment is more permanent than private employment.¹

The new matches are given by:

$$m_t^j = \rho_m^j (v_t^j)^\alpha (u_t^j)^{1-\alpha} \quad (3.2)$$

where the matching efficiency, ρ_m^j , can differ in the two sectors. From the matching functions specified above we can define, for each sector j , the probability of a jobseeker being hired, ψ_t^{hj} , and of a vacancy being filled, ψ_t^{fj} :

$$\psi_t^{hj} \equiv \frac{m_t^j}{u_t^j} \quad (3.3)$$

$$\psi_t^{fj} \equiv \frac{m_t^j}{v_t^j} \quad (3.4)$$

3.2.2 Households

The representative household consists of a continuum of infinitely lived agents. The members of the household derive utility from leisure, which corresponds to the fraction of members that are out of the labour force, l_t , and a consumption bundle, c_t . Following Neiss and Pappa (2005), we also allow for variable labour effort, x_t , which leads to separable disutility. The instantaneous utility function is thus given by:

$$U(c_t, l_t, x_t) = \frac{c_t^{1-\eta}}{1-\eta} + \Phi \frac{l_t^{1+\varphi}}{1+\varphi} - \Upsilon \frac{x_t^{1+\xi}}{1+\xi}$$

where η is the inverse of the intertemporal elasticity of substitution, $\Phi > 0$ is the relative preference for leisure, φ is the inverse of the Frisch elasticity of labour supply, and $\Upsilon > 0$ and ξ are the utility parameters for variable labour effort.

At any point in time, a fraction n_t^p (n_t^g) of the household members are private (public) employees. Campolmi and Gnocchi (2014) and Bruckner and Pappa (2012) have added a labour force participation choice in New Keynesian models of equilibrium unemployment. Following Ravn (2008), the participation choice is modelled as a trade-off between the cost of giving up leisure and the prospect of finding a job. In particular, the household chooses the fraction of the unemployed actively searching for a job, u_t , and the fraction which are out of the labour force and enjoying leisure,

¹For example, Gomes (2015a), Gomes (2015b) and Albrecht et al. (2014) find empirical evidence that separation rates in the public sector are lower than the private sector in the UK, US and Colombia respectively.

l_t , so that:

$$n_t^p + n_t^g + u_t + l_t = 1 \quad (3.5)$$

The household chooses the fraction of jobseekers searching in each sector: a share s_t of jobseekers look for a job in the public sector, while the remainder, $(1 - s_t)$, seek employment in the private sector. That is, $u_t^g \equiv s_t u_t$ and $u_t^p \equiv (1 - s_t)u_t$.² This decision will depend on the expected utility from searching in each sector, which in turn depends on the probability of finding a job, ψ_t^{hj} , the separation rate, σ^j , and the wage in each sector. In other words, a wage differential can arise between the two sectors in a non-degenerate equilibrium if there are differences in the number of vacancies, the matching efficiency or the separation rate.³

The household owns the private capital stock, which evolves according to:

$$k_{t+1}^p = \left[1 - \frac{\omega}{2} \left(\frac{i_t^p}{i_{t-1}^p} - 1 \right)^2 \right] i_t^p + (1 - \delta^p) k_t^p \quad (3.6)$$

where i_t^p is private investment, δ^p is a constant depreciation rate and ω dictates the size of investment adjustment costs.

The budget constraint, in real terms, is given by

$$(1 + \tau_c) c_t + i_t^p + b_{g,t+1} + e_t r_{f,t-1} b_{f,t} \leq (1 - \tau_n) (w_t^p n_t^p x_t + w_t^g n_t^g) + r_{t-1} b_{g,t} \quad (3.7)$$

$$+ e_t b_{f,t+1} + [r_t^p - \tau_k (r_t^p - \delta^p)] k_t^p + b u_t + \Pi_t^p + T_t$$

where w_t^j are the real wages in the two sectors, r_t^p is the real return on capital, b denotes unemployment benefits, Π_t^p are the profits of the monopolistic retailers, discussed below, and τ_c , τ_k , τ_n , and T_t represent taxes on private consumption, private capital, labour income and lump-sum transfers, respectively. $b_{g,t}$ are government bonds which pay the real return r_{t-1} , whereas $b_{f,t}$ denote liabilities with the Foreign country. Although the nominal exchange rate is fixed, the interest rate on foreign assets, $r_{f,t}$, is still affected by consumer inflation differentials between the two countries, which are captured by the real exchange rate, e_t . In fact, we can define the nominal interest rate at Home, R_t , through Fisher equation

²For simplicity, we will abstract from variable labour effort in the public sector.

³This point can be seen more clearly from the household's first order conditions, provided in the appendix.

$$r_t = \frac{R_t}{\pi_{t+1}} \quad (3.8)$$

where π_t is the gross consumer inflation rate.

Thus the problem of the household is to choose c_t , u_t , s_t , n_{t+1}^p , n_{t+1}^g , x_t , i_t^p , k_{t+1}^p , $b_{g,t+1}$, $b_{f,t+1}$ to maximise lifetime utility subject to the budget constraint, (3.7), the law of motion of employment in each sector, (3.1), the law of motion of capital, (3.6), and the composition of the household, (3.5). The resulting first order conditions are provided in the appendix. For use below, we define the marginal value of an additional private sector employee as:

$$\begin{aligned} V_{n^p t}^H &= \lambda_{ct} w_t^p x_t (1 - \tau_n) - \Phi l_t^p + (1 - \sigma^p) \lambda_{n^p t} \\ &= \lambda_{ct} w_t^p x_t (1 - \tau_n) - \Phi l_t^p + (1 - \sigma^p) \beta E_t (V_{n^p t+1}^H) \end{aligned} \quad (3.9)$$

where λ_{ct} and $\lambda_{n^p t}$ are the Lagrange multipliers on the budget constraint and the law of motion of private employment respectively.

3.2.3 Production

3.2.3.1 Intermediate goods firms

Intermediate goods are produced with a Cobb-Douglas technology:

$$y_t^p = (A_t n_t^p x_t)^{1-\phi} (k_t^p)^\phi (y_t^g)^\nu \quad (3.10)$$

where A_t is a labour augmenting productivity factor, k_t^p and n_t^p are private capital and labour inputs, x_t is the effort intensity of labour. Following Barro (1990) and Turnovsky (1999), we allow the public good, y_t^g , to enter the private production function, taken as exogenous by the firms. The parameter ν regulates how the public input affects private production: when ν is zero, the government good is unproductive.

Since current hires give future value to intermediate firms, the optimization problem is dynamic and hence firms maximize the discounted value of future profits. The number of workers currently employed, n_t^p , is taken as given and the employment decision concerns the number of vacancies posted in the current period, v_t^p , so as

to employ the desired number of workers next period, n_{t+1}^p .⁴ Firms also decide the amount of the private capital, k_t^p , to be rented from the household at rate r_t^p . The problem of an intermediate firm with n_t^p currently employed workers consists of choosing k_t^p and v_t^p to maximize:

$$Q^p(n_t^p) = \max_{k_t^p, v_t^p} \{ p_{x,t} (A_t x_t n_t^p)^{1-\phi} (k_t^p)^\phi (y_t^g)^\nu - w_t^p n_t^p x_t - r_t^p k_t^p - \kappa v_t^p + E_t [\Lambda_{t,t+1} Q^p(n_{t+1}^p)] \} \quad (3.11)$$

where $p_{x,t}$ is the relative price of intermediate goods, κ is a utility cost associated with posting a new vacancy, and $\Lambda_{t,t+1} = \beta \frac{\lambda_{ct+1}}{\lambda_{ct}}$ is the discount factor. The maximization takes place subject to the private employment transition equation, where the firm takes the probability of the vacancy being filled as given:

$$n_{t+1}^p = (1 - \sigma^p) n_t^p + \psi_t^{fp} v_t^p \quad (3.12)$$

The first-order conditions are:

$$p_{x,t} \phi \frac{y_t^p}{k_t^p} = r_t^p \quad (3.13)$$

$$\frac{\kappa}{\psi_t^{fp}} = E_t \Lambda_{t,t+1} [p_{x,t+1} (1 - \phi) \frac{y_{t+1}^p}{n_{t+1}^p} - w_{t+1}^p x_{t+1} + (1 - \sigma^p) \frac{\kappa}{\psi_{t+1}^{fp}}] \quad (3.14)$$

According to (3.13) and (3.14) the value of the marginal product of private capital should equal the real rental rate and the marginal cost of opening a vacancy should equal the expected marginal benefit. The latter includes the marginal productivity of labour minus the wage plus the continuation value, knowing that with probability σ^p the match can be destroyed.

The expected value of the marginal job for the intermediate firm, $V_{n^p t}^F$ is:

$$V_{n^p t}^F \equiv \frac{\partial Q^p(n_t^p)}{\partial n_t^p} = p_{x,t} (1 - \phi) \frac{y_t^p}{n_t^p} - w_t^p x_t + \frac{(1 - \sigma^p) \kappa}{\psi_t^{fp}} \quad (3.15)$$

3.2.3.2 Retailers

There is a continuum of monopolistically competitive retailers indexed by i on the unit interval. Retailers buy intermediate goods and differentiate them with a technology that transforms one unit of intermediate goods into one unit of retail goods, and

⁴Firms adjust employment by varying the number of workers (extensive margin) rather than the number of hours per worker. According to Hansen (1985), most of the employment fluctuations arise from movements in this margin.

thus the relative price of intermediate goods, $p_{x,t}$, coincides with the real marginal cost faced by the retailers. Let y_{it} be the quantity of output sold by retailer i . The final consumption good can be expressed as:

$$y_t^r = \left[\int_0^1 (y_{it})^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}$$

where $\epsilon > 1$ is the constant elasticity of demand for each variety of retail goods. The final good is sold at a price $P_{h,t} = \left(\int (P_{i,h,t})^{\epsilon-1} di \right)^{\frac{1}{\epsilon-1}}$. The demand for each intermediate good depends on its relative price and on aggregate demand

$$y_{i,t} = \left(\frac{P_{i,h,t}}{P_{h,t}} \right)^{-\epsilon} y_t^r \quad (3.16)$$

Following Calvo (1983), we assume that in any given period each retailer can reset its price with a fixed probability $(1 - \chi)$. Firms that are able to reset their price choose $P_{i,h,t}^*$ so as to maximize expected real profits given by

$$\Pi_t(i) = \text{Max}_{P_{i,h,t}^*} \text{E}_t \sum_{s=0}^{\infty} (\beta\chi)^s \Lambda_{t,t+s} \left(\left[\frac{P_{i,h,t}}{p_{t+s}} - p_{x,t+s} \right] y_{i,t+s} \right)$$

subject to the demand schedule (3.16), in each period. Since all firms are ex-ante identical, $P_{i,h,t}^* = P_{h,t}^*$ for all i . The resulting expression for $p_{h,t}^* \equiv P_{h,t}^*/P_t$ is

$$\frac{p_{h,t}^*}{p_{h,t}} = \frac{\epsilon}{\epsilon - 1} \frac{\mathcal{N}_t}{\mathcal{D}_t} \quad (3.17)$$

where

$$\mathcal{N}_t = p_{x,t} y_t^r + \beta\chi \Lambda_{t,t+1} (\pi_{h,t+1})^\epsilon \mathcal{N}_{t+1} \quad (3.18)$$

$$\mathcal{D}_t = p_{h,t} y_t^r + \beta\chi \Lambda_{t,t+1} (\pi_{h,t+1})^{\epsilon-1} \mathcal{D}_{t+1} \quad (3.19)$$

$p_{h,t} \equiv P_{h,t}/P_t$ is the real domestic price of y_t^r and $\pi_{h,t}$ denotes producer inflation. Under the assumption of Calvo pricing, the price index, in nominal terms, is given by

$$P_{h,t} = \chi (P_{h,t-1})^{\epsilon-1} + (1 - \chi) (P_{h,t}^*)^{1-\epsilon} \quad (3.20)$$

Retail goods are sold domestically and abroad. In aggregate,

$$y_t^r = y_{h,t} + y_{h,t}^* \quad (3.21)$$

where $y_{h,t}$ is the share of retail goods sold domestically and $y_{h,t}^*$ the quantity sold abroad, and we have assumed the law of one price holds

$$p_{h,t} = e_t p_{h,t}^* \quad (3.22)$$

3.2.3.3 Final Goods Producer

Finally, in each country perfectly competitive firms produce a non-tradeable final good by aggregating domestic and foreign aggregate retail goods using technology

$$y_t = \left[(\varpi)^{\frac{1}{\gamma}} (y_{h,t})^{\frac{\gamma-1}{\gamma}} + (1-\varpi)^{\frac{1}{\gamma}} (\bar{\tau} y_{f,t})^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}}$$

where $\bar{\tau} \equiv (1-n)/n$ normalizes the amount of imported goods at Home to *per capita* terms. The home-bias parameter ϖ denotes the fraction of goods produced at home that are used in the production of the final good. The elasticity of substitution between home-produced and imported goods is given by γ . Final good producers maximize profits $y_t - p_{h,t} y_{h,t} - p_{f,t} \bar{\tau} y_{f,t}$ each period. Solving for the optimal demand functions gives

$$y_{h,t} = \varpi (p_{h,t})^{-\gamma} y_t \quad (3.23)$$

$$y_{f,t} = (1-\varpi) (p_{f,t})^{-\gamma} \frac{n}{1-n} y_t \quad (3.24)$$

The consumer price index, P_t , is defined by substituting out $y_{h,t}$ and $y_{f,t}$ in the CES above by the respective demand curves, which yields

$$P_t = \varpi (P_{h,t})^{1-\gamma} + (1-\varpi) (P_{f,t})^{1-\gamma} \quad (3.25)$$

3.2.4 Government

The government sector produces the public good using public capital and labour:

$$y_t^g = (A_t n_t^g)^{1-\mu} (\bar{k}^g)^\mu \quad (3.26)$$

where we assume that productivity shocks are not sector specific and μ is the share of public capital, \bar{k}^g , which is assumed fixed. The public good, which is provided for free, provides productivity and utility enhancing services. Government expenditure consists of public wages, public vacancy costs and unemployment benefits, while revenues come from the consumption, capital income, labour income and lump-sum

taxes. The government deficit is therefore defined by:

$$DF_t = w_t^g n_t^g + \kappa v_t^g + b u_t - TR_t$$

where $TR_t \equiv \tau_n(w_t^p n_t^p x_t + w_t^g n_t^g) + \tau_k(r_t^p - \delta^p)k_t^p + T + \tau_c c_t$ denotes tax revenues.

The government budget constraint is given by:

$$b_{g,t} + DF_t = \frac{b_{g,t+1}}{r_t} \quad (3.27)$$

We assume that tax rates are constant and fixed at their steady state levels, and we do not consider them as active instruments for fiscal consolidation. Similarly we assume that government investment is held fixed at its steady state value, $i^g = \delta^g k^g$, keeping the public capital stock constant. Thus the government has two potential fiscal instruments, v_g and w_g . We consider each instrument separately, assuming that if one is active, the other remains fixed at its steady state value. For $\Psi \in \{v_g, w_g\}$, we assume fiscal rules of the form, following Erceg and Linde (2013) and Pappa et al. (2015):

$$\Psi_t = \Psi^{(1-\beta_{\Psi 0})} \Psi_{t-1}^{\beta_{\Psi 0}} \left[\left(\frac{\tilde{b}_{g,t}}{b_{g,t}^*} \right)^{\beta_{\Psi 1}} \left(\frac{\Delta \tilde{b}_{g,t+1}}{\Delta b_{g,t+1}^*} \right)^{\beta_{\Psi 2}} \right]^{(1-\beta_{\Psi 0})} \quad (3.28)$$

where $\tilde{b}_{g,t} \equiv \frac{b_{g,t}}{rgdp_t}$ is the debt-to-GDP ratio and $b_{g,t}^*$ is the target debt-to-GDP ratio, given by the AR(2) process:

$$\log b_{g,t}^* - \log b_{g,t-1}^* = \mu_b + \rho_1 (\log b_{g,t-1}^* - \log b_{g,t-2}^*) - \rho_2 \log b_{g,t-1}^* - \varepsilon_t^b$$

where ε_t^b is a white noise shock representing a fiscal consolidation.⁵

3.2.5 Closing the model

3.2.5.1 Monetary policy

There is a single independent monetary authority that sets the nominal interest rate to target zero net inflation, subject to the ZLB:

$$R_t^* = \text{Max} \{1, \rho R_{t-1}^* + (1 - \rho) \rho_\pi \tilde{\pi}_t\} \quad (3.29)$$

⁵Notice that public wage cuts reduce the wage bill in the public sector in the same period, while public vacancy cuts reduce it with a lag from next period.

where $\tilde{\pi}_t$ is the sum of national consumer inflations, weighted by population sizes, $n\pi_t + (1 - n)\pi_t^*$. For the Home, consumer inflation is defined as:

$$\frac{\pi_{h,t}}{\pi_t} = \frac{p_{h,t}}{p_{h,t-1}} \quad (3.30)$$

With fixed nominal exchange rates, the real exchange rate equals the ratio of consumer prices:

$$\frac{e_t}{e_{t-1}} = \frac{\pi_t^*}{\pi_t} \quad (3.31)$$

Finally, and to render the model stationary, we introduce a risk premium charged to Home households depending on the relative size of net-foreign-liabilities to total output:

$$r_{f,t} = r_t^* \exp \left\{ \Gamma \bar{e}_t \frac{b_{f,t+1}}{rgdp_t} \right\} \quad (3.32)$$

where Γ is the elasticity of the risk premium with respect to the liabilities.

3.2.5.2 Resource constraint

The non-tradeable domestic final good is sold for consumption and for investment:

$$y_t = c_t + i_t^p + \kappa v_t^p + \kappa v_t^g \quad (3.33)$$

and, following, Gomes (2015a), total output is defined as private output plus the wage bill:

$$rgdp_t = p_{x,t} y_t^p + w_t^g n_t^g \quad (3.34)$$

Aggregating the budget constraint of households using the market clearing conditions, the budget constraint of the government, and aggregate profits $V_t = \int_i \Pi_{\mathbf{R}}(i) di$, we obtain the law of motion for net foreign assets, which is given by:

$$e_t (r_{f,t-1} b_{f,t} - b_{f,t+1}) = nx_t \quad (3.35)$$

and where nx_t are net exports defined as:

$$nx_t = p_{h,t} y_{h,t}^* - p_{f,t} \bar{y}_{f,t} \quad (3.36)$$

3.2.5.3 Wage bargaining

Private sector wages are determined by ex post (after matching) Nash bargaining. Workers and firms split rents and the part of the surplus they receive depends on their bargaining power. If we denote by $\vartheta \in (0, 1)$ the firms' bargaining power, the Nash bargaining problem is to maximize the weighted sum of log surpluses:

$$\max_{w_t^p} \{ (1 - \vartheta) \ln V_{n^p t}^H + \vartheta \ln V_{n^p t}^F \}$$

where $V_{n^p t}^H$ and $V_{n^p t}^F$ have been defined above. The optimization problem leads to the following solution for w_t^p :

$$w_t^p x_t = (1 - \vartheta) p_{x,t} (1 - \phi) \frac{y_t^p}{n_t^p} + \frac{\vartheta}{(1 - \tau_n) \lambda_{c,t}} \Phi l_t^\varphi \quad (3.37)$$

Hence, the equilibrium wage is a weighted average of the marginal product of employment and the disutility from labour, with the weights given by the firm and household's bargaining power respectively.⁶

3.2.6 Model Solution and Calibration

We solve the model by linearising the equilibrium conditions around a non-stochastic steady state in which all prices are flexible, the price of the private good is normalized to unity, and inflation is zero.

Table 3.1 shows some of the key parameters and steady-state values targeted in our calibration. We set $n = 0.5$ and consider the Home and Foreign block as two perfectly symmetric countries.⁷

When considering the ZLB, which is a non-linear constraint, we use the Occbin toolkit provided by Guerrieri and Iacoviello (2015). Following the literature, this environment is induced by assuming a positive shock to the household's discount rate, β , in both countries.⁸ This causes inflation to fall across the monetary union, driving the nominal interest rate to its lower bound.

⁶See the appendix for the full derivation.

⁷Full details of the calibration strategy are provided in the appendix.

⁸We assume that the shock decays with auto-regressive parameter 0.5.

Table 3.1: Calibration of Parameters and Steady-State Values

Parameter/Variable	Description	Value
n	Size of Home Block	0.5
<i>Preferences:</i>		
β	Household discount factor	0.99
η	Intertemporal Elasticity of Substitution	1
φ	Inverse Frisch Elasticity of Labour	4
<i>Labour Market:</i>		
$(1 - l)$	Labour force participation	65%
$u/(1-l)$	Unemployment rate	10%
n^g/n	Share of public employment	18%
κ/w^p	Vacancy costs as a share of wages	4.5%
<i>Production:</i>		
ν	Productivity of public good	0.05
ϕ, μ	Share of capital in production	0.36
k^g/k^p	Public-private capital ratio	0.31
χ	Price-stickiness	0.75
<i>Policy Parameters:</i>		
ρ_π	Taylor-rule inflation targeting parameter	2.5
ρ_1, ρ_2	Debt-target law of motion	0.85, 0.0001
\tilde{b}_g	Steady-state debt-to-GDP ratio	50%

3.3 Results

We consider a shock which drives the debt-to-GDP ratio target around 2pp below its steady state after 10 quarters. We simulate the response to this shock under the two alternative policy instruments, v^g and w^g . We then consider the same shock in a low inflation environment.

To further investigate the results, we also show the role of the different mechanisms of the model. Firstly, with respect to the assumptions about monetary and fiscal policy, we consider the role of the consolidation shock, the speed of adjustment during consolidation and the strength of the monetary policy response. Finally, we carry out sensitivity analysis with respect to some of the parameters in the model, looking in particular at the productivity of the public good, the size of investment adjustment costs and the elasticity of labour supply.

3.3.1 Consolidation in Normal Times

In this section we analyse the role of consolidation in normal times, when the economy is not subject to deflationary shocks.

3.3.1.1 Quantity-based Measures: Public Vacancy Cuts

We start by analyzing the effects of fiscal consolidation when vacancy cuts are assumed to be the fiscal policy instrument for achieving the lower debt target. Results from this exercise are presented in the solid lines in Figure 3.5. We see that the cut in public vacancies causes a fall in public employment, and hence both the public wage bill falls with a lag.

The share of jobseekers searching in the public sector falls as workers move towards the private sector, causing a fall in private wages, a rise in private labour demand, and hence a rise in private employment. At the same time, the reduction in expenditure on the public wage bill creates a positive wealth effect for the household, causing a rise in private consumption and investment. The latter raises the private capital stock. Thus, private output increases, despite the fall in public output, which also serves as an input in private production. The unemployment rate increases persistently due to the fall in public employment and the increase in the labour force participation rate. Finally, despite the boost to private output, real GDP falls after the consolidation as a result of the fall in the public wage bill.

3.3.1.2 Price-based Measures: Public Wage Cuts

The dashed lines in Figure 3.5 depicts the case in which fiscal consolidation is achieved through cuts in the public wage. Despite the fact that the public wage falls less steeply than vacancies, the public wage bill falls by a lot more as public employment also falls, and so the consolidation is much more effective.

The public wage cut causes a significant shift in jobseekers towards the private sector, leading to a fall in public employment.⁹ As before, the subsequent decrease of the private wage reduces marginal costs of firms in the private sector and this increases the demand for labour and boosts private employment. Differently from before, the adjustment is less sluggish, as labour force participation also rises, and so the unemployment rate falls during the consolidation. As before, despite the fall in income, we see that again the consolidation causes a positive wealth effect for the household, raising consumption and investment. Hence, despite the fall in public output, we again see a rise in private output. Nonetheless, real GDP falls much more steeply than the case of vacancy cuts due to the fall in the public wage bill.

Hence, in line with Bradley et al. (2015), we find that in normal times cuts in the public wage bill reduce public sector employment and increase hiring in the private

⁹Recall that public output moves proportionally to public employment.

sector. However, our results indicate that the effects on aggregate unemployment are different for the two instruments considered: in the case of public wage cuts (price-based measure) the increase in private-sector employment prevails and we observe a fall in the unemployment rate, while in the case of public vacancy cuts (quantity-based measure) the fall in public employment is such that leads to an increase in the unemployment rate.

3.3.2 Consolidation in a Low Inflation Environment

In this section we analyse how our conclusions about fiscal consolidation through public wage bill cuts change when the monetary union operates in a low inflation environment.

3.3.2.1 Quantity-based Measures: Public Vacancy Cuts

Figure 3.6 shows the impulse response functions when public vacancies are the active consolidation instrument in a low inflation environment. For comparability purposes, the solid lines depict the baseline simulations in response to the fiscal consolidation shock only. First, notice that the effects of the consolidation shock alone are very small compared to the effects of the discount rate shock. The dashed lines depict the responses in the presence of the shock to the household's discount rate when the ZLB constraint is not imposed, while the dash-dotted line depicts the responses when imposing the ZLB. We see that the nominal interest rate falls sharply. Relative to the unconstrained case, when the nominal rate hits the ZLB, the real interest rate remains too high and inflation falls by a much larger amount. Importantly, the discount rate shock has important direct consequences for public debt. In the unconstrained case, the debt-to-GDP ratio falls below the target, such that public vacancies and the public wage bill actually rise. In contrast, when the ZLB constraint is imposed, the debt-to-GDP ratio rises sharply and remains well above its initial level, despite a large fall in public vacancies.

With the negative demand shock, we observe a fall in private consumption and investment. The demand contraction leads to a fall in private labour demand. The negative wealth effect is so strong that agents increase further their participation, leading to a considerable increase in unemployment, and mitigates the fall in private employment. Nonetheless, the fall in investment, and hence capital, as well as labour effort and the public output, lead to a significant contraction of private output.

The simultaneous contraction in the private and the public sector leads to a rise

in public debt despite the consolidation. This means that public vacancies need to fall by much more than the baseline case, reducing public employment and output by more. This further reinforces the fall in private output and makes consolidation difficult to achieve.

3.3.2.2 Price-based Measures: Public Wage Cuts

Figure 3.7 plots impulse responses for the case of public wage cuts in the baseline, unconstrained and constrained cases.

Responses look very similar with the responses of the vacancy cut case. When the interest rate is not bounded by the zero constraint, the discount rate shock causes a sharp fall in debt-to-GDP and so consolidation is reversed, leading to increases in public wages. This shifts labour supply towards the public sector, reducing employment in the private sector and contracting private output despite the surge in private investment induced by the low real interest rate. On the other hand, public output expands so much that total real GDP increases after the first 4 quarters.

Moving to the more interesting case of the equilibrium in which the ZLB constraint is imposed, we see that inflation falls much more, keeping the real interest rate higher than the unconstrained case. The sharp rise in the debt-to-GDP ratio induces a much larger fall in public wages, and hence the public wage bill and public employment. Accordingly, the response of the private labour market is amplified relative to the baseline case, including a larger rise in private employment, except for a mitigated rise in labour demand, due to the contraction in private consumption.

The higher real rate means that investment rises less than in the unconstrained case, but it does not fall, as in the case of vacancy cuts. However, as before, the fall in labour effort and public output lead to a significant contraction both private output and real GDP.

To sum up, the fall in private output induced by the negative effects of the deflationary shock makes it more difficult for the government to consolidate debt and attenuates the positive effects of the consolidation in normal times. In this case, public wage cuts lead to a rise in unemployment for several periods, and have a similar negative effect on private output, hence they are no longer obviously preferable to vacancy cuts.

3.3.3 Sensitivity Analysis I: Fiscal and Monetary Policy

We now carry out a series of alternative simulations to investigate the sensitivity of our results to the assumptions we made regarding fiscal and monetary policy. For the purpose of this section, for brevity we present only the IRFs of some key variables, and present only the simulations at the ZLB. All other IRFs are available from the authors on request.

3.3.3.1 The Role of the Consolidation Shock

To understand better how consolidation affects the economy at the ZLB, in this subsection we compare the dynamics of the economy in the baseline simulations to the economy at the ZLB when the consolidation is not imposed. The results are presented in Figures 3.8 and 3.9 for vacancy cuts and wage cuts, respectively.

For the case of vacancy cuts, the presence of fiscal consolidation when a deflationary shock hits the economy makes very little difference. The deflationary shock increases debt and according to the debt rule specified in Equation (3.28), public vacancies react even without the consolidation shock. The response of the private sector is only marginally affected by the consolidation shock, for example private employment falls by more without consolidation since there is less reallocation of jobseekers from the public sector. Nonetheless, the responses of private output and real GDP are very similar.

The differences are slightly more noticeable in the case of public wage cuts. The consolidation in this case does help the faster recovery of the private sector by leading to stronger positive reaction of investment and private employment, which in fact initially falls without the fiscal consolidation. As a result, private output falls less under this scenario, making the recovery of the economy following the combined shocks faster.

3.3.3.2 The Speed of Adjustment during Consolidation

In Figures 3.10 and 3.11 we examine how our conclusions would change if we considered a faster speed of adjustment for the fiscal consolidations. Notice that because of difficulties in satisfying the stability criteria in the model we cannot freely change the parameters of debt adjustments for the two instruments. Nonetheless, faster debt adjustment seems to imply that for both fiscal instruments the recovery of the private sector is somewhat faster. In the case of vacancy cuts, the main effect is seen in private employment and the participation rate, while private output and real

GDP look very similar and the debt-to-GDP ratio only falls slightly faster after 6 periods. For public wage cuts, the differences are again slightly more noticeable, but again the final effect on private output and debt-to-GDP is negligible, although the stronger fall in the public wage bill does lead to a more negative response of real GDP.

3.3.3.3 The Strength of Monetary Policy

In Figures 3.12 and 3.13 we examine the sensitivity of our results to the conduct of monetary policy at the union level. In particular we compare the baseline case to a case where $\rho_\pi=1.1$.

The strength of monetary policy has different effects in the two cases. For vacancy cuts, the responses begin to diverge around 3 or 4 quarters after shock: once the economy is close to exiting the ZLB, the lax inflation targeting implies a continuing high real rate, which leads to higher private investment and higher private output. This lowers the debt-to-GDP ratio, requiring a smaller contraction in public vacancies, and hence mitigating the negative effects of the consolidation.

Contrary to this, in the case of public wage cuts, lax monetary policy makes consolidation harder. The rise in debt-to-GDP is higher from the first period, implying a larger adjustment in public wages. This amplifies the rise in private employment, but mitigates the rise in investment and hence the response of private output is quite similar. The larger fall in the public wage bill implies a bigger fall in real GDP.

3.3.4 Sensitivity Analysis II: Deep Parameters

Our results might be sensitive not only to the policy specification we adopt for the fiscal and monetary authority, but also to some assumptions about deep parameters in the model. In this section we examine some of them that we find are crucial for our analysis.

3.3.4.1 The Productivity of Public Output

The results we present are, of course, very sensitive to the assumed value for the productivity of the public good, ν , as this is crucial in determining the effects of cuts in public wages or vacancies even in the baseline model when the ZLB does not bind. Despite the positive effects of the consolidation on private employment and capital, we have seen that both instruments lead to a fall in public output, and this leads to a direct negative effect in the private production function. The balance of these

effects, and hence the effect of the consolidation on private output, depends on the productivity of the public good.

Given the importance of the parameter ν , it is only natural to ask how the productivity of the public output affects our conclusions about the effects of fiscal consolidation in the ZLB. Figure 3.14 and 3.15 compare the responses of the baseline model with the responses when we assume a higher productivity of the public good in private production, setting $\nu = 0.1$. As it is clear from the results, making the public sector more productive implies a need for stronger fiscal consolidation after the discount factor shock, and a larger and more persistent fall in private output.

3.3.4.2 Investment Adjustment Costs

Investment adjustment costs are crucial determinants of the reaction of private capital to the consolidation shock, in particular in the presence of the demand shock. As we saw, the negative demand shock, by increasing the desire to save, increases private investment, which boosts private output and aids the consolidation effort. This is clearly indicated in Figures 3.16 and 3.17 where we plot the responses of the economy when we increase the adjustment cost parameter from 0.5 to 3.5. With higher adjustment costs, investment and hence private capital do not rise as much, private output falls more, and the debt-to-GDP rises more.

3.3.4.3 Endogenous Labour Force Participation

The assumption of labour force participation could also affect our results since, as we have seen in the baseline analysis, agents adjust their participation decision when they feel the possibility of finding a job increases or when they suffer from a negative wealth effect. In turn, the change in participation affects labour supply and thus the equilibrium wage and production levels. In Figures 3.18 and 3.19 we compare the responses of the model economy when we shut the participation margin with the baseline responses.

The responses look very similar when agents are not allowed to adjust their participation. As discussed above, the consolidation creates a shift of jobseekers towards the private sector. Even when labour participation does not increase, the reduction in public employment increases the pool of unemployed, and this shift towards the private sector can still occur. The effect on private employment is slightly mitigated, as is the rise in private investment, meaning that private output falls slightly more. However, these effects are small.

3.3.5 Sensitivity Analysis III: Open vs. Closed Economy

Finally, in Figures 3.20-3.23 we compare the responses of the open economy, described above, to a closed economy version in which we consider the Home block in autarky.

Comparing the closed and open economy versions in the baseline simulations, we can see in Figures 3.20 and 3.21 that the effects of the fiscal consolidation are largely unaffected by the presence of the second country. The fact that the Home economy has independent monetary policy acts in a similar way to strict monetary policy case described above, since the nominal interest rate is now targetting domestic inflation only. Hence, we see that the consolidation is more successful in the closed economy for both instruments, therefore requiring a smaller adjustment in the instrument and hence mitigating the negative effects of the consolidation. This confirms the results of Erceg and Linde (2013) about spending cuts: a fiscal consolidation in a monetary union is more detrimental relative to the case of independent monetary policy.

However, the differences between the two cases at the ZLB, shown in Figures 3.22 and 3.23, are more notable. These effects are mainly driven by the fact that inflation falls by more in the case of a monetary union and, as a result, the real interest rate falls and private investment increases by much less than in the case of a closed economy. In the closed economy, therefore, the initial rise in the debt-to-GDP ratio is much smaller. This implies that the consolidation is much more successful for both instruments, which then mitigates the negative effects on private output and real GDP.

3.4 Conclusions

In this paper, we have set up a DSGE model of a monetary union with search and matching frictions, nominal rigidities, and public employment. This rich model allows us to study non-trivial reallocation of agents in and out of the labour force, and between the public and private sector. In the baseline case, a fiscal consolidation through a cut in public wages is able to reduce the public debt-to-GDP ratio faster than public vacancy costs, although both have similar effects on private output and lead to a reduction in public employment and an increase in private-sector hirings. However, in the case of public wage cuts the increase in private-sector employment prevails, leading to a fall in the unemployment rate, while in the case of public vacancy cuts the fall in public employment is such that raises the unemployment rate. Hence, public wage cuts are a preferable consolidation strategy to public vacancy cuts in normal times.

In a low inflation environment a much larger cut in the public wage bill is required to bring the debt-to-GDP ratio to the desired level. The high real interest rate when the ZLB constraint is binding leads to a rise in public debt and, as a result, makes consolidation more costly. The fall in demand creates a drag on the private sector, meaning that the consolidation in this environment has large negative effects. The differences between the two instruments appear less pronounced in a low inflation environment; nonetheless public wage cuts lead to a reduction in the unemployment rate in the medium run, while public vacancy cuts induce a persistent rise in unemployment.

As our sensitivity analysis showed, our model and parameter assumptions are important for determining the results. Given our model structure we could not extend our sensitivity analysis to all possible assumptions we have adopted. Nonetheless there are three directions in particular in which we plan to extend our analysis.

Firstly, with respect to the labour market, we know that the allocation between private and public sector is key for our results. However, we have abstracted from the fact that a jobseeker with previous experience in a particular sector will be more likely to find a job in the same sector. It would therefore be interesting to introduce a friction in the reallocation of workers between the public and private sector. Related to this, it would be interesting to allow for wage rigidities, which could be important particularly in the low inflation environment. Secondly, we saw that the productivity of the public good is also key. It is therefore important to consider alternative formulations for the public sector, for example providing a utility-enhancing good directly to the households. We know that the provision of such a good is important for determining the response of the household to changes in fiscal policy, and so it may have important consequences for the macro-economic impact of the consolidation. Finally, we would like to consider alternative shocks that can replicate the ZLB crisis. In particular, we saw that the discount rate shock created an investment boom during the ZLB crisis, although the size depends on the investment adjustment costs. This is contrary to the experience in Europe since the crisis, where investment has fallen and failed to recover. Alternative shocks, or combinations of shocks, which can reproduce the current low inflation environment more closely may provide deeper insights. In future versions of this paper we plan to extend our analysis to these and other primitives of our model.

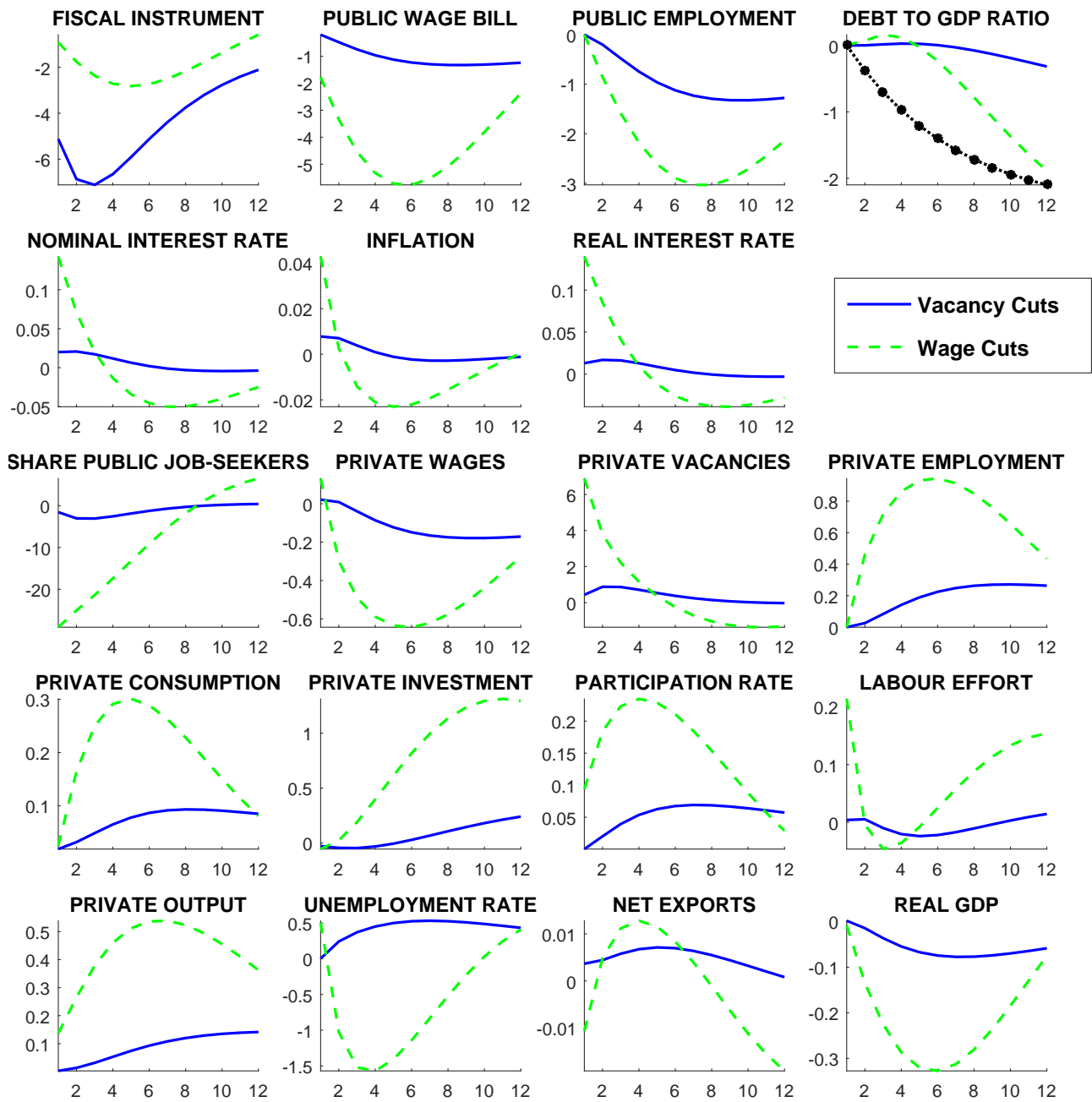


Figure 3.5: Fiscal Consolidation in Normal Times: Vacancy Cuts vs. Wage Cuts

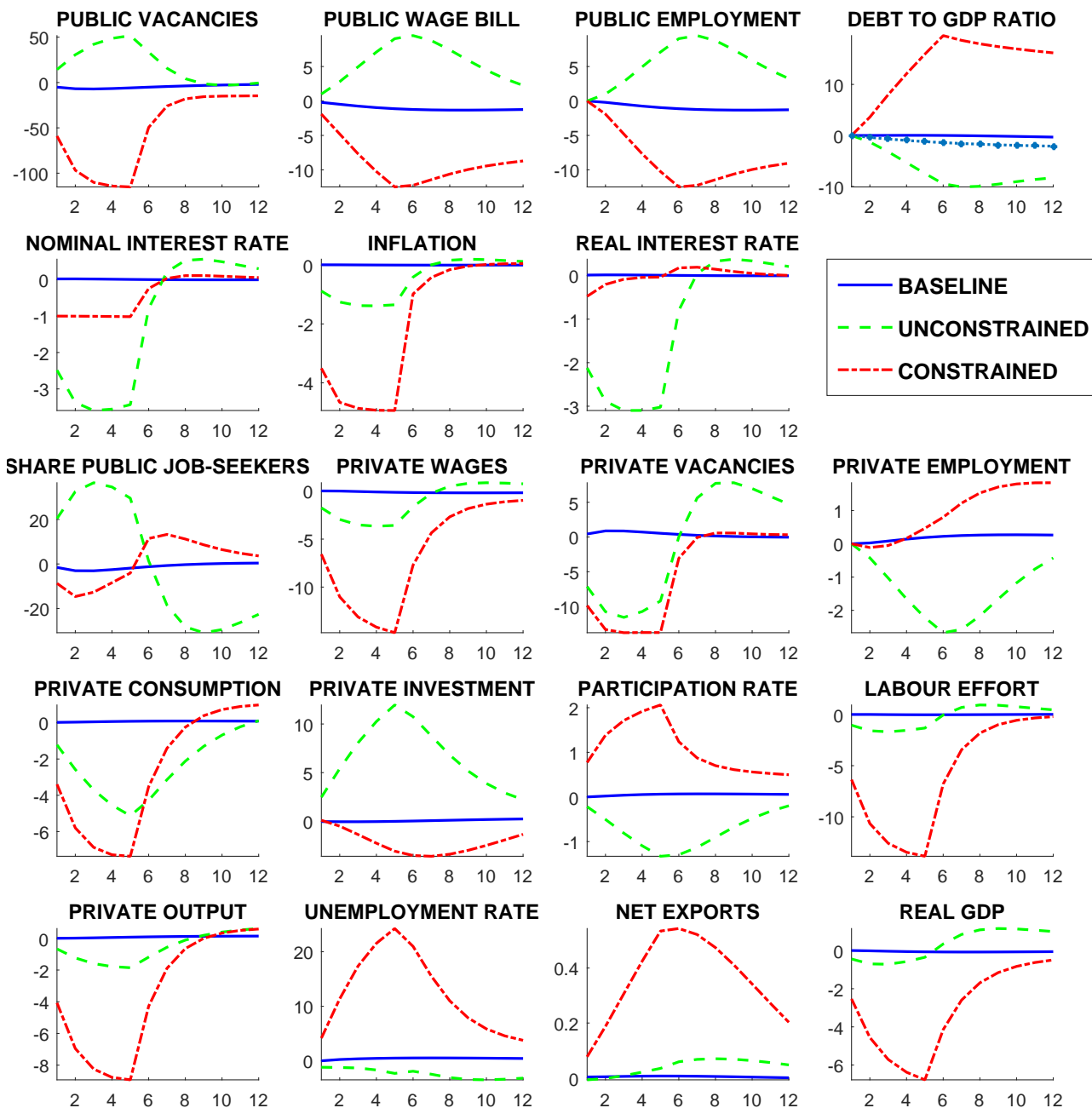


Figure 3.6: Fiscal Consolidation in a Low Inflation Environment: Public Vacancy Cuts

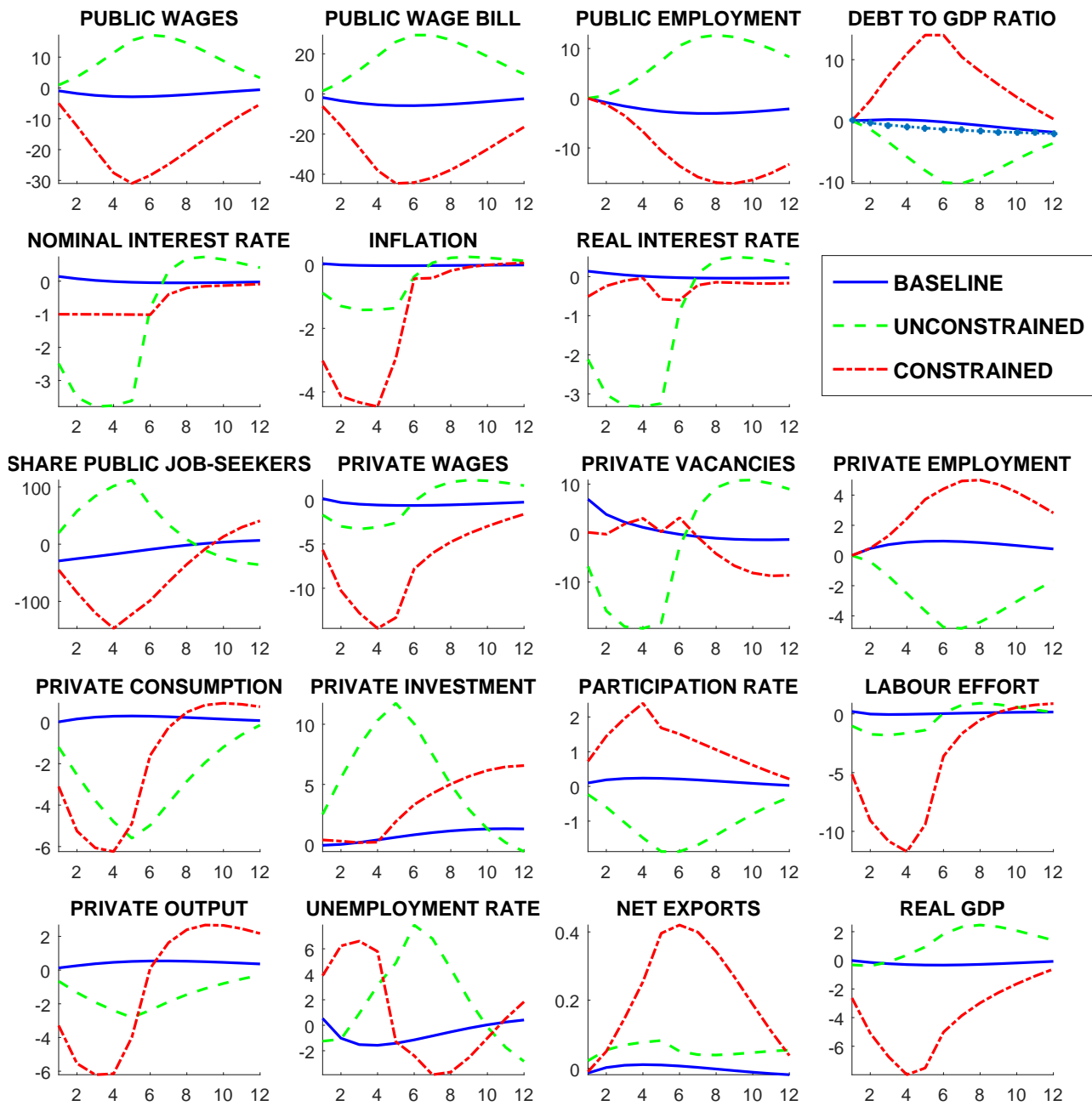


Figure 3.7: Fiscal Consolidation in a Low Inflation Environment: Public Wage Cuts

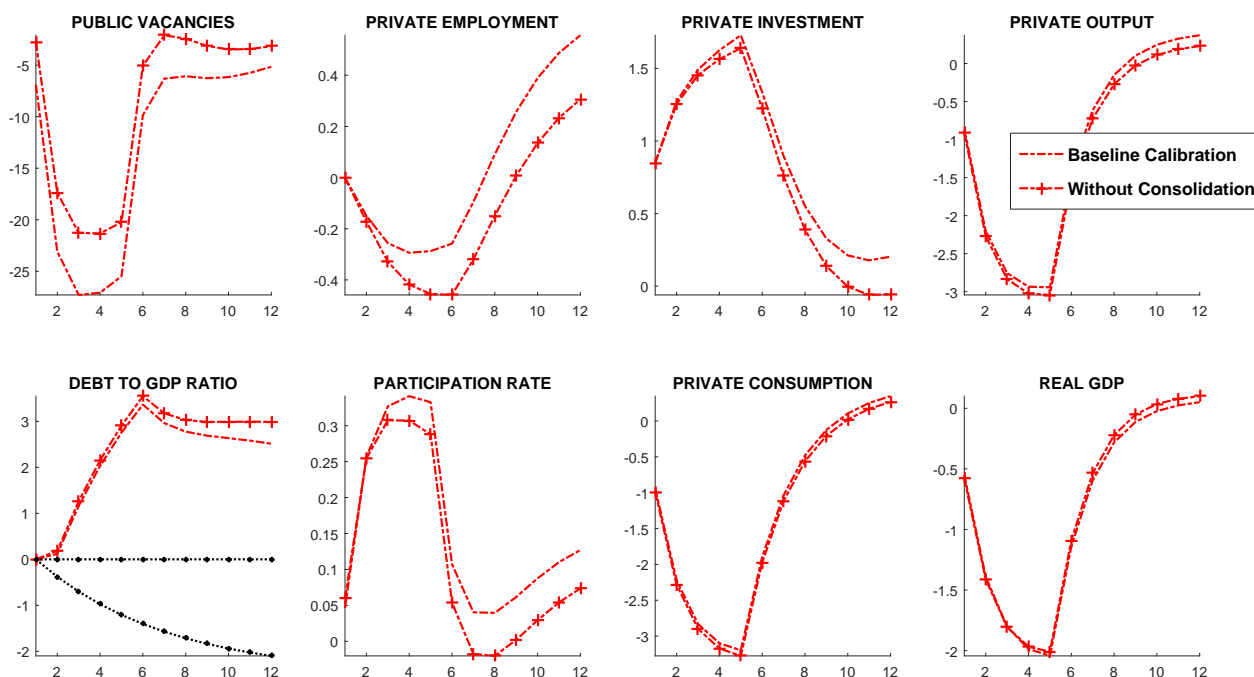


Figure 3.8: Public Vacancy Cuts in a Low Inflation Environment: the Role of Consolidation

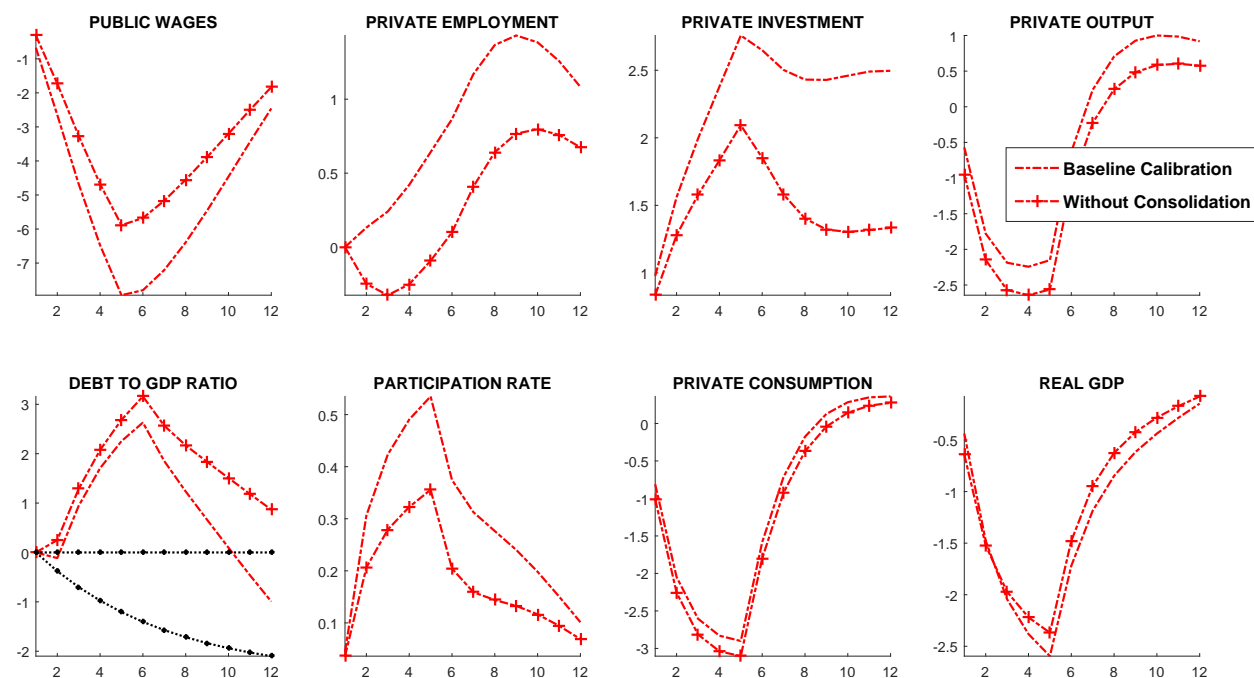


Figure 3.9: Public Wage Cuts in a Low Inflation Environment: the Role of Consolidation

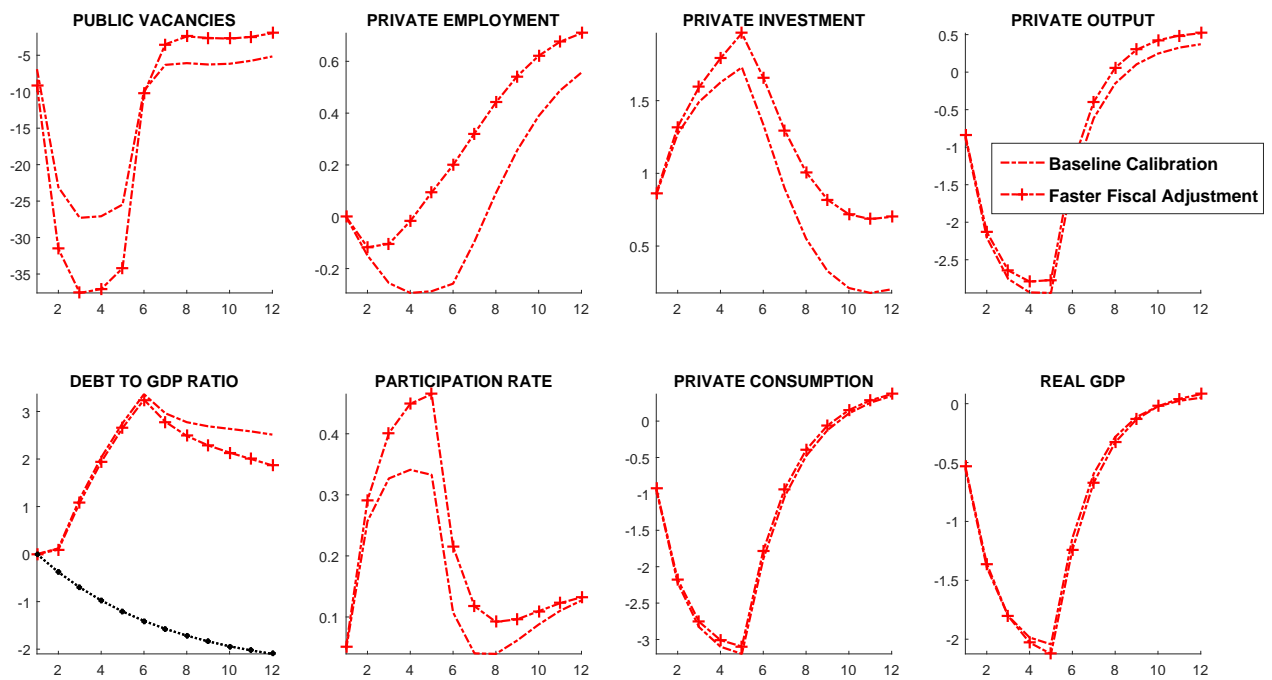


Figure 3.10: Public Vacancy Cuts in a Low Inflation Environment: the Speed of Consolidation

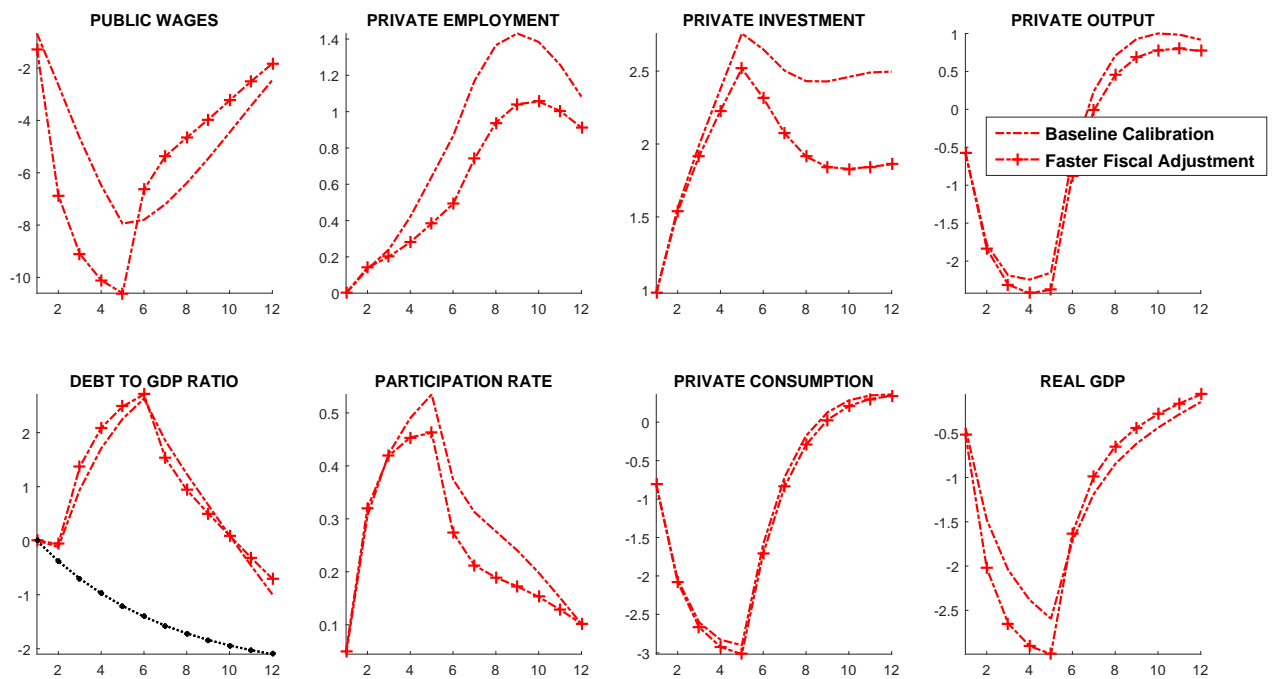


Figure 3.11: Public Wage Cuts in a Low Inflation Environment: the Speed of Consolidation

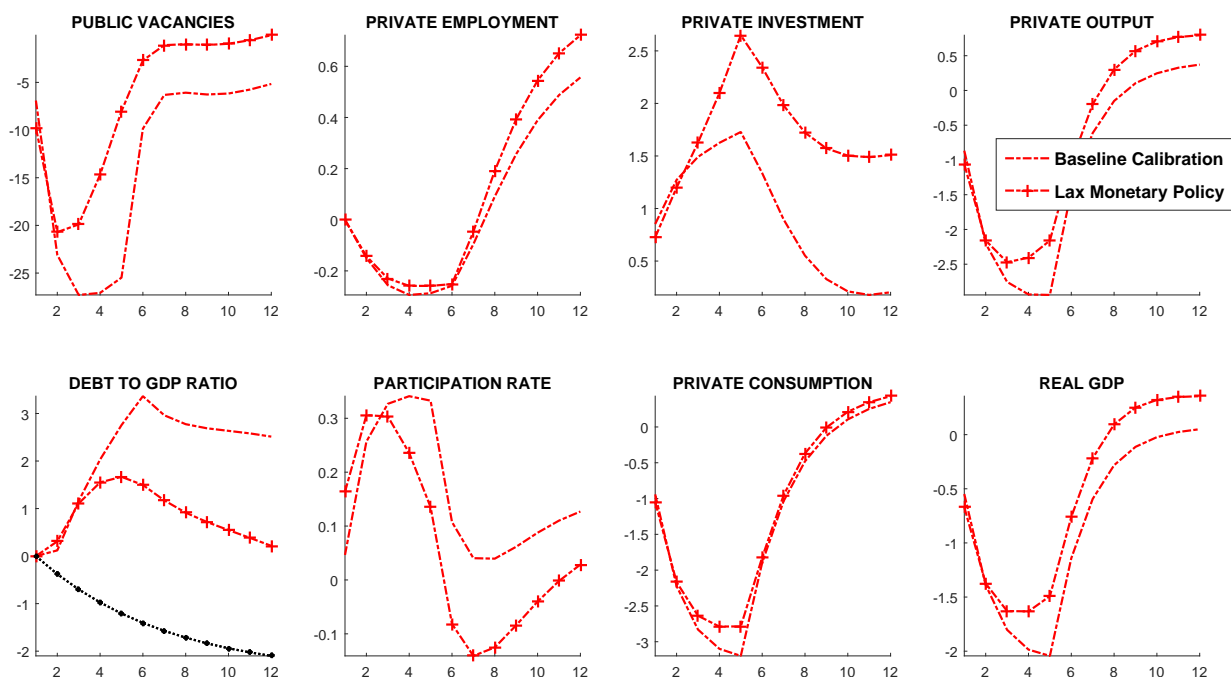


Figure 3.12: Public Vacancy Cuts in a Low Inflation Environment: the Role of Monetary Policy Strength

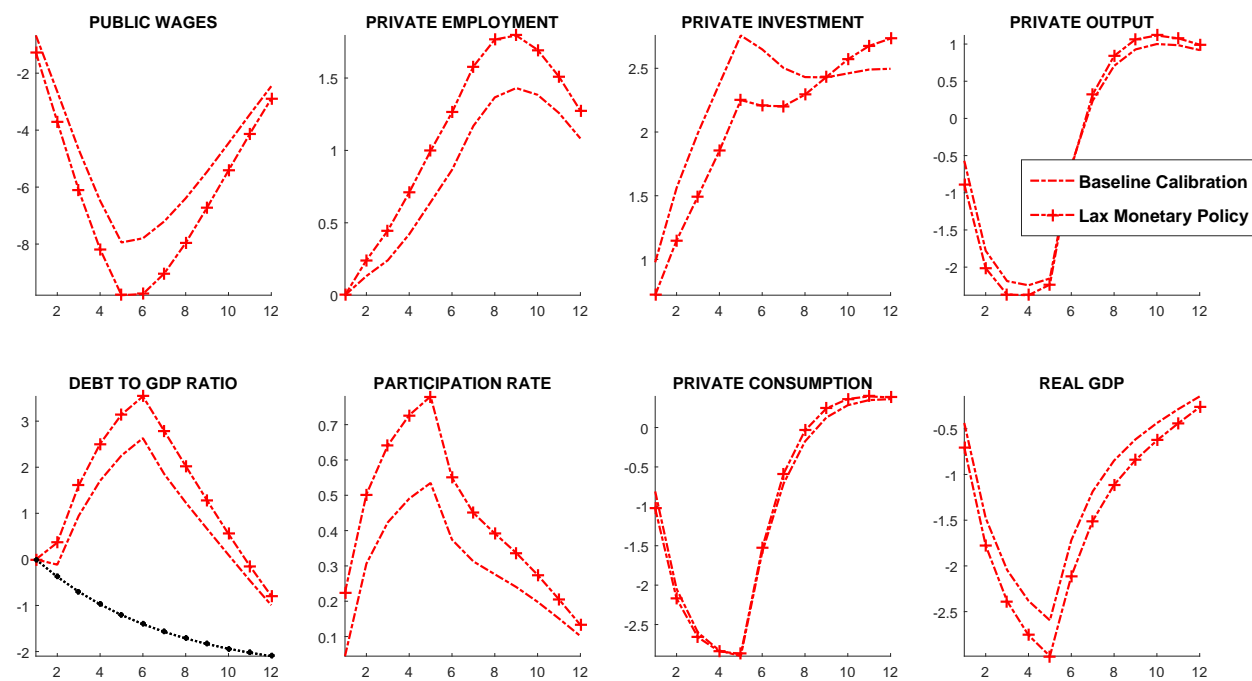


Figure 3.13: Public Wage Cuts in a Low Inflation Environment: the Role of Monetary Policy Strength

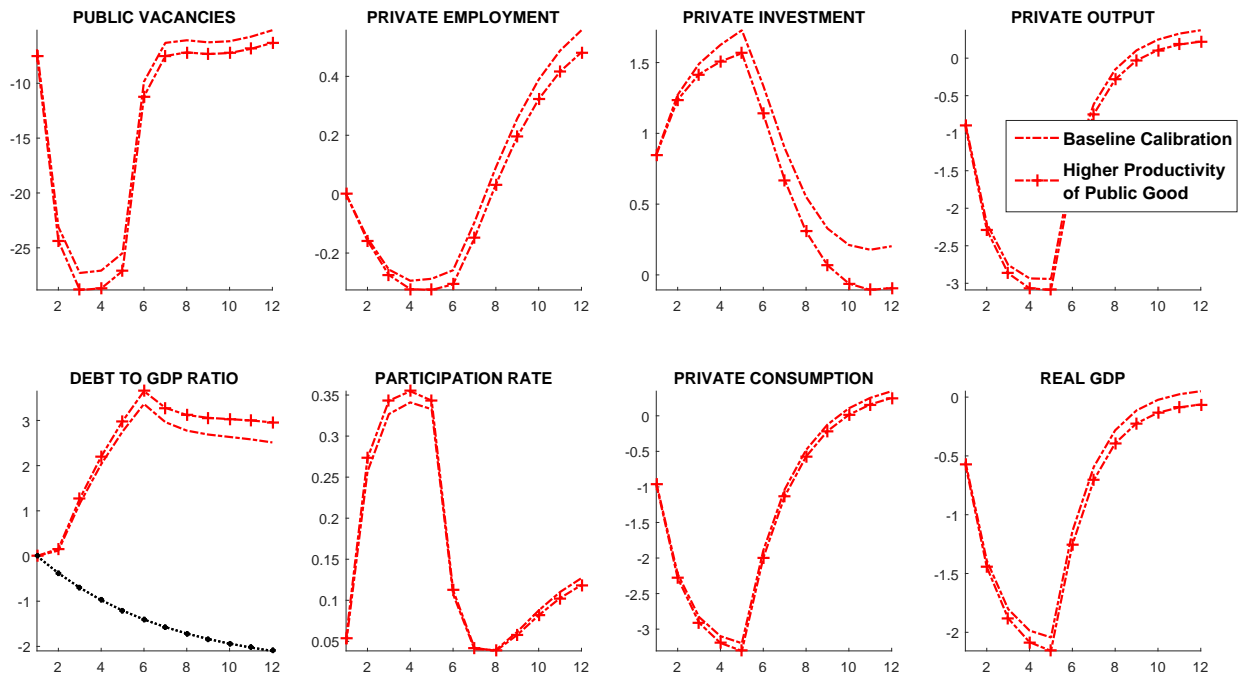


Figure 3.14: Public Vacancy Cuts in a Low Inflation Environment: the Productivity of Public Output

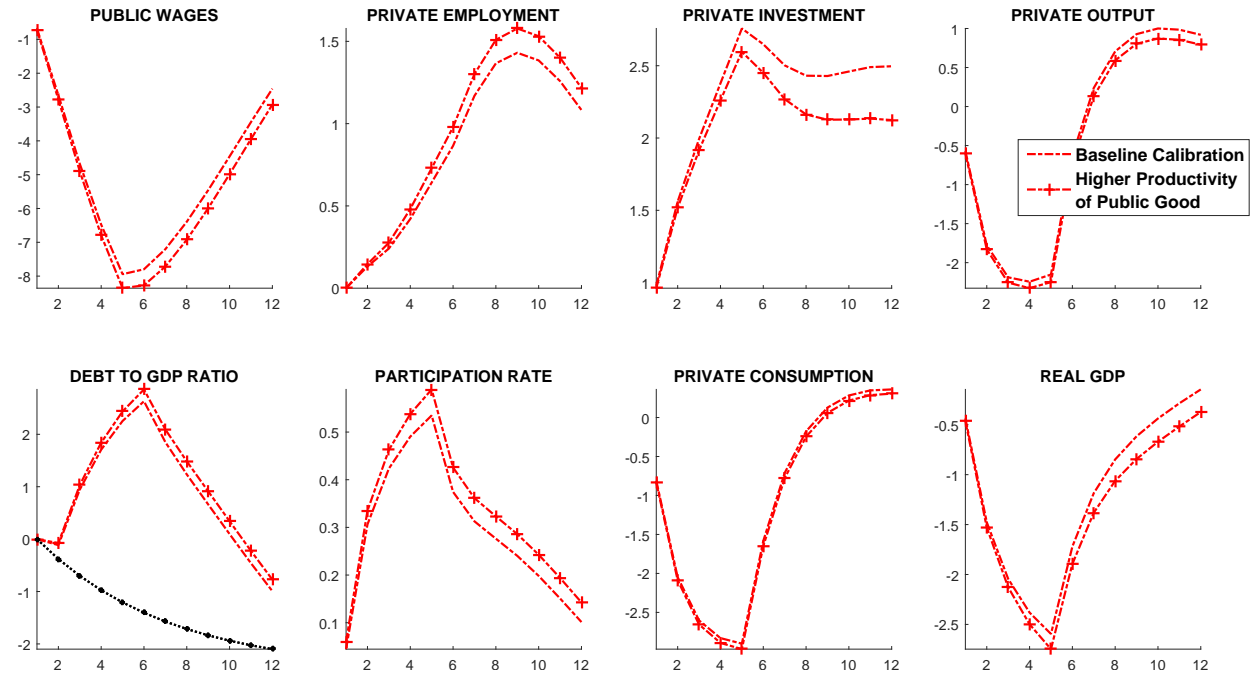


Figure 3.15: Public Wage Cuts in a Low Inflation Environment: the Productivity of Public Output

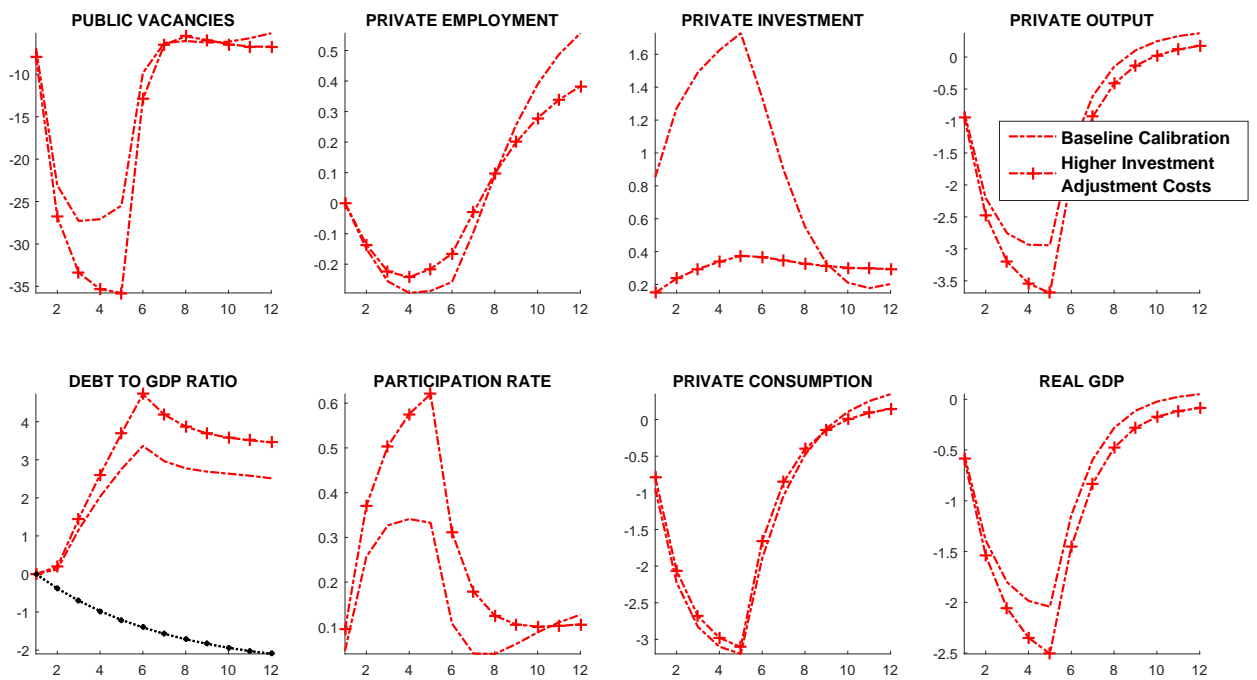


Figure 3.16: Public Vacancy Cuts in a Low Inflation Environment: Investment Adjustment Costs

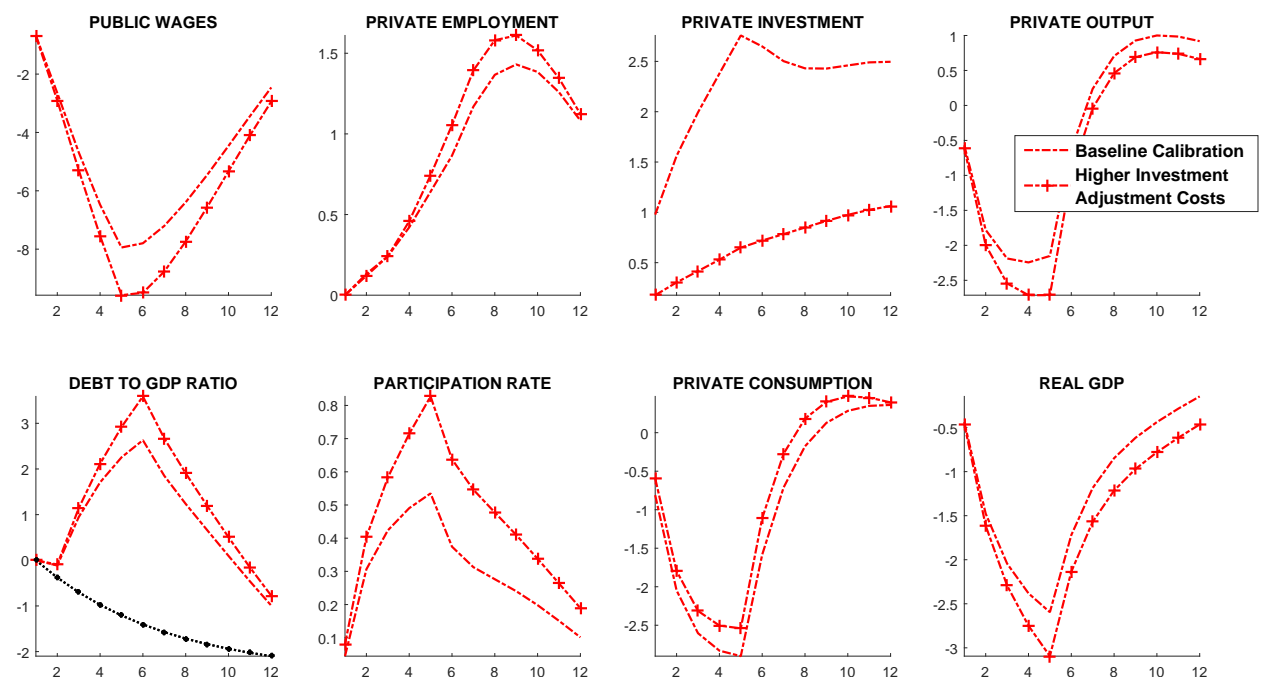


Figure 3.17: Public Wage Cuts in a Low Inflation Environment: Investment Adjustment Costs

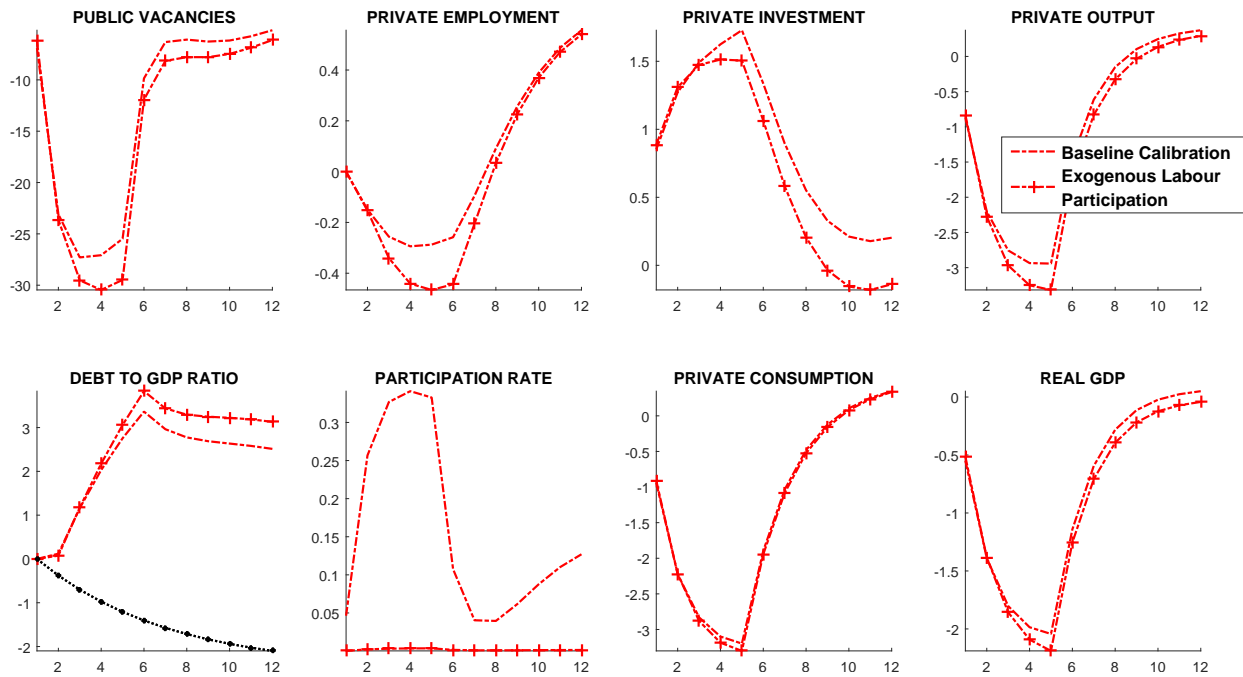


Figure 3.18: Public Vacancy Cuts in a Low Inflation Environment: Exogenous Labour Force Participation

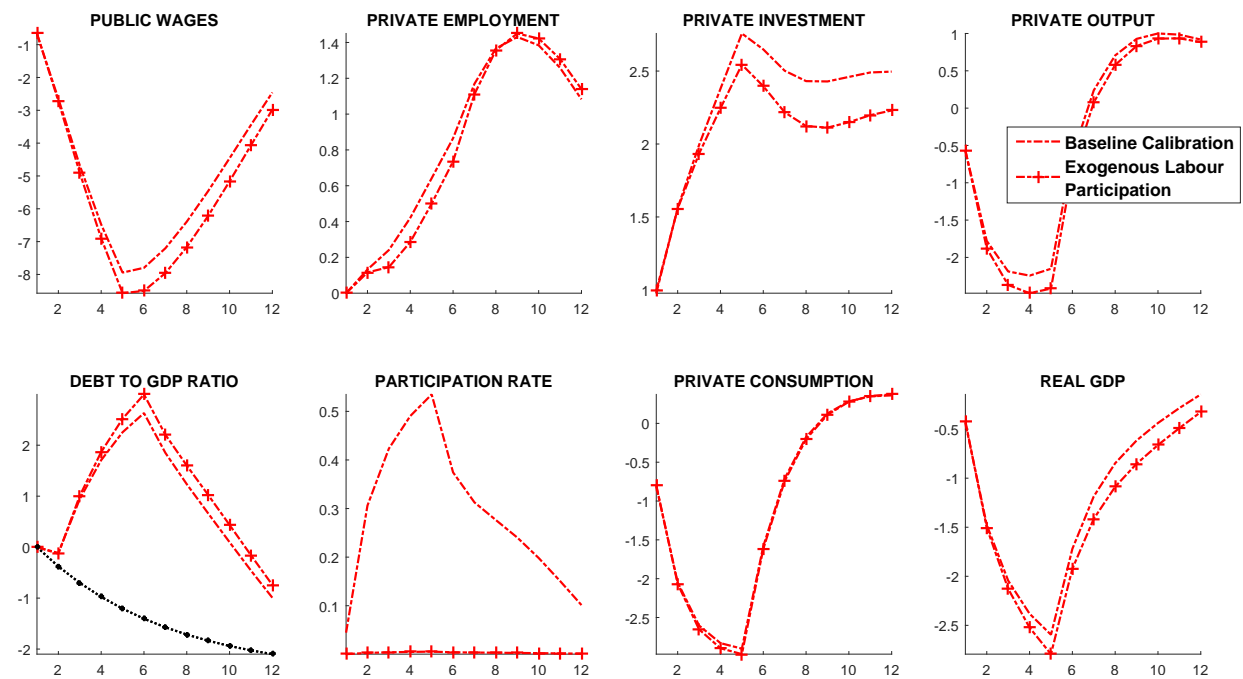


Figure 3.19: Public Wage Cuts in a Low Inflation Environment: Exogenous Labour Force Participation

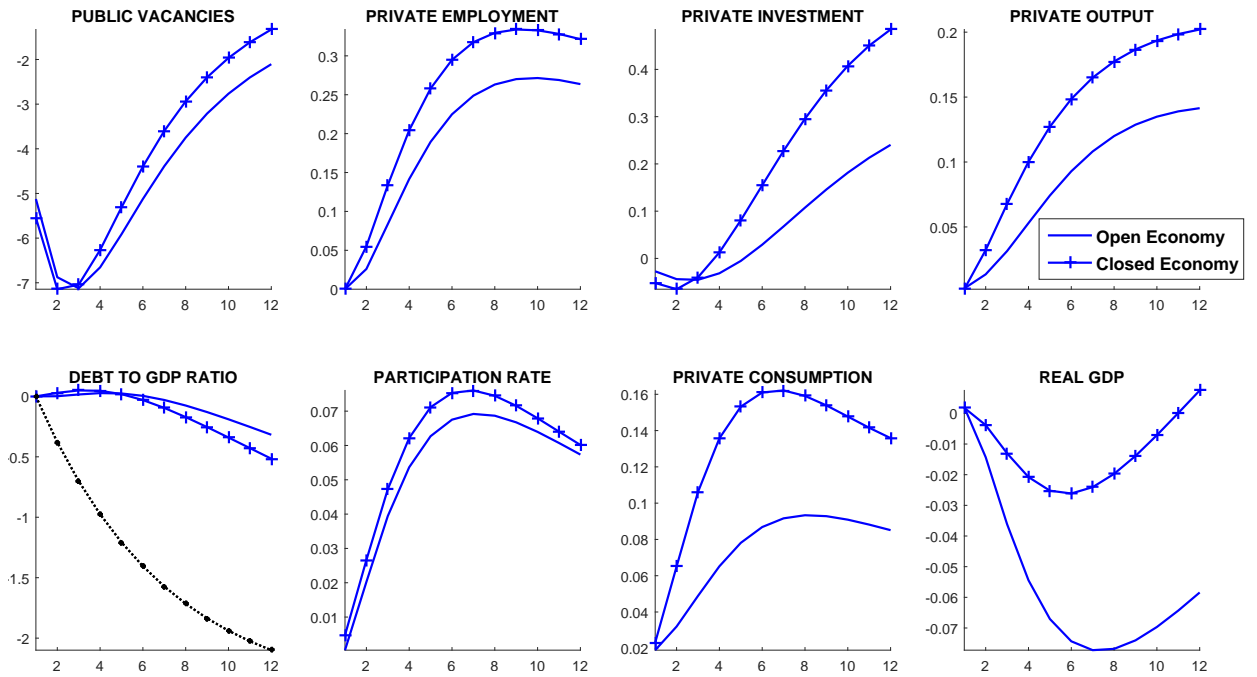


Figure 3.20: Public Vacancy Cuts in Normal Times: Closed versus Open Economy

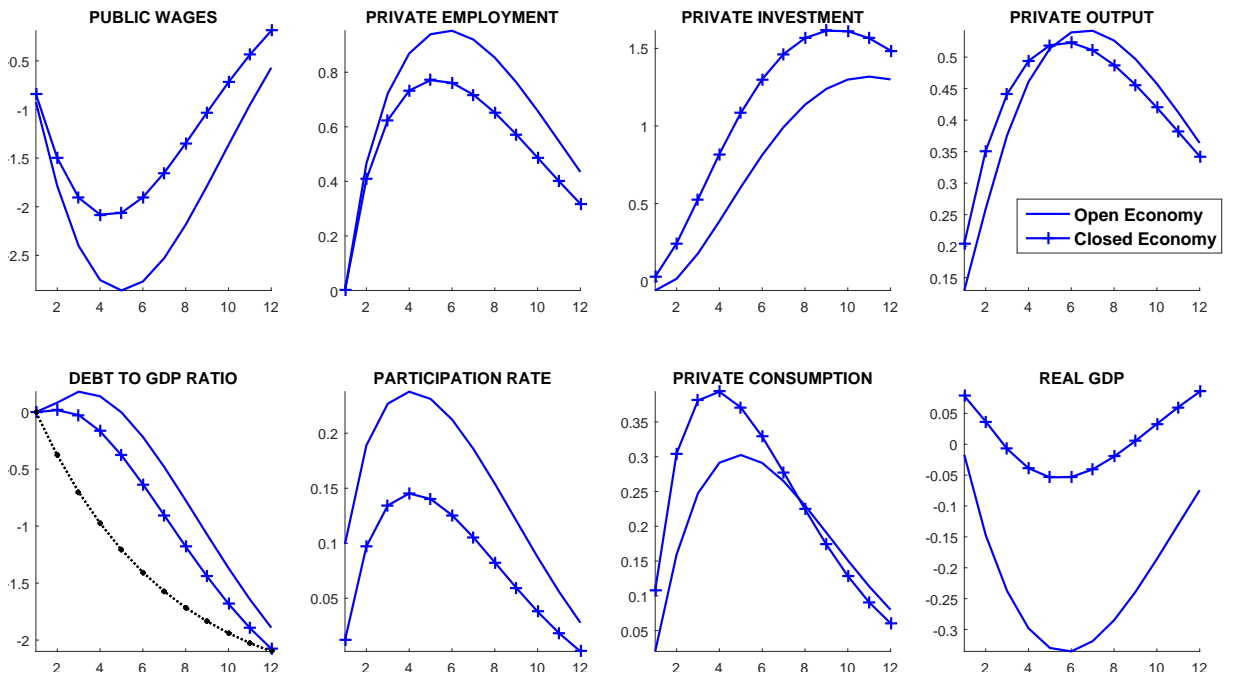


Figure 3.21: Public Wage Cuts in Normal Times: Closed versus Open Economy

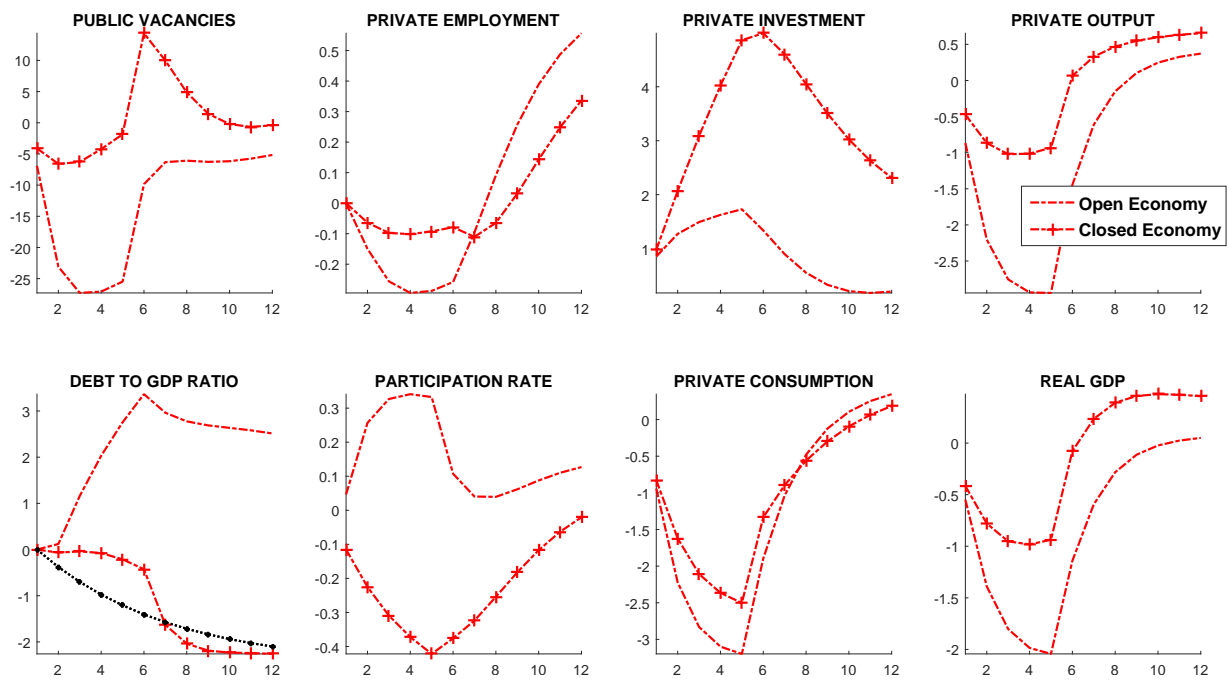


Figure 3.22: Public Vacancy Cuts in a Low Inflation Environment: Closed versus Open Economy

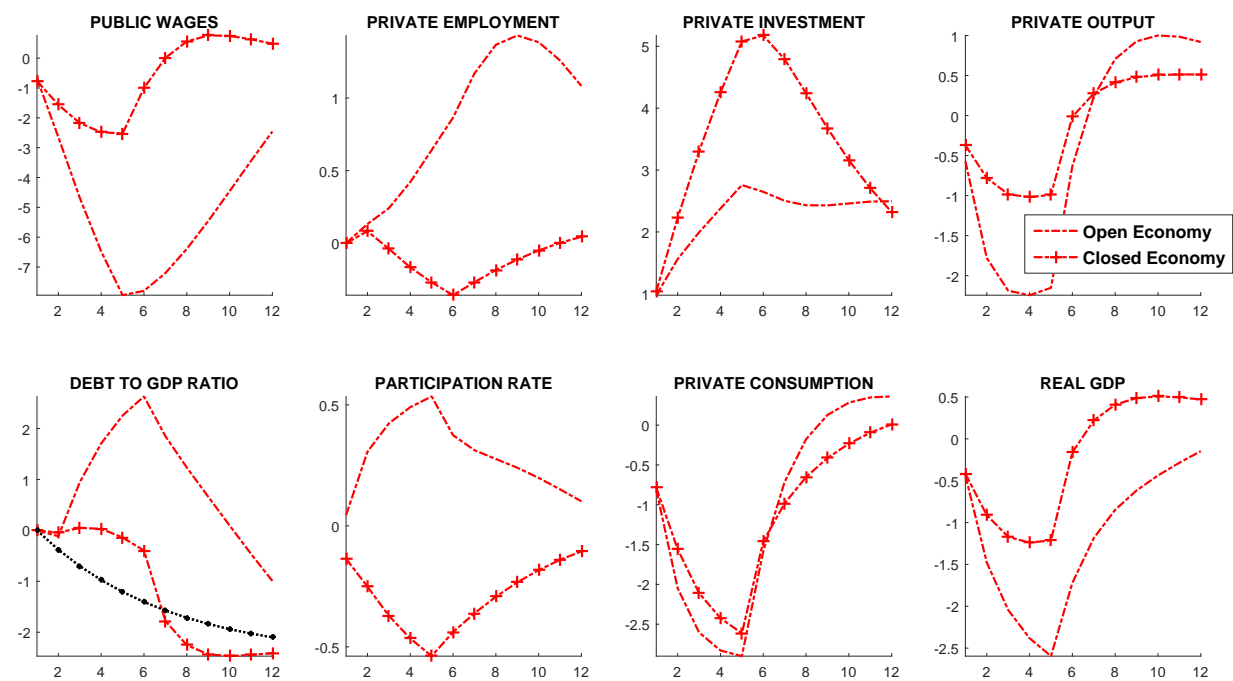


Figure 3.23: Public Wage Cuts in a Low Inflation Environment: Closed versus Open Economy

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Appendix

Household's maximisation problem

The household's Lagrangean can be written as

$$\begin{aligned}
\mathcal{L} = & \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_t^{1-\eta}}{1-\eta} + \Phi \frac{(1 - n_t^p - n_t^g - u_t)^{1+\varphi}}{1+\varphi} - \Upsilon \frac{x_t^{1+\xi}}{1+\xi} \right. \\
& - \lambda_{c,t} [(1 + \tau_c) c_t + i_t^p + b_{g,t+1} + e_t r_{f,t-1} b_{f,t} - [r_t^p - \tau_k (r_t^p - \delta^p)] k_t^p \\
& \quad - r_{t-1} b_{g,t} - e_t b_{f,t+1} - (1 - \tau_n) (w_t^p n_t^p x_t + w_t^g n_t^g) - b u_t - \Pi_t^p - T_t] \\
& - \lambda_{k,t} \left[k_{t+1}^p - \left[1 - \frac{\omega}{2} \left(\frac{i_t^p}{i_{t-1}^p} - 1 \right)^2 \right] i_t^p - (1 - \delta^p) k_t^p \right] \\
& - \lambda_{n^p,t} \left[n_{t+1}^p - (1 - \sigma^p) n_t^p - \psi_t^{hp} (1 - s_t) u_t \right] \\
& \left. - \lambda_{n^g,t} \left[n_{t+1}^g - (1 - \sigma^g) n_t^g - \psi_t^{hg} s_t u_t \right] \right\}
\end{aligned}$$

where the household's composition has been substituted into the utility function, and the household takes as given the probability of finding a job in each sector and does not internalise the effect of their choice of u_t^j on the number of matches. The choice variables are c_t , i_t^p , k_{t+1}^p , n_{t+1}^p , n_{t+1}^g , u_t , s_t , x_t , $b_{g,t+1}$ and $b_{f,t+1}$.

The first order conditions are:

[wrt c_t]

$$\lambda_{c,t}(1 + \tau_c) = c_t^{-\eta} \quad (38)$$

[wrt i_t^p]

$$\lambda_{c,t} - \lambda_{k,t} \left\{ 1 - \frac{\omega}{2} \left(\frac{i_t^p}{i_{t-1}^p} - 1 \right)^2 - \omega \left(\frac{i_t^p}{i_{t-1}^p} - 1 \right) \frac{i_t^p}{i_{t-1}^p} \right\} = \beta \lambda_{k,t+1} \omega \left(\frac{i_{t+1}^p}{i_t^p} - 1 \right) \left(\frac{i_{t+1}^p}{i_t^p} \right)^2 \quad (39)$$

[wrt k_{t+1}^p]

$$\lambda_{k,t} = \beta \{ \lambda_{k,t+1} (1 - \delta^p) + \lambda_{c,t+1} [r_{t+1}^p - \tau_k (r_{t+1}^p - \delta^p)] \} \quad (40)$$

[wrt n_{t+1}^p]

$$\lambda_{n^p,t} = \beta [\lambda_{n^p,t+1} (1 - \sigma^p) + \lambda_{c,t+1} (1 - \tau_n) w_{t+1}^p x_{t+1} - \Phi l_{t+1}^\varphi] \quad (41)$$

[wrt n_{t+1}^g]

$$\lambda_{n^g,t} = \beta [\lambda_{n^g,t+1} (1 - \sigma^g) + \lambda_{c,t+1} (1 - \tau_n) w_{t+1}^g - \Phi l_{t+1}^\varphi] \quad (42)$$

[wrt u_t]

$$\Phi l_t^\varphi = \lambda_{c,t} b + \lambda_{n^p,t} \psi_t^{hp} (1 - s_t) + \lambda_{n^g,t} \psi_t^{hg} s_t \quad (43)$$

[wrt s_t]

$$\lambda_{n^g,t} \psi_t^{hg} = \lambda_{n^p,t} \psi_t^{hp} \quad (44)$$

[wrt x_t]

$$\Upsilon x_t^\xi = \lambda_{c,t} (1 - \tau_n) w_t^p n_t^p \quad (45)$$

[wrt $b_{g,t+1}$]

$$1 = \beta \frac{\lambda_{c,t+1}}{\lambda_{c,t}} r_t \quad (46)$$

[wrt $b_{f,t+1}$]

$$1 = \beta \frac{\lambda_{c,t+1}}{\lambda_{c,t}} \frac{e_{t+1}}{e_t} r_{f,t} \quad (47)$$

We can define the marginal value to the household of having an additional member employed in the private sector, as follows:

$$\begin{aligned} V_{n^p t}^h &\equiv \frac{\partial \mathcal{L}}{\partial n_t^p} = \lambda_{ct} w_t^p x_t (1 - \tau_n) - \Phi l_t^\varphi + (1 - \sigma^p) \lambda_{n^p t} \\ &= \lambda_{ct} w_t^p x_t (1 - \tau_n) - \Phi l_t^\varphi + (1 - \sigma^p) \beta E_t(V_{n^p t+1}^h) \end{aligned} \quad (48)$$

where the second equalities come from equation (41).

Derivation of the private wage

The Nash bargaining problem is to maximize the weighted sum of log surpluses:

$$\max_{w_t^p} \left\{ (1 - \vartheta) \ln V_{n^p t}^h + \vartheta \ln V_{n^p t}^f \right\}$$

where $V_{n^j t}^h$ and $V_{n^j t}^f$ are defined as:

$$V_{n^p t}^h \equiv \frac{\partial \mathcal{L}}{\partial n_t^p} = \lambda_{ct} w_t^p x_t (1 - \tau_t^n) - \Phi l_t^\varphi + (1 - \sigma^p) \lambda_{n^p t} \quad (49)$$

$$V_{n^p t}^f \equiv \frac{\partial Q^p}{\partial n_t^p} = p_{x,t} (1 - \phi) \frac{y_t^p}{n_t^p} - w_t^p x_t + \frac{(1 - \sigma^p) \kappa}{\psi_t^{fp}} \quad (50)$$

The first order conditions of this optimization problem is:

$$\vartheta V_{n^p t}^h = (1 - \vartheta) \lambda_{ct} (1 - \tau_t^n) V_{n^p t}^f \quad (51)$$

Plugging the expressions for the value functions into the FOC, we can rearrange to

find the expression for the private wage. Using (49),(50) and (51) we obtain:

$$w_t^p x_t = (1 - \vartheta) \left[p_{x,t} (1 - \phi) \frac{y_t^p}{n_t^p} + \frac{(1 - \sigma^p) \kappa}{\psi_t^{fp}} \right] + \frac{\vartheta}{(1 - \tau_n) \lambda_{c,t}} (\Phi l_t^\varphi - (1 - \sigma^p) \lambda_{n^p t}) \quad (52)$$

Finally, taking the time t expectation of (51) evaluated at time $t + 1$, and using the FOCs of the household and firm, we obtain

$$\vartheta \lambda_{n^p t} = (1 - \vartheta) \lambda_{c,t} (1 - \tau_n^n) \frac{\kappa}{\psi_t^{fp}}$$

which allows us to simplify (52) to obtain the final expression for the private wage

$$w_t^p x_t = (1 - \vartheta) p_{x,t} (1 - \phi) \frac{y_t^p}{n_t^p} + \frac{\vartheta}{(1 - \tau_n) \lambda_{c,t}} \Phi l_t^\varphi \quad (53)$$

Calibration

Below, we outline in detail the calibration strategy. In places, a superscript j is used to indicate a variable in both the private and public sector. Unless otherwise stated, the two countries are symmetric, and we assume that $b_f = 0$, so that there is balanced trade at steady state.

Labour market variables

We set $e = 1$, such that it does not effect the rest of the steady state. We calibrate the labour force participation rate, the unemployment rate, and the share of public employment in total employment to match the observed average values from Italian data: $1 - l = 65\%$, $u^{rate} = \frac{u}{1-l} = 10\%$ and $\frac{n^g}{n^p+n^g} = 18\%$. From these we get u , n^p and n^g .

We set the separation rates at $\sigma^p = 6.3\%$ and $\sigma^g = 6\%$. This gives us $m^j = \sigma^j n^j$, from the steady state version of the law of motion of employment. We calibrate the ratio of unemployed searching in two sectors $s = 20\%$, which also gives us u^j and so ψ^{hj} by its definition.

Since there is no exact estimate for the value of the private vacancy-filling probability, ψ^{fp} , in the literature, we use what is considered as standard by setting it equal to 0.1 and then we assume that $\psi^{fp} = \psi^{fg}$. This gives us v^j by inverting the definition of ψ^{fj} .

The elasticity in the matching functions, α , is set equal to 0.5. Then the efficiency parameter for private matches, ρ_m^p , is given by inverting the matching function.

Production

We set the capital depreciation rates, δ^p , equal to 2%. The tax rates on capital and labour income are calibrated to 30%. The return on capital, r^p , is determined by the household's first order condition with respect to capital.

The elasticity of demand for intermediate goods, ϵ , is set equal to 10, which gives a markup of 11%. The CPI in both countries is normalised to one, and their definitions are used to derive p_h and p_f . We assume a steady state subsidy offsets the markup, so that $p_x = p_h$.

The stochastic labour productivity, A , is normalised to one. We set the capital share in the production function of both the public and private good equal to 0.36, and set the productivity of the public good in private production, ν , equal to 0.05. Finally, using data from Kamps (2006) we set $\frac{k^g}{k^p} = 0.31$, close to the mean value for 1970-2002. This gives us y^p , y^g , k^p and k^g from the two production functions and the firm's first order condition with respect to capital, and i^p from the law of motion of private capital $i^p = \delta^p k^p$.

Following Galí (2011), we calibrate the cost of posting a vacancy, κ , by targeting vacancy costs as a fraction of the real private wage, $\frac{\kappa}{w^p} = 4.5\%$. We set the replacement rate, $\frac{b}{w^p}$, equal to 40%, in the range [0.2, 0.4] in Petrongolo and Pissarides (2001). Then we can get w^p from the firm's FOC with respect to private vacancies.

Households

We derive private consumption from the resource constraint given y^p , i^p , κ and v^j . We set the consumption tax rate to 15%, the intertemporal elasticity of substitution, $\frac{1}{\eta}$, equal to 1, the Frisch elasticity of labour supply, $\frac{1}{\varphi}$, equal to 0.25 (in the range of Domeij and Floden, 2006). From the household's first order conditions we can then derive λ_c and λ_{n^p} , and set $\Phi = l^{-\varphi}(\lambda_c b + \psi^{hp} \lambda_{n^p})$. The firm's bargaining power is set by inverting the solution of the wage bargaining problem. Following Neiss and Pappa (2011) we set $\xi = 0.5$, and set $\Upsilon = -\lambda_c w^p n^p$ to ensure $e = 1$.

Finally, we derive λ_{n^g} and w^g from the household's remaining first order conditions, and this also allows us to define total output, $rgdp = y^p + w^g n^g$.

Fiscal Policy

We set the steady state *annual* debt-to-GDP ratio equal to 50%, so that $\tilde{b}_g = 4 * 50\%$. Using the government's budget constraint in steady state, we have $DF = (\beta - 1)\tilde{b}_g r gdp$. Finally, we calibrate the steady state value for lump-sum transfers, T , from the definition of the deficit.

Other parameters

Finally, we set the probability that a firm does not change its price within a given period, χ , equal to 0.75, the Taylor rule coefficient, ζ_π , equal to 2.5, and the adjustment costs parameter, ω , equal to 0.5. Finally, we set the parameters for the persistence of the debt-target shock, ρ_1 and ρ_2 , equal to 0.85 and 0.0001, respectively.