

Fiscal Consolidation in a Low Inflation Environment: Pay Cuts versus Lost Jobs*

Guilherme Bandeira[†] Evi Pappa[‡] Rana Sajedi[§] Eugenia Vella[¶]

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Abstract

We construct a model of a monetary union to study fiscal consolidation in the Periphery of the Euro area, through cuts in public sector wages or hiring when the nominal interest rate is constrained at its lower bound. Consolidation induces a positive wealth effect that increases demand, as well as a reallocation of workers towards the private sector, which together boost private activity. However, in a low inflation environment, demand is suppressed and the private sector is not able to absorb the additional workers. Comparing the two instruments, cuts in public hiring increase unemployment persistently in this environment, while wage cuts can reduce it. Regions with higher mobility of labor between the two sectors are able to consolidate more effectively. Price flexibility is also key at the zero lower bound: for a higher degree of price rigidity in the Periphery, consolidation becomes harder to achieve. Consolidations can be self-defeating when the public good is productive.

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[†]*Banco de España. e-mail: guilherme.almeida@bde.es*

[‡]Corresponding author: *European University Institute. e-mail: evi.pappa@eui.eu*

[§]*Bank of England. e-mail: rana.sajedi@bankofengland.co.uk*

[¶]*University of Sheffield. e-mail: e.vella@sheffield.ac.uk*

1 Introduction

Fiscal consolidation policies implemented in the Euro area in recent years have placed special emphasis on reducing the public wage bill, which represents a sizable component of the government budget.¹ The fall in the nominal government wage bill has been particularly pronounced in Periphery countries of the Euro area, such as Ireland, Greece and Portugal (see Figure 1), and has come from cuts in both wages and the number of employees in the public sector (see Figure 2).² At the same time, the Euro area has been experiencing a prolonged period of inflation uncertainty: with monetary policy constrained by the zero lower bound (ZLB henceforth), inflation has remained below the ECB's medium run objective for some time. This environment of low inflation has important implications for the design and implementation of fiscal policy. This paper offers a positive analysis of the relative effectiveness of cutting wages versus cutting hiring for reducing the public wage bill in a monetary union when inflation is low.

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 (Reinhart et al. 2015). On the contrary, low inflation, all else equal, raises deficit- and debt-to-GDP ratios by reducing the growth in nominal GDP. Debt dynamics would be left unchanged if nominal interest rates adjust 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.

Recent studies, both theoretical and empirical, have looked at a less direct effect of low inflation on fiscal policy, namely the impact of the ZLB on fiscal multipliers. Much of the literature has found that fiscal multipliers are higher when monetary policy is constrained.³

¹Before the crisis the government wage bill accounted, on average, for almost 25% of total public spending and more than 10% of GDP, and almost 15% of the labor force in the Euro area was employed in the public sector (see Holm-Hadulla et al. 2010).

²These policies have been implemented through reducing overtime pay, retrenching specific indemnities or benefits, implementing attrition rules to reduce new hiring or simply by outright lay-offs and pay cuts. In Greece, for example, a 10% cut across all public sector wages was legislated in 2010, followed by further cuts. In Spain, the attrition rule allowed a new hire for every 10 exits.

³Eggertsson (2011), Christiano et al. (2011), Coenen et al. (2012) and De Long and Summers (2012) find that the government spending multiplier increases significantly at the ZLB. Erceg and Linde (2013) show 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. Ilzetki et al. (2013) report substantially higher multipliers in countries operating under fixed exchange rates, another form of constrained monetary policy.

Based on this principle, several papers discuss the potential role of fiscal stimulus in alleviating a ZLB crisis: Correia et al. (2013) suggest a stimulus strategy based on consumption taxation, and Rendahl (2016) focuses on how expansionary fiscal policy can best exploit the amplification of labor market movements at the ZLB. 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 interaction between fiscal and monetary policy is the fact that inflation can have a different impact, both in terms of size and timing, across different components of public expenditure and revenue. Jalil (2012) shows 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, 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) demonstrate that the ZLB has different effects on different fiscal consolidation instruments, and should therefore be considered when designing fiscal policy. We extend this literature by comparing the effectiveness of two different instruments for reducing the public wage bill at the ZLB and compare them with traditional instruments of fiscal consolidation considered in the existing literature.

We consider a New Keynesian model of a two-block monetary union, calibrated for the Periphery and Core of the Euro area. In order to build a complete model of the labor market, we incorporate both search and matching frictions, leading to involuntary unemployment, and an endogenous labor force participation decision, leading to voluntary unemployment. We allow the government to hire public employees to produce a public good. Following Erceg and Linde (2013) and Pappa et al. (2015), we compare a given public debt consolidation through two alternative fiscal instruments, namely public wage cuts and public vacancy cuts, in normal times and in a low inflation environment.⁴

In normal times, cuts in the public wage bill using either instrument cause a reallocation of labor towards the private sector, facilitating hiring and leading to a fall in the private wage

⁴An example of fiscal consolidation through the public wage bill in normal times comes from the German economy. In 2000, spending cuts amounted in Germany to DM 30.1 billion or 0.75% of GDP, involving mainly the public sector wage bill, social programs, and subsidies.

in the medium run. This induces an internal devaluation: by increasing the competitiveness of the private sector of the Periphery, the consolidation leads to a depreciation of the real exchange rate. Together with the positive wealth effect of the cut in government spending, which raises private demand, this boosts private output. Both types of consolidation bring about a fall in the unemployment rate. Public wage cuts lead to a larger fall in unemployment as the private sector quickly absorbs the increased share of jobseekers, while public vacancy cuts lead to a more sluggish adjustment in the labor market. Comparing with the traditional instruments of fiscal consolidation in the existing literature, both tax hikes and spending cuts tend to decrease private output. Tax hikes reduce labor force participation, increasing the private wage and marginal costs for firms. Spending cuts, although they crowd-in private consumption and investment, they induce a reduction in labor supply, which leads to a fall in vacancies and employment in the private sector, and counterbalances the positive wealth effect of the consolidation.

In a low inflation environment, induced by negative demand shocks and a ZLB constraint on monetary policy, the government debt-to-GDP ratio rises, and, hence, a significantly larger cut in the public wage bill is required. Furthermore, with the contraction in demand, the private sector is much more limited in its ability to absorb jobseekers leaving the public sector job search, and private employment falls during the liquidity trap. Still, the reallocation of jobseekers after a public wage cuts quickly reverses the path of private employment by reducing labor costs, and decreases unemployment in the medium run. Public vacancy cuts do not induce a strong reallocation of jobseekers and reduce public employment more significantly. As a result, vacancy cuts increase unemployment in the medium run. Again, standard fiscal instruments would deepen the recession induced by the negative demand shocks relative to consolidation through the public wage bill.

We run a series of alternative simulations to investigate the mechanisms at play in our model. First, we find that the ability of jobseekers to reallocate their search is of key importance: rigidities in the mobility of labor between the public and private sectors mitigate the positive effects of the fiscal consolidation on private employment after the liquidity trap, making consolidation itself more difficult to achieve. Second, price flexibility is crucial for the success of the fiscal consolidation at the ZLB. When the degree of price stickiness in the Pe-

riphery is assumed to be higher than in the Core, the internal devaluation channel is reversed, making the consolidation harder to achieve. Third, looking at the role of the public good in the economy, we find that consolidation in a low inflation environment is more difficult if the public good is productive, such that the cut in public sector output has an effect on the marginal product of private labor. Finally, concerning parameters related to the openness of the Periphery, we show that lower elasticity of substitution between home-produced and imported goods makes consolidation harder to achieve, whereas a bigger size of the block implementing the consolidation implies that it becomes less costly.

Our work is related to a few recent articles. On the empirical side, our results are consistent with the recent findings of Pérez et al. (2016), who show that while government wage and employment reforms have adverse short term effects, such measures can yield medium to long term benefits due to possible competitiveness gains, through spillover effects on private sector wages, and efficiency gains, through their impact on labor market dynamics. Another related paper is the empirical work of Lamo et al. (2016), who find that the contractionary effects of employment cuts appear more damaging for the Spanish economy than those of wage cuts. Using US data, Bermperoglou et al. (2017) find that public employment shocks are mildly expansionary at the federal level and strongly expansionary at the state and local level by crowding in private consumption and increasing labor force participation and private sector employment. Similarly, state and local government wage shocks lead to increases in consumption and output, while shocks to federal government wages induce significant contractionary effects.

On the theoretical side, the literature has also investigated the impact of shocks in the public sector on the level and volatility of employment and wages (see e.g. Quadrini and Trigari (2007) and Gomes (2015)). Bradley et al. (2016) estimate a structural model with a public sector and a labor market with search and matching frictions, using UK data. The authors run simulations of austerity measures, such as a reduction in public sector hiring, an increase in public sector lay-offs, and progressive and proportional cuts to the distribution of wages in the public sector, that were implemented after the 2008 recession. In line with our results away from the ZLB, they find that all policies increase hiring and turnover in the private sector. In an earlier contribution, Demekas and Kontolemis (2000) developed a

simple two-sector model of the labor market with endogenous unemployment, but without explicit dynamics, showing that increases in government wages lead to increases in private sector wages and higher unemployment, while increases in government employment do not have a significant impact on unemployment. Similarly, Ardagna (2007) has shown that, in a DSGE model with a unionized labor market, unions demand higher wages in response to a debt-financed increase in public sector employment and wages, which leads to a fall in private sector employment and a contraction in the economy. We extend the existing literature by considering a DSGE model of a monetary union, and by explicitly incorporating the ZLB and analyzing its consequences for the effects of cuts in the public wage bill.⁵

The remainder of the paper is organized follows. In Section 2, we provide the details of the model. Section 3 discusses the results of the different policy experiments and Section 4 provides extensive sensitivity analysis. Section 5 concludes.

2 The Model

We consider a DSGE model of a two-block monetary union with search and matching frictions, endogenous labor 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 denote goods produced in the Home and Foreign economy and their respective prices.

There are four types of firms in each block: (i) a government-owned firm that produces the public good, (ii) private competitive firms that use labor and effective capital to produce a non-tradable intermediate good, (iii) monopolistic retailers that transform the intermediate good into a tradable good, and (iv) competitive final goods producers that use domestic and foreign produced retail goods to produce a final, non-tradable good that is used for investment and consumption. Price rigidities arise at the retail level, while labor market frictions occur

⁵A link can also be established with the two-country model of a currency union in Kuvshinov et al. (2016). The authors look at a deleveraging shock taking place in the Periphery and find that deleveraging generates deflationary spillovers which cannot be contained by monetary policy, as it becomes constrained by the zero lower bound.

in the intermediate goods sector. The representative household consists of private and public employees, unemployed, and labor force non-participants. The government collects taxes and issues debt to finance the wages of public employees, the cost of opening new vacancies in the public sector and the provision of unemployment benefits.

2.1 Labor markets

We consider search and matching frictions in both the private and public labor 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:

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

We assume that $\sigma^p > \sigma^g$ in order to capture the fact that, in general, public employment is more permanent than private employment.⁶

The new matches are given by:

$$m_t^j = \bar{\mu}^j (v_t^j)^\mu (u_t^j)^{1-\mu} \quad (2)$$

where v and u are vacancies and jobseekers respectively, and the matching efficiency, $\bar{\mu}^j$, 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} :

$$\psi_t^{hj} \equiv \frac{m_t^j}{u_t^j} \quad (3)$$

$$\psi_t^{fj} \equiv \frac{m_t^j}{v_t^j} \quad (4)$$

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

⁶For example, Albrecht et al. (2015) and Gomes (2015) find empirical evidence that separation rates in the public sector are lower than the private sector in the UK, US and Colombia, respectively.

that are out of the labor force, l_t , and a consumption bundle, c_t . Life-time utility of the representative household is defined as $\sum_{t=0}^{\infty} \beta^t \varrho_t^\beta U(c_t, l_t)$, where the instantaneous utility function is given by:

$$U(c_t, l_t) = \frac{(c_t - \zeta c_{t-1})^{1-\eta}}{1-\eta} + \Phi \frac{l_t^{1-\varphi}}{1-\varphi} \quad (5)$$

where η is the inverse of the intertemporal elasticity of substitution, ζ is the parameter determining habits in consumption, $\Phi > 0$ is the relative preference for leisure, φ is the inverse of the Frisch elasticity of labor supply, β is the discount factor and ϱ_t^β is a demand shock.

At any point in time, a fraction n_t^p (n_t^g) of the household members are private (public) employees. Bruckner and Pappa (2012) and Campolmi and Gnocchi (2016) have added a labor force participation choice in New Keynesian models of equilibrium unemployment. Following Ravn (2008), the participation choice is modeled 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 . Normalising the size of the household to 1, the composition of the household is given by:

$$n_t^p + n_t^g + u_t + l_t = 1 \quad (6)$$

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 $u_t^p \equiv (1 - s_t) u_t$.

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

$$k_{t+1}^p = \varrho_t^i \left[1 - \frac{\omega}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 \right] i_t + (1 - \delta(x_t)) k_t^p \quad (7)$$

where i_t is private investment, ϱ_t^i is a shock to the marginal efficiency of investment, and ω dictates the size of investment adjustment costs. Following Neiss and Pappa (2005), the

depreciation rate, $\delta(x_t)$, will depend on the degree of capital utilization, x_t , according to:

$$\delta(x_t) = \bar{\delta} x_t^\xi \quad (8)$$

where $\bar{\delta}$ and ξ are positive constants.

The budget constraint, in real terms, is given by:

$$\begin{aligned} (1 + \tau^c) c_t + i_t + b_{g,t+1} + e_t r_{f,t-1} b_{f,t} &\leq \left[r_t^k - \tau^k (r_t^k - \delta(x_t)) \right] x_t k_t^p + r_{t-1} b_{g,t} + e_t b_{f,t+1} \\ &+ (1 - \tau_t^n) (w_t^p n_t^p + w_t^g n_t^g) + bu_t + \Pi_t^p + T_t \end{aligned} \quad (9)$$

where w_t^j , $j = g, p$, are the real wages in the two sectors, r_t^k is the real return on effective capital, b denotes unemployment benefits, Π_t^p are the profits of the monopolistic retailers, discussed below, and τ^c , τ^k , τ_t^n , and T_t represent taxes on private consumption, private capital, labor income and lump-sum transfers, respectively. Government bonds are denoted by $b_{g,t}$, and pay the real return r_{t-1} , while $b_{f,t}$ denote liabilities with the Foreign country.⁷ Although the nominal exchange rate is fixed, the interest rate on foreign assets, $r_{f,t}$, is still affected by consumer price inflation differentials between the two countries, which are captured by the real exchange rate, e_t . In fact, we can define the gross nominal interest rate at Home, R_t , through the Fisher equation:

$$r_t = \frac{R_t}{E_t \pi_{t+1}} \quad (10)$$

where π_t is the gross consumer price inflation rate.

The problem of the household is to choose c_t , u_t , s_t , n_{t+1}^p , n_{t+1}^g , i_t , k_{t+1}^p , x_t , $b_{g,t+1}$ and $b_{f,t+1}$ to maximize lifetime utility subject to the budget constraint, (9), the law of motion of employment in each sector, (1), taking the probability of finding a job as given, the law of motion of capital, (7), the definition of capital depreciation, (8), and the composition of the household, (6). The resulting first order conditions are provided in an online appendix.⁸

⁷Assuming government debt is only held by local households captures well the case of Periphery countries like Italy and Spain, where the largest fraction of public debt is held domestically. An interesting extension would be to allow for public debt to also be held externally.

⁸The online appendix can be found at <https://me.eui.eu/evi-pappa/>

We can derive the marginal value of an additional private sector employee as:

$$V_{n^p t}^H = \lambda_{ct} w_t^p (1 - \tau_t^n) - \Phi l_t^{-\varphi} + (1 - \sigma^p) \beta \mathbb{E}_t (V_{n^p t+1}^H) \quad (11)$$

where λ_{ct} is the Lagrange multiplier on the budget constraint. Using (11) together with the equivalent expression for the value of an additional public sector employee, the definition of hiring rates, (3), and the first order condition with respect to s_t , we obtain:

$$\mathbb{E}_t (V_{n^g, t+1}^H) \psi_t^{hg} = \mathbb{E}_t (V_{n^p, t+1}^H) \psi_t^{hp} \quad (12)$$

This equation shows that, in equilibrium, the expected value of searching in the two sectors is equalized. This expected value will depend not only on the probability of finding a job in each sector, ψ_t^{hj} , but also on the expected utility from having an additional worker in each sector, which, in turn, will depend on the respective wage in each sector and the separation rate, σ^j . This means that 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.

2.3 Production

2.3.1 Intermediate goods firms

Intermediate goods are produced with a Cobb-Douglas technology:

$$y_t^p = (n_t^p)^{1-\phi} (x_t k_t^p)^\phi \quad (13)$$

where k_t^p and n_t^p are private capital and labor inputs, and x_t is the degree of capital utilization.⁹

⁹The assumption of variable capital utilization here is important: note that, without it, all factors of production would be predetermined, meaning that output cannot adjust on impact in response to shocks. In this case, the nominal interest rate needs to adjust sharply to bring the economy to equilibrium. To illustrate this, we present, in the appendix, the results of our model without variable capital utilization away from the ZLB.

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 . Firms also decide the amount of the private capital, k_t^p , to be rented from the household at rate r_t^k . The problem of an intermediate firm with n_t^p workers currently employed can be written as:

$$Q^p(n_t^p) = \max_{k_t^p, v_t^p} \{ p_{x,t} (n_t^p)^{1-\phi} (x_t k_t^p)^\phi - w_t^p n_t^p - r_t^k x_t k_t^p - \kappa v_t^p + E_t [\Lambda_{t,t+1} Q^p(n_{t+1}^p)] \} \quad (14)$$

where $p_{x,t}$ is the relative price of intermediate goods, κ is a utility cost associated with posting a new vacancy, and $\Lambda_{t,t+1}$ is the household's stochastic 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. The first order conditions with respect to capital and vacancies are:

$$p_{x,t} \phi \frac{y_t^p}{x_t k_t^p} = r_t^k \quad (15)$$

$$\frac{\kappa}{\psi_t^{fp}} = E_t \Lambda_{t,t+1} [p_{x,t+1} (1-\phi) \frac{y_{t+1}^p}{n_{t+1}^p} - w_{t+1}^p + (1-\sigma^p) \frac{\kappa}{\psi_{t+1}^{fp}}] \quad (16)$$

According to (15) and (16) the value of the marginal product of private capital should equal the real rental rate and the marginal cost of hiring an additional worker should equal the expected marginal benefit. The latter includes the marginal productivity of labor minus the wage plus the continuation value, knowing that with probability σ^p the match can be destroyed.

The marginal value, for the firm, of an additional employee is:

$$V_{n^p}^F \equiv \frac{\partial Q^p(n_t^p)}{\partial n_t^p} = p_{x,t} (1-\phi) \frac{y_t^p}{n_t^p} - w_t^p + \frac{(1-\sigma^p)\kappa}{\psi_t^{fp}} \quad (17)$$

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, thus, the relative price of intermediate goods, $p_{x,t}$, coincides with the real marginal cost faced by the retailers. Let $y_{i,t}$ be the quantity of output produced by retailer i . These goods are aggregated into a tradable good, which is given by:

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

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

$$y_{i,t} = \left(\frac{P_{i,h,t}}{P_{h,t}} \right)^{-\epsilon} y_t^r \quad (18)$$

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 nominal price choose $P_{i,h,t}^*$ so as to maximize expected real profits given by:

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

subject to the demand schedule, (18), in each period. Since all firms are ex-ante identical, $P_{i,h,t}^* = P_{h,t}^*$ for all i . The resulting expression for the real price $p_{h,t}^* \equiv P_{h,t}^*/P_t$ is:

$$\frac{p_{h,t}^*}{p_{h,t}} = \frac{\epsilon}{(\epsilon-1)} \frac{\mathcal{N}_t}{\mathcal{D}_t} \quad (19)$$

where:

$$\mathcal{N}_t = p_{x,t} y_t^r + \beta\chi E_t \Lambda_{t,t+1} (\pi_{h,t+1})^\epsilon \mathcal{N}_{t+1} \quad (20)$$

$$\mathcal{D}_t = p_{h,t} y_t^r + \beta\chi E_t \Lambda_{t,t+1} (\pi_{h,t+1})^{\epsilon-1} \mathcal{D}_{t+1} \quad (21)$$

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

$$(P_{h,t})^{1-\epsilon} = \chi (P_{h,t-1})^{1-\epsilon} + (1-\chi) (P_{h,t}^*)^{1-\epsilon} \quad (22)$$

The aggregate tradable good is sold domestically and abroad:

$$y_t^r = y_{h,t} + y_{h,t}^* \quad (23)$$

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

$$p_{h,t} = e_t p_{h,t}^* \quad (24)$$

2.3.3 Final Goods Producer

Finally, in each block, perfectly competitive firms produce a non-tradable final good by aggregating domestic and foreign aggregate retail goods using CES 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 the final good that is produced at home. 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:

$$y_{h,t} = \varpi (p_{h,t})^{-\gamma} y_t \quad (25)$$

$$y_{f,t} = (1-\varpi) (p_{f,t})^{-\gamma} \frac{1}{\bar{\tau}} y_t \quad (26)$$

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:

$$P_t^{1-\gamma} = \varpi (P_{h,t})^{1-\gamma} + (1 - \varpi) (P_{f,t})^{1-\gamma} \quad (27)$$

2.4 Government

The government sector produces a public good using public capital and labor:

$$y_t^g = (n_t^g)^{1-\alpha} (\bar{k}^g)^\alpha \quad (28)$$

where α is the share of public capital, \bar{k}^g , which is assumed to be fixed. In our baseline exercises below, we assume that y_t^g does not increase the productivity of the private sector, whereas in section 4.3 we also consider the case in which public production is used to increase private productivity. Government expenditure consists of public wages, public vacancy costs, unemployment benefits, consumption expenditure and lump-sum transfers, while revenues come from the consumption, capital income and labor income taxes.¹⁰ The government deficit is, therefore, defined by:

$$DF_t = w_t^g n_t^g + \kappa v_t^g + b u_t + g_t + T_t - \tau_t^n (w_t^p n_t^p + w_t^g n_t^g) - \tau^k (r_t^k - \delta_t) x_t k_t^p - \tau^c c_t$$

and the government budget constraint is given by:

$$b_{g,t} + DF_t = \frac{b_{g,t+1}}{r_t} \quad (29)$$

When considering public wage bill cuts, the government has two potential fiscal instruments, v^g and w^g . For comparison, we will also consider consolidation through traditional fiscal instruments, labor income tax rates, τ^n , and government consumption expenditure, g . The other tax rates, τ^k and τ^c , will be treated as parameters and not considered as potential instruments. We consider each instrument separately, assuming that if one is active, the

¹⁰Note that although the two types of public expenditure are wasteful, they have different functions in the economy. While g_t represents purchases of final goods produced by the private sector, producing y_t^g requires the payment of wages to the household, keeping workers out of productive work.

other remains fixed at its steady state value. For $\Psi \in \{v^g, w^g, g, \tau^n\}$, following Erceg and Linde (2013) and Pappa et al. (2015), we assume fiscal rules of the form:

$$\Psi_t = \Psi^{(1-\beta_{\Psi 0})} \Psi_{t-1}^{\beta_{\Psi 0}} \left[\left(\frac{\tilde{b}_{g,t}}{\tilde{b}_{g,t}^*} \right)^{\beta_{\Psi 1}} \left(\frac{\Delta \tilde{b}_{g,t+1}}{\Delta \tilde{b}_{g,t+1}^*} \right)^{\beta_{\Psi 2}} \right]^{(1-\beta_{\Psi 0})} \quad (30)$$

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:

$$\log b_{g,t}^* - \log b_{g,t-1}^* = \rho_2 \log \bar{b} + \rho_1 (\log b_{g,t-1}^* - \log b_{g,t-2}^*) - \rho_2 \log b_{g,t-1}^* - \varepsilon_t^b \quad (31)$$

where \bar{b} is the steady state debt-to-GDP level and ε_t^b is a white noise process representing a fiscal consolidation shock.

2.5 Closing the model

2.5.1 Monetary policy

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

$$R_t^* = \text{Max} \{1, \rho_R R_{t-1}^* + (1 - \rho_R) \rho_\pi \tilde{\pi}_t\} \quad (32)$$

where $\tilde{\pi}_t = n\pi_t + (1 - n)\pi_t^*$. For the Home economy, consumer price inflation is defined as:

$$\pi_t = \frac{P_t}{P_{t-1}} \quad (33)$$

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

$$e_t = \frac{P_t^*}{P_t} \quad (34)$$

2.5.2 Resource constraint

The non-tradable domestic final good is sold for private and public consumption and for investment, and is also used for the costs of vacancy postings:

$$y_t = c_t + i_t + g_t + \kappa(v_t^p + v_t^g) \quad (35)$$

In turn, following the national accounting identity, total output is defined as tradable output plus the government wage bill:

$$rgdp_t = p_{h,t}y_t^r + w_t^g n_t^g \quad (36)$$

Aggregating the budget constraint of households using the market clearing conditions, the budget constraint of the government, and aggregate profits, we obtain the law of motion for net foreign assets, which is given by:

$$e_t (r_{f,t-1} b_{f,t} - b_{f,t+1}) = nx_t \quad (37)$$

and where nx_t are net exports defined as:

$$nx_t = p_{h,t}y_{h,t}^* - p_{f,t}\bar{\tau}y_{f,t} \quad (38)$$

Finally, we introduce a risk premium charged to Home households depending on the relative size of net foreign liabilities to real GDP:

$$r_{f,t} = r_t^* \exp \left\{ \Gamma e_t \frac{b_{f,t+1}}{rgdp_t} \right\} \quad (39)$$

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

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. Denoting 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 $V_{n^p t}^F$ are given by (11) and (17), respectively. The optimization problem leads to the following solution for w_t^p :

$$w_t^p = (1 - \vartheta) p_{x,t} (1 - \phi) \frac{y_t^p}{n_t^p} + \frac{\vartheta}{(1 - \tau_t^n) \lambda_{c,t}} \Phi_t^{-\varphi} \quad (40)$$

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

2.6 Model Solution and Calibration

We solve the model by linearizing 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. To account for the ZLB, which is a non-linear constraint, we use the Occbin toolkit provided by Guerrieri and Iacoviello (2015). Following the literature, the low inflation environment is induced by assuming a shock to the household's discount rate, ϱ_t^β , in both countries. An unexpected fall in ϱ_t^β translates to a fall in the relative weight on today's consumption relative to future consumption, therefore pushing the stochastic discount factor up. Hence, this shock contracts demand and causes inflation to fall across the monetary union, driving the common nominal interest rate to its lower bound. By raising the household's propensity to save, the discount factor shock by itself induces a rise in investment. To avoid this counterfactual behavior for investment, we also introduce a shock to the price of investment, ϱ_t^i , that leads to a fall in investment.¹¹

¹¹Responses for the low inflation environment without the investment shock are shown in the online appendix. The responses of variables other than investment are not qualitatively affected by this shock.

The stochastic processes for these fluctuations are as follows:

$$\begin{aligned} \varrho_t^\beta &= (1 - \rho_\beta)\varrho^\beta + \rho_\beta\varrho_{t-1}^\beta + \epsilon_t^\beta \\ \varrho_t^i &= (1 - \rho_i)\varrho^i + \rho_i\varrho_{t-1}^i + \epsilon_t^i \end{aligned}$$

where we set $\rho_\beta = 0.6$ and $\rho_i = 0.85$.

Table 1: Calibration of Parameters and Steady State Values

Parameter/Variable	Value	Description
<i>Preferences:</i>		
β	0.99	discount factor
η	1.00	intertemporal elasticity of substitution
ζ	0.70	habits in consumption
φ	4.00	inverse Frisch elasticity of labor supply
ϖ	0.85	home bias in the Periphery
γ	1.50	elasticity of substitution between home and foreign goods
<i>Ratios:</i>		
n	30%	relative size of Periphery
$y^p/rgdP$	77%	private output to GDP
$B_g/rgdP$	80%	annual public debt to GDP
$g/rgdP$	8.3%	government consumption to GDP
<i>Labor Market:</i>		
$(1 - l)$	65%	labor force participation
$u/(1 - l)$	12%	unemployment rate
u^g/u	20%	share of jobseekers in the public sector
n^g/n	18%	share of public employment
$b/(1 - \tau_n)w^p$	52.3%	net replacement rate
κ/w^p	7.29%	vacancy costs as a share of wages
ψ^{fp}, ψ^{fg}	7%	probability of vacancy filling (private, public)
σ^p	4.18%	private job destruction rate
σ^g	$0.95 \times \sigma^p$	public job destruction rate
μ	0.50	elasticity of matching wrt vacancies
<i>Production:</i>		
ω	7.3	investment adjustment costs
ξ	2.15	elasticity of depreciation to changes in utilization
$\bar{\delta}$	2%	depreciation rate
ϕ, α	36%	capital share (private, public)
ϵ	1.1	markup
χ	0.75	Calvo lottery
<i>Policy:</i>		
ρ_R	0.85	interest rate inertia
ρ_π	1.50	Taylor rule inflation targeting
ρ_1, ρ_2	0.79, 0.0001	persistence debt target
$\beta_{v0}, \beta_{v1}, \beta_{v2}$	0.6, 3.4, 3	fiscal rule parameters for vacancy cuts
$\beta_{w0}, \beta_{w1}, \beta_{w2}$	0.85, 0.45, 0.3	fiscal rule parameters for wage cuts

Unless otherwise stated, parameter values are equal for both countries.

Table 1 shows the key parameters and steady state values targeted in our calibration. We calibrate the model at a quarterly frequency and consider the Home economy to represent the Periphery of the Euro area, consisting of Greece, Ireland, Italy, Portugal and Spain. We follow Erceg and Linde (2013) and assume symmetry across the two blocks for most parameters. However, because we set $n = 0.3$ and assume zero net foreign assets in the steady state, the two blocks necessarily differ in the degree of home bias, ϖ and ϖ^* , which is set to 0.85 in the Periphery and 0.94 in the Core. Again following Erceg and Linde (2013), we set the elasticity between domestic and foreign consumption goods to 1.5, and set private output, y^p , to represent 77% of GDP.

We choose an annual government debt-to-GDP ratio of 80%, significantly above the Maastricht limit and, therefore, consistent with an environment in which fiscal consolidation is deemed necessary. We set the share of government consumption to GDP equal to the average share of government intermediate consumption to GDP in the European Periphery. We set the steady state labor income tax rate at 30%, and set government consumption expenditure at 80% of the public wage bill, in line with the euro area average.

The rest of the utility function parameters are standard. The intertemporal elasticity of substitution is set to 1 and the habit parameter is set equal to 0.6 in order to increase persistence and the duration of the lower bound. We assume a Frisch elasticity of labor supply equal to 0.25.

We set the labor force participation rate to 65%, assume that 20% of jobseekers are searching in the public sector, and that 18% of employed workers are working for the government.¹² For the remaining labor market parameters, we follow Moyen et al. (2016), who calibrate a model for the Euro area with one block matching the Periphery. As such, the unemployment rate is set to 12%, the net replacement rate to equal 52.3% and vacancy posting costs to represent 7.29% of private wages. We assume equal probabilities of a vacancy to be filled in both sectors, $\psi^{fp} = \psi^{fg} = 7\%$. As discussed above, we assume that the average duration of employment is shorter in the private sector, and therefore set the separation rate in the

¹²Under our preferred calibration we obtain a public wage premium over the private wage of slightly above 1%. If we assume instead that 26% of jobseekers are searching in the public sector, we obtain a premium of 5%: employment conditions relatively more attractive in the public sector justify the increase in jobseekers searching for a public job. Our results, presented in the online appendix, do not change significantly in the presence of a higher public wage premium.

public sector 5% lower than in the private sector.

The parameters in the production function are standard: the capital share is set to 0.36 in both sectors. The depreciation rate implies an annual depreciation of 10% and the investment adjustment costs are set equal to 7.3.¹³ We set the elasticity of capital depreciation to capital utilization, ξ , such that capital utilization is 1 at steady state. Finally, we assume prices are sticky for four quarters and that the central bank reacts only to deviations of inflation.

For the parameters governing fiscal policy, we set ρ_1 and ρ_2 , which govern the path of the debt-to-GDP target, such that any change in the target is observed fully after 30 quarters and lasts for an arbitrarily long period of time, beyond the relevant policy horizon.¹⁴ Finally, we set the parameters governing the fiscal instruments in equation (30) such that, in normal times, the actual debt-to-GDP ratio meets the target after 30 quarters for both instruments.

3 Fiscal Consolidation through the Wage Bill

We consider a shock that drives the debt-to-GDP target 10% below its steady state. We simulate the responses to this shock with either public vacancies, v^g , or public wages, w^g , adjusting to achieve fiscal consolidation, and compare the effects of the consolidation under these two instruments and under two alternative instruments, namely public consumption spending, g_t , and the labor income tax rate, τ_t^n , for the sake of comparison with the existing literature. We first look at the effects of this shock in normal times, and then compare these results to when the consolidation is implemented in a low inflation environment.

3.1 Consolidation in Normal Times

Figure 3 presents the comparison between cutting public vacancies and cutting public wages to meet the new debt-to-GDP target, when the economy is not subject to the demand

¹³We have investigated the sensitivity of our results to changes in this parameter. Lower values of ω imply a higher initial drop in investment after the shock to its price and makes consolidation tougher for both instruments.

¹⁴All shocks considered in the exercises below are temporary, including the shock that induces the fall in the debt-to-GDP target. However, we calibrate the target rule (31) such that the debt-to-GDP target returns to its steady state at a slow pace.

shocks.¹⁵ For both instruments, the consolidation induces a gradual fall in the public wage bill, and a contraction in public employment and, hence, public output. In the case of public vacancies, the reduction in the public wage bill has a slight lag relative to the wage cuts, due to the lag in the adjustment of public employment. Crucially, for both instruments, the share of public sector jobseekers in total jobseekers falls. In the case of public vacancy cuts, there is a fall in the number of matches, and hence the probability of finding a job in the public sector. The public wage cuts cause the value of the public sector job, in the case of a match, to fall. As a result, in both cases, the expected value of searching for a job in the public sector is reduced. Since agents redirect their search until the expected value of searching in each sector is equalized, this leads to a reallocation of jobseekers towards the private sector.¹⁶ With public wages as the active instrument, this mechanism induces an endogenous reduction in public employment, which further aids the consolidation. In contrast, public vacancies need to adjust a lot more to achieve a similar fall in the public wage bill, since in this case public wages are assumed to be fixed.

The reduction in expenditure on the public wage bill creates a positive wealth effect for the household, which leads to falling labor force participation and hence lower labor supply. In the short run, this raises private wages. Nonetheless, the increase in the supply of labor in the private sector, due to the reallocation of jobseekers, eventually pushes down on private wages. Hence, by increasing the competitiveness of the Periphery within the monetary union, consolidation induces an internal devaluation, and so implies a depreciation of the real exchange rate and eventually a rise in net exports.

The rise in demand for the private good, and the fall in private wages, also imply a rise in private vacancies. The expansion of both the demand and supply of private labor raises private employment. As the labor markets adjust, the faster response of private employment in the case of public wage cuts means that more jobseekers are absorbed into private employment, and unemployment continues to fall. On the other hand, in the case of vacancy cuts, the sluggish response of the private sector labor market means that fewer jobseekers

¹⁵All responses are in percent deviations from steady state, except for interest rates and inflation, which are in annualized levels, the share of public jobseekers, which is in percentage point deviation from steady state, and net exports, which are in levels. In all figures, the line with diamond markers on the top-left panel reports the path for the debt-to-GDP target following (31).

¹⁶Note that, in equilibrium, the expected value of searching for a job will be lower in both sectors.

are hired. Along with the fact that public employment falls by much more in the medium to long run, this implies that the unemployment rate falls less noticeably when vacancy cuts are the active instrument.¹⁷

Recalling the definition of GDP as the sum of private and public output, with the latter measured by the public wage bill, we can see that the consolidation process initially boosts GDP following the increase in private sector output, but then depresses GDP for many periods, given the fall in the public wage bill. In the short to medium run, this effect is somewhat bigger for wage cuts, given the larger increase in tradable output. The long run effect on tradable output is higher for vacancy cuts, which mitigates the fall in real GDP relative to public wage cuts.

Although our model differs substantially from Bradley et al. (2016), we also find that in normal times cuts in the public wage bill expand the private sector, both by raising demand and causing a reallocation of jobseekers to the private sector. We have also underlined an additional mechanism not considered in Bradley et al. (2016), namely that for both instruments the public wage bill cut in a monetary union induces an internal devaluation, therefore aiding the recovery by raising external demand. Comparing the two instruments, cutting public wages implies a faster expansion in the private sector, and hence a larger fall in unemployment. Public vacancy cuts, on the other hand, imply an overall larger cut in public employment and a significantly more sluggish response of workers, such that the positive effects in the private sector take longer to materialize.

To gain some more insight about the nature of the consolidation we consider relative to the existing literature, we also plot in Figure 3 the responses of the economy when debt consolidation is achieved through the traditional fiscal instruments, namely wasteful public consumption spending and labor income taxes. With both wages and vacancies in the public sector kept fixed, these alternative instruments do not affect public employment or the allocation of jobseekers in the two sectors. In the case of government spending cuts, there is a positive wealth effect that leads to an increase in private consumption and a fall in labor

¹⁷The responses of total employment are presented in the online appendix. For all fiscal instruments considered, except for public wage cuts, total employment falls with consolidation in normal times. For the case of vacancy cuts, the smaller crowding in of private employment and the bigger reduction in public employment brings total employment down. For the case of wage cuts, public employment falls by less, while private employment is increased more.

force participation, as in the case of public wage bill cuts. The exit of jobseekers from the labor force also lowers the unemployment rate. This inward shift in labor supply induces an increase in real wages and firms' marginal costs which, together with the fall in spending, induces labor demand, and therefore private vacancies, to fall. Coupled with the fact that unemployed jobseekers do not switch sector, this induces a fall in private employment, and hence in tradable output and real GDP. As standard in the existing literature, and in contrast to cuts to the public wage bill, government spending multipliers are found to be positive.

The rise in the labor tax rate also lowers labor force participation substantially, by directly reducing the incentives to work. Since consumption also falls in this case, given the drop in after-tax income, this leads to a bigger drop in private vacancies, and hence larger negative effects on private employment and tradable output. Responses are significantly larger and more persistent than in the case of consumption spending cuts, due to a fall in investment. Furthermore, the rise in labor taxes increases unemployment after the short run and reduces the competitiveness of the Periphery leading to a real exchange rate appreciation, unlike all of the spending based consolidations.

3.2 Consolidation in a Low Inflation Environment

We now turn to the case where the consolidation occurs while monetary policy is constrained at the ZLB and inflation is stuck below steady state. Figures 4 and 5 plot the IRFs for vacancy cuts and wage cuts, respectively. In each figure, to aid comparison, we again plot the baseline consolidation in normal times in the blue solid lines, as in Figure 3.

For completeness, we also plot the case where the economy is hit by the negative demand shocks but the ZLB constraint is not imposed: these are the green dashed lines. In both Figures, in this unconstrained case the net nominal interest rate becomes negative for around five quarters. This depresses the real interest rate, offsetting the effects of the negative demand shocks through a smaller fall in private consumption and investment. It is interesting to note that the fall in the real interest rate is actually a boost to public finances, and the government's debt-to-GDP ratio quickly falls close to the target with only a smaller adjustment in the fiscal instruments needed.

Conversely, when the ZLB is imposed, shown by the red dash-dotted lines, the nominal rate remains at its lower bound for around five quarters: the real interest rate is higher than the unconstrained case and inflation falls by more. The contraction of tradable output, coupled with the fall in inflation, push the government's debt-to-GDP ratio in an upward trajectory, in spite of the consolidation. Hence, a much larger adjustment of the fiscal instrument is needed in this environment, and in fact the target is not fully reached after 30 quarters.

At the ZLB, with both consumption and investment contracting, private vacancies fall sharply and the private sector is no longer able to absorb the increasing number of private jobseekers. In fact, the share of jobseekers in the public sector rises on impact in the case of cuts in public vacancies. As a result, in the short run, private employment falls and the unemployment rate rises, in line with the recent experience of countries in the Periphery of the Euro area. As the consolidation in the public sector deepens, in the medium to long run, we again see a shift of jobseekers to the private sector, a rise in private vacancies, and a rise in private employment. Tradable output follows a similar path, contracting in the short to medium run, but rising above steady state in the long run. Real GDP also falls sharply during the liquidity trap, and remains persistently below steady state due to the larger fall in the public wage bill.

What does the low inflation environment imply about the comparison of fiscal instruments? In Figure 6 we plot together the responses for the different instruments when the ZLB constraint is binding. Compared to Figure 3, we see that the responses for cuts in public vacancies and cuts in public wages are now relatively closer in general, and, particularly, for tradable output and real GDP. This comes about because the relatively larger size of the demand shocks dominates the shape of most responses. The most striking difference is in unemployment: after the impact period, the unemployment rate falls substantially in the case of wage cuts, while it remains elevated in the case of vacancy cuts. This difference stems mainly from the weaker performance of private employment, and the larger fall in public employment. Hence, in terms of the response of unemployment and the private sector employment, the effects of public wage cuts are less adverse than those of vacancy cuts in a

low inflation environment.¹⁸

Again, in Figure 6 we compare consolidation in the public wage bill with consolidations through standard cuts in government consumption or tax hikes. As we have seen above, when the consolidation is implemented at the ZLB, the fall in demand causes a contraction in the private sector, pushing down on both private sector wages and vacancies. When wages and vacancies in the public sector do not adjust, this increases the incentives of jobseekers to search in the public sector, and we see a sizable reallocation of labor towards the public sector. This leads to large and persistent fall in both private employment and tradable output with the traditional fiscal instruments. Hence, in a low inflation environment, the contraction in the public sector through cuts in public vacancies or public wages helps the economy recover in the medium run, while traditional consolidation instruments do not.

3.3 The Role of the Consolidation Shock

Since we are considering simultaneous shocks, it is useful to separate their effects. To this end, we now compare the responses of the economy at the ZLB, as discussed above, to a case where the economy hits the ZLB but the public debt target is held constant. The comparison is shown in Figures 7a and 7b for vacancy cuts and wage cuts, respectively, with the blue solid lines reporting the scenario with the consolidation shock and the green dashed lines the one without.

For both policy instruments, consolidation is, in fact, induced by the negative demand shocks alone. As discussed above, by inducing a fall in inflation and a contraction in the private sector, the demand shocks increase the debt-to-GDP ratio above the target. As a result, and according to the fiscal rule specified in equation (30), public vacancies or wages are automatically cut, even without the fall in the debt-to-GDP target. Nonetheless, these cuts are smaller compared to the scenario with the consolidation shock. Importantly, this means that there is a smaller reallocation of jobseekers to the private sector after the initial

¹⁸In the online appendix we show that at the zero lower bound total employment increases in the medium run in the case of public wage cuts and falls in the case of vacancy cuts. Also, in exercises we do not show here for economy of space, we find that the increase in unemployment following vacancy cuts can be mitigated by assuming a lower Frisch elasticity. Nonetheless, these results are robust for reasonable values, $0.1 \leq \frac{1}{\varphi} \leq 1$, and do not affect our conclusions regarding the effects of wage cuts versus vacancy cuts for reducing the unemployment rate.

impact of the negative demand shocks. Due to the drop in private demand, now households initially reallocate jobseekers towards the public sector for both instruments. This leads to a smaller depreciation of the real exchange rate, and a bigger fall in private consumption. The fall in investment is also noticeably larger. The response of private employment now becomes persistently negative. Along with the implied smaller drop in labor force participation, this means that, for both instruments, the unemployment rate is higher without the consolidation shock, too. Hence, we conclude that at the ZLB the consolidation shock aids the recovery of the economy.

4 Sensitivity Analysis

We now perform different exercises to investigate how the mechanisms of the model affect our results at the ZLB. First, we explore the role of labor market rigidities, by assuming that the household cannot reallocate jobseekers between the two sectors.¹⁹ Second, we investigate the importance of price rigidities for the effects of fiscal consolidation. Third, we consider the alternative scenario in which the public good is used in private production. Finally, we test the sensitivity of our results with regards to the parameters that determine the openness of the economy.

4.1 Fixed Allocation of Jobseekers

Our analysis has highlighted the role of the labor market channels in driving the effects of fiscal consolidation through public wage bill cuts. We now explore the extent to which muting the reallocation of unemployed jobseekers between the two sectors, affects our findings. Letting households choose the fraction of unemployed workers that look for a job in each of the two sectors is important for the dynamics of our model. This assumption implies that jobseekers can costlessly optimize their search between sectors in each period. However, in reality, human capital derived from learned skills, past experience and in-job networking introduce an asymmetry to the mobility of workers. Hence jobseekers with previous experience

¹⁹We have also investigated the effects of wage rigidity in the private sector, assuming that private real wages evolve as in Monacelli et al. (2010). These results are available in the online appendix. In line with Krause and Lubik (2007), sticky wages do not seem to substantially affect any of our previous conclusions.

in one sector would find it more difficult to be hired in the other. To explore the consequences of imperfect mobility, we impose that the fraction of jobseekers in the public sector, s_t , is held fixed at steady state. Hence, although the number of workers employed in each sector can evolve separately through the dynamics of vacancy postings, matches, and labor force participation, households cannot freely decide to reallocate jobseekers to one particular sector.

The green dashed lines in Figures 8a and 8b depict the responses under this scenario. With no reallocation of jobseekers to the private sector, the recovery is now much slower. Firstly, as debt-to-GDP falls more slowly after the liquidity trap, larger and more persistent cuts in public vacancies and wages are needed for consolidation. In fact, the target now takes significantly longer to be met. Output and unemployment effects become more adverse. This mechanism is particularly important for wage cuts, where, without the rise of jobseekers in the private sector, private employment now does not increase. Nonetheless, the unemployment rate continues to fall, since public employment does not fall, and labor force participation falls persistently, as lower wages mean that household members find it optimal to stay at home and enjoy leisure.

Overall, rigidities in the reallocation of jobseekers from the public to the private sector imply that fiscal consolidation through cuts in the public wage bill is more difficult to implement, and comes at the cost of higher unemployment in the case of vacancy cuts, and lower private employment in the case of wage cuts.

4.2 Price Rigidities

We have seen that fiscal consolidation through the public wage bill induces changes in relative prices, which, under a fixed exchange rate regime, plays a role in the reallocation of resources within the monetary union. This is particularly true at the ZLB, when monetary policy cannot undo changes in relative prices induced by asymmetric fiscal shocks and, as a result, the degree of price stickiness becomes important for the effects of fiscal consolidation.

The green dashed lines in Figures 9a and 9b depict the responses when we assume that the degree of price rigidities increases for both regions by setting $\chi = 0.85$. It is clear that

price rigidities matter for the success of the consolidation at the ZLB. The larger the share of firms that cannot change their prices on impact, the weaker the negative effects of the demand shocks on inflation and the milder the necessary consolidation. However, this result is reversed when the degree of price stickiness is asymmetric between member states. The red dotted lines in Figures 9a and 9b depict the responses when we assume that the degree of price rigidities increases only in the Periphery. In this case, consolidation effort decreases in the short run as inflation moves less than in the benchmark model. Still, higher price stickiness in the Periphery implies larger effects from the negative demand shocks. The relative inability of prices to adjust in the Periphery induces a reversal of the internal devaluation, meaning an appreciation of the real exchange rate, which significantly reduces net exports. This effect is then mirrored in the response of tradable output and employment.²⁰

Overall, a higher degree of price rigidities in the Periphery implies an additional channel, which operates through an appreciation of the real exchange rate, with adverse effects on net exports, output, private employment, and unemployment.

4.3 The Productivity of the Public Good

So far, we have assumed that the public good, y_t^g , does not play any role in the economy. As an alternative, following Barro (1990) and Turnovsky (1999), we allow the public good, y_t^g , to enter the production function, taken as exogenous by the firms. To this end, we augment the private production function to:

$$y_t^p = (n_t^p)^{1-\phi} (x_t k_t^p)^\phi (y_t^g)^\nu \quad (41)$$

The parameter ν regulates how the public input affects private production: when ν is zero, the government good is unproductive. This parameter is crucial in determining the effects of consolidation, even in normal times. When $\nu > 0$, fiscal consolidation in this environment reduces the productive capacity of the firms by reducing the public good, and at the same

²⁰In the online appendix we show that asymmetries in wage stickiness, or in the mobility of jobseekers across sectors, are less important for our results. We also show that the degree of price stickiness is inconsequential during normal times, as monetary policy will always react to undo possible rigidities stemming from price dispersion.

time induces a positive wealth effect, which raises private demand and therefore private labor demand. Hence, ν is at the center of the balance between two opposite effects on private production.

The green dashed lines in Figures 10a and 10b compare the responses of the baseline model against the responses when we assume that $\nu = 0.15$. When the public good is productive, the reduction in the public wage bill implies a drop in the marginal product of labor, and this leads to a bigger fall in private wages. For both instruments, there is a bigger contraction in household consumption and investment, and ultimately a much larger and more persistent drop in tradable output. In the case of vacancy cuts, where public employment, and hence public output, falls more significantly, the differences are much starker. In this case, the reallocation of jobseekers towards the private sector in the medium to long run is smaller, since the expected return from working in the private sector is now smaller. Similarly, the fact that the consolidation reduces the productivity of private jobs lowers the expected returns from an additional hire for the firm, and, as a result, private vacancies fall more in this case, inducing a bigger drop in private employment. More specifically, the initial drop in private employment is larger and its subsequent evolution is always below baseline, raising the unemployment rate considerably and persistently. With public wage cuts, since public employment does not fall by as much when compared to the case of vacancy cuts, this channel of amplification through the productivity of the public good is less important. The fact that the consolidation decreases private productivity also implies that there is no internal devaluation after vacancy cuts: the real exchange rate even appreciates after the liquidity trap.²¹

In summary, when the public good is productive, there is a bigger fall in the private wage, consumption, investment, and tradable output. For vacancy cuts, the impact on the responses of private employment and the unemployment rate is more pronounced.

²¹In results we present in the online appendix we show that assuming that the public good provides utility to the households by being a substitute of private consumption does not significantly affect our baseline results.

4.4 Particularities of the Open Economy

In this section we explore the open economy dimension of the model, in particular investigating the sensitivity of our findings to changes in the degree of trade elasticity and the relative size of the member country implementing consolidation within the monetary union.

4.4.1 Elasticity of Trade

There is no strong consensus from the empirical literature regarding the value of the elasticity of substitution between home-produced and imported goods, γ . Some recent contributions have suggested low values for this parameter, in some cases with estimates well below one. The green dashed lines in Figures 11a and 11b show the IRFs for the case when this elasticity is reduced from 1.5 to 0.5, implying complementarity between traded goods.

With the foreign and domestic goods as complements, the internal devaluation no longer leads to a substitution of both domestic and foreign demand towards the domestically produced good. Instead, it contracts demand for both types of goods in the Periphery. The fall in domestic demand produces a larger fall in domestic inflation, resulting in a bigger exchange rate depreciation and a larger rise in net exports.²² The deflationary pressures increase the debt burden, rendering consolidation more difficult to achieve and increasing its associated costs. Note in particular that, for vacancy cuts, the unemployment rate increases significantly when domestic and foreign goods are assumed to be complements.

In conclusion, complementarity between home-produced and imported goods implies that the deflationary pressures increase the debt burden, rendering consolidation more costly.

4.4.2 The Relative Size of Member Countries

The red dash-dotted lines in Figures 11a and 11b show the implications of increasing the size of the Periphery to 50% of the monetary union. Since we assume that net foreign assets are zero in the steady state, increasing the size of the Periphery also implies reducing the home bias in the Core.²³ Hence the differences in the composition of CPI across regions are

²²The results of the fall in domestic demand are clearly illustrated in the online appendix where we plot the sensitivity of results to changes in the trade elasticity in normal times. For a lower elasticity of trade, consumption and investment fall after the consolidation since agents cannot substitute domestic for foreign goods and this results in downward pressures on inflation.

²³For $n = 0.5$ and $\varpi = 0.85$, we have $\varpi^* = 0.85$

smaller, CPI differentials are reduced and this dampens the adjustment of the real exchange rate. Furthermore, although final good producers in the Periphery still substitute between domestic and foreign retail goods, their demand now represents a bigger share of total demand for foreign goods and, therefore, affects foreign prices more. In the short to medium run, this benefits firms in the Periphery, and it translates to a slightly smaller adjustment in private demand, particularly in investment. This, in turn, helps the consolidation effort and reduces the adjustment of both fiscal instruments required to meet the debt target.

Hence, we conclude that it is easier to consolidate for larger countries in a monetary union, although the associated relative differences are small.

5 Conclusions

5.1 Summary

In this paper, we have set up a DSGE model of a monetary union with search and matching frictions, nominal rigidities, and public employment, to study the effects of fiscal consolidation through cuts in the public wage bill in a low inflation environment. Our model allows us to study non-trivial reallocation of agents both in and out of the labor force and between the public and private sector. In normal times, a reduction in the government wage bill induces a reallocation of labor towards the private sector, due to the contraction in the public sector, and so pushes down on private wages in the medium run. This leads to an internal devaluation within the monetary union, which, along with the positive wealth effect from the cut in government expenditure, raises aggregate demand and so implies an expansion in the private sector.

In a low inflation environment, induced by negative demand shocks, the debt-to-GDP ratio rises, and so larger fiscal cuts are needed to lower this ratio. Given the expansionary effects this has for the private sector, consolidation helps the recovery of the economy in a liquidity trap in the medium to long run. Nonetheless, with the contraction in demand, the private sector is much more limited in its ability to absorb the workers leaving the public sector, and so the expansionary effects of the consolidation are contained. On the other hand,

the effects of consolidation on the unemployment rate depend on the fiscal instrument used at the ZLB: while public wage cuts quickly and effectively reduce the unemployment rate, public vacancy cuts lead to a significant and more persistent rise in the unemployment rate.

5.2 Policy Implications

Our findings can be used as a roadmap for successful fiscal consolidations through cuts in the public wage bill. First, since vacancy cuts have indirect and lagged effects on the dynamics of the private wage and no effects for the public wage, they could be more easily implemented. In normal times, they also decrease unemployment relative to wage cuts and, moreover, generate more persistent increases in employment, output and net exports. Clearly, in terms of implementability but also long run effects, consolidating through vacancy cuts in normal times presents certain advantages. At the ZLB, the two instruments deliver similar outcomes apart from unemployment that decreases for wage cuts and remains high for vacancy cuts. This creates a trade-off for policy makers that must strike a balance between the easier implementation of unfavourable policies using vacancy cuts, or controlling the rise in unemployment due to the negative demand shocks using wage cuts.

We point to several factors that matter for the recovery from the low inflation environment. The most important are rigidities in the mobility of unemployed jobseekers between the public and private sectors and nominal price stickiness. Rigidities in the reallocation of workers between the two sectors make consolidation through cuts in the public wage bill more adverse and come at the cost of higher unemployment in the medium to long run. Hence, the presence of active labor market policies that can help channel workers from the public to the private sector are crucial for the success of fiscal consolidations like the ones considered in this paper. In a similar sense, relative price rigidities are also important: higher price stickiness in the Periphery reverses the internal devaluation and leads instead to an appreciation of the real exchange rate, which reinforces the negative effects of the demand shocks and makes consolidation harder to achieve. Also in this case, structural reforms that reduce those types of rigidities would ease consolidations in the Periphery. Furthermore, when the public good which is being cut is a productive factor for the private sector, consolidation is

more difficult, since it reduces the marginal productivity of labor. This pushes down both on firm's demand for labor and household's supply of labor in the private sector, and results in a drag on the economy. Thus, policymakers should consider not only the number, but also the quality, of workers when cutting jobs, and the sector in which pay cuts are implemented.

Also, we have compared consolidations through the public wage bill with traditional instruments of fiscal consolidation considered in the existing literature, like tax hikes or government consumption cuts. Public wage cuts continue to offer certain advantages in terms of a fast recovery of the private sector and a reduction in the unemployment rate. Still in a low inflation environment, even such a consolidation policy, cannot fully undo the negative effects of the demand shocks.

References

- Albrecht, J., Robayo-Abril, M. and Vroman, S.: 2015, Public Sector Employment in an Equilibrium Search and Matching Model, *Manuscript* .
- Ardagna, S.: 2007, Fiscal policy in unionized labor markets, *Journal of Economic Dynamics and Control* **31**(5), 1498 – 1534.
- Barro, R. J.: 1990, Government Spending in a Simple Model of Endogenous Growth, *Journal of Political Economy* **98**(5), S103–26.
- Bermperoglou, D., Pappa, E. and Vella, E.: 2017, The government wage bill and private activity, *Journal of Economic Dynamics and Control* **79**, 21–47.
- Bradley, J., Postel-Vinay, F. and Turon, H.: 2016, Public sector wage policy and labor market equilibrium: a structural model, *Journal of European Economic Association* (*forthcoming*).
- Bruckner, M. and Pappa, E.: 2012, Fiscal expansions, unemployment, and labor force participation: theory and evidence, *International Economic Review* **53**(4), 1205–1228.
- Campolmi, A. and Gnocchi, S.: 2016, Labor market participation, unemployment and monetary policy, *Journal of Monetary Economics* **79**, 17–29.

- Christiano, L., Eichenbaum, M. and Rebelo, S.: 2011, When Is the Government Spending Multiplier Large?, *Journal of Political Economy* **119**(1), 78–121.
- Coenen, G., Erceg, C. J., Freedman, C., Furceri, D., Kumhof, M., Lalonde, R., ... and Trabandt, M.: 2012, Effects of Fiscal Stimulus in Structural Models, *American Economic Journal: Macroeconomics* **4**(1), 22–68.
- Correia, I., Farhi, E., Nicolini, J. and Teles, P.: 2013, Unconventional Fiscal Policy at the Zero Bound, *American Economic Review* **103**(4), 1172–1211.
- De Long, J. and Summers, L.: 2012, Fiscal Policy in a Depressed Economy, *Brookings Papers on Economic Activity* pp. 233–297.
- Demekas, D. G. and Kontolemis, Z. G.: 2000, Government employment and wages and labour market performance, *Oxford Bulletin of Economics and Statistics* **62**(3), 391–415.
- Eggertsson, G.: 2011, What Fiscal Policy is Effective at Zero Interest Rates?, *NBER Macroeconomics Annual 2010* **25**, 59–112.
- Erceg, C. and Linde, J.: 2013, Fiscal Consolidation in a Currency Union: Spending Cuts vs. Tax Hikes, *Journal of Economic Dynamics and Control* **37**(2), 422–445.
- Gomes, P.: 2015, Optimal public sector wages, *The Economic Journal* **125**(587), 1425–1451.
- Guerrieri, L. and Iacoviello, M.: 2015, OccBin: A toolkit for solving dynamic models with occasionally binding constraints easily, *Journal of Monetary Economics* **70**(C), 22–38.
- Holm-Hadulla, F., Kamath, K., Lamo, A., Pérez, J. J. and Schuknecht, L.: 2010, Public wages in the euro area: towards securing stability and competitiveness, *ECB Occasional Paper* (112).
- Ilzetzki, E., Mendoza, E. and Vegh, C.: 2013, How Big (Small?) Are Fiscal Multipliers?, *Journal of Monetary Economics* **60**(2), 239–254.
- Jalil, A.: 2012, Comparing Tax and Spending Multipliers: It's All About Controlling for Monetary Policy, *Available at SSRN 2139855*.

- Krause, M. U. and Lubik, T. A.: 2007, The (ir) relevance of real wage rigidity in the new keynesian model with search frictions, *Journal of Monetary Economics* **54**(3), 706–727.
- Kuvshinov, D., Müller, G. J. and Wolf, M.: 2016, Deleveraging, deflation and depreciation in the euro area, *European Economic Review* **88**, 42–66.
- Lamo, A., Moral-Benito, E. and Pérez, J. J.: 2016, Does slack influence public and private labor market interactions?, *Working Paper Series 1890*, European Central Bank.
- McManus, R., Ozkan, F. G. and Trzeciakiewicz, D.: 2014, Self-defeating austerity at the zero lower bound, *Department of Economics, University of York*.
- Monacelli, T., Perotti, R. and Trigari, A.: 2010, Unemployment fiscal multipliers, *Journal of Monetary Economics* **57**, 531–553.
- Moyen, S., Stähler, N. and Winkler, F.: 2016, Optimal Unemployment Insurance and International Risk Sharing, *Finance and Economics Discussion Series 2016-054*, Board of Governors of the Federal Reserve System.
- Neiss, K. S. and Pappa, E.: 2005, Persistence without too much price stickiness: the role of variable factor utilization, *Review of Economic Dynamics* **8**(1), 231–255.
- Pappa, E., Sajedi, R. and Vella, E.: 2015, Fiscal Consolidation with Tax Evasion and Corruption, *Journal of International Economics* **96**(S1), 56–75.
- Pérez, J. J., Aouriri, M., Campos, M. M., Celov, D., Depalo, D., Papapetrou, E., Pesliakaite, J., Ramos, R. and Rodríguez-Vives, M.: 2016, The fiscal and macroeconomic effects of government wages and employment reform, *Occasional Papers 1607*, Banco de Espana.
- Quadrini, V. and Trigari, A.: 2007, Public employment and the business cycle, *The Scandinavian Journal of Economics* **109**(4), 723–742.
- Ravn, M.: 2008, The consumption-tightness puzzle, *NBER International Seminar on Macroeconomics 2006* pp. 9–63.
- Reinhart, C., Reinhart, V. and Rogoff, K.: 2015, Dealing with Debt, *Journal of International Economics* **96**(S1), 43–55.

Rendahl, P.: 2016, Fiscal Policy in an Unemployment Crisis, *Review of Economic Studies* **83**(3), 1189–1224.

Turnovsky, S. J.: 1999, Productive government expenditure in a stochastically growing economy, *Macroeconomic Dynamics* **3**, 544–570.

Figures

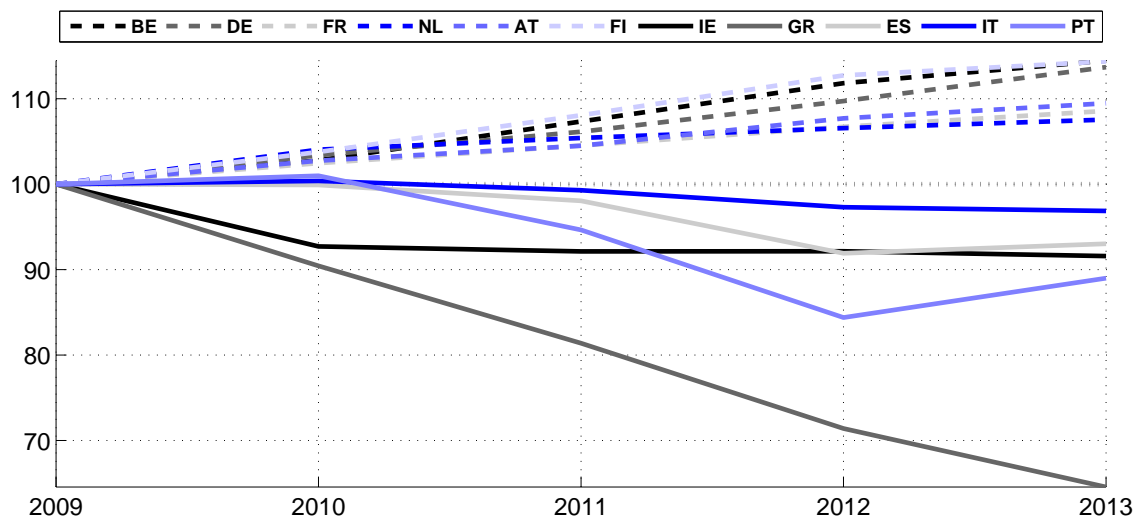
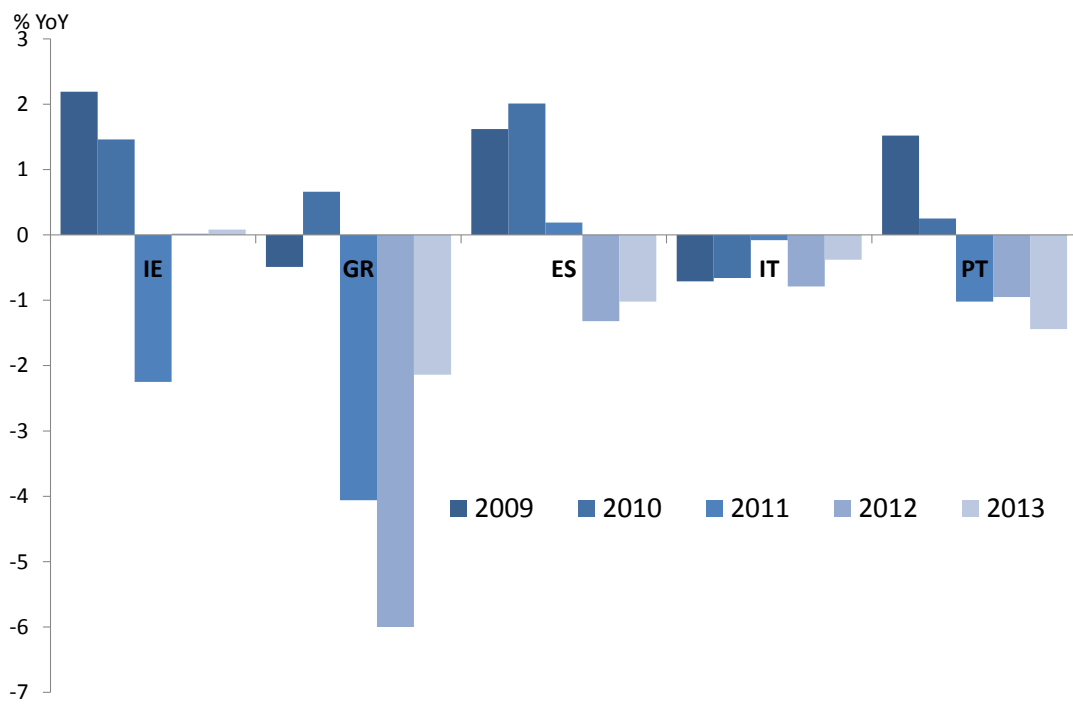


Figure 1: Evolution of the Public Wage Bill

Wages and salaries in the public sector, current prices. For comparability, country series have been normalized to 100 in 2009. *Source: Eurostat and authors' calculations.*



(a) Average Wage per Employee



(b) Employment

Figure 2: Changes in Public Sector Wages and Employment

Source: Eurostat and authors' calculations.

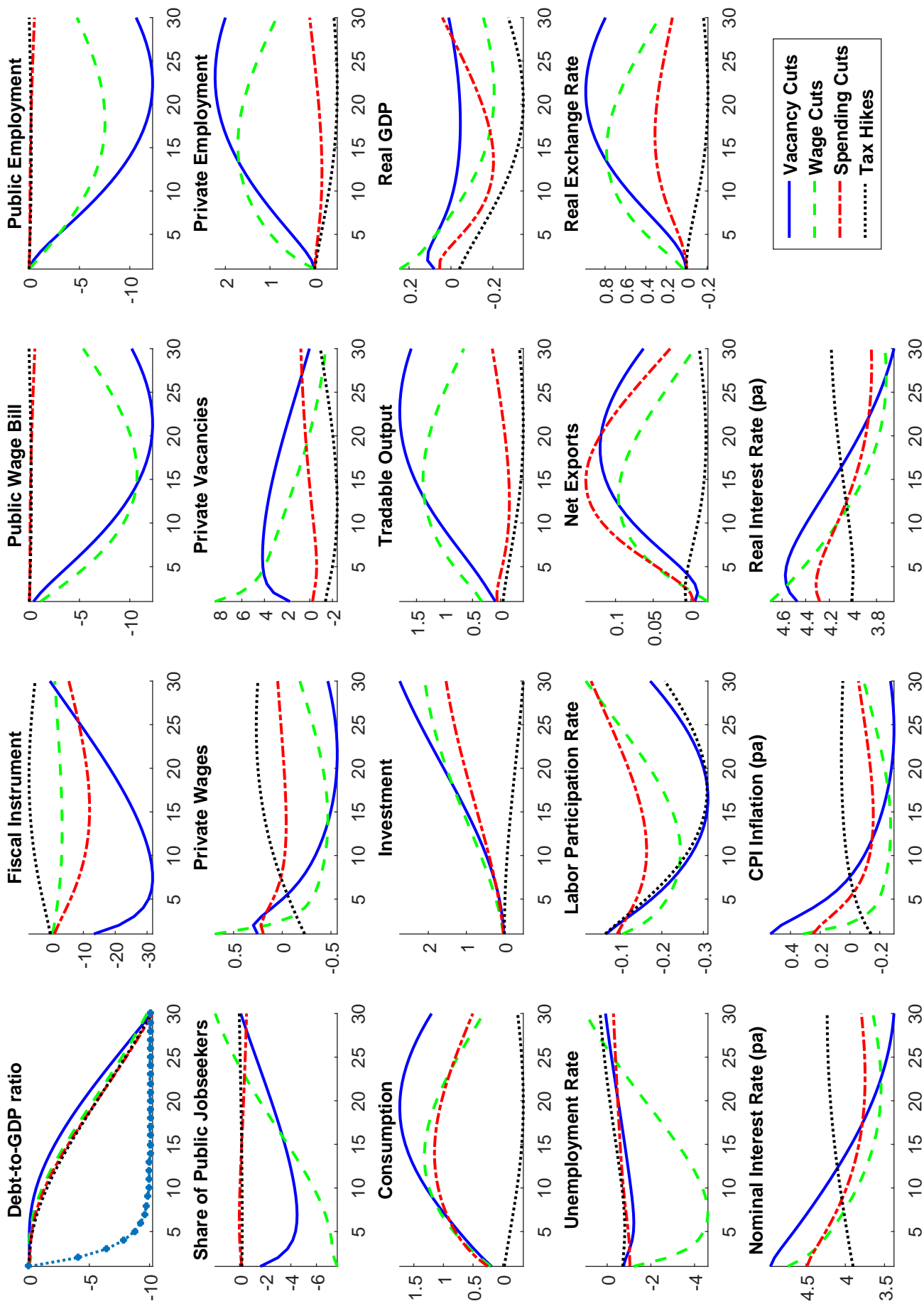


Figure 3: Normal Times: Comparison of Fiscal Instruments

Responses are in percent deviations from steady state, except for interest rates and inflation, which are in annualized levels, the share of public jobseekers, which is in percentage point deviation from steady state, and net exports, which are in levels. The line with diamond markers on the top-left panel reports the path for the debt-to-GDP target.

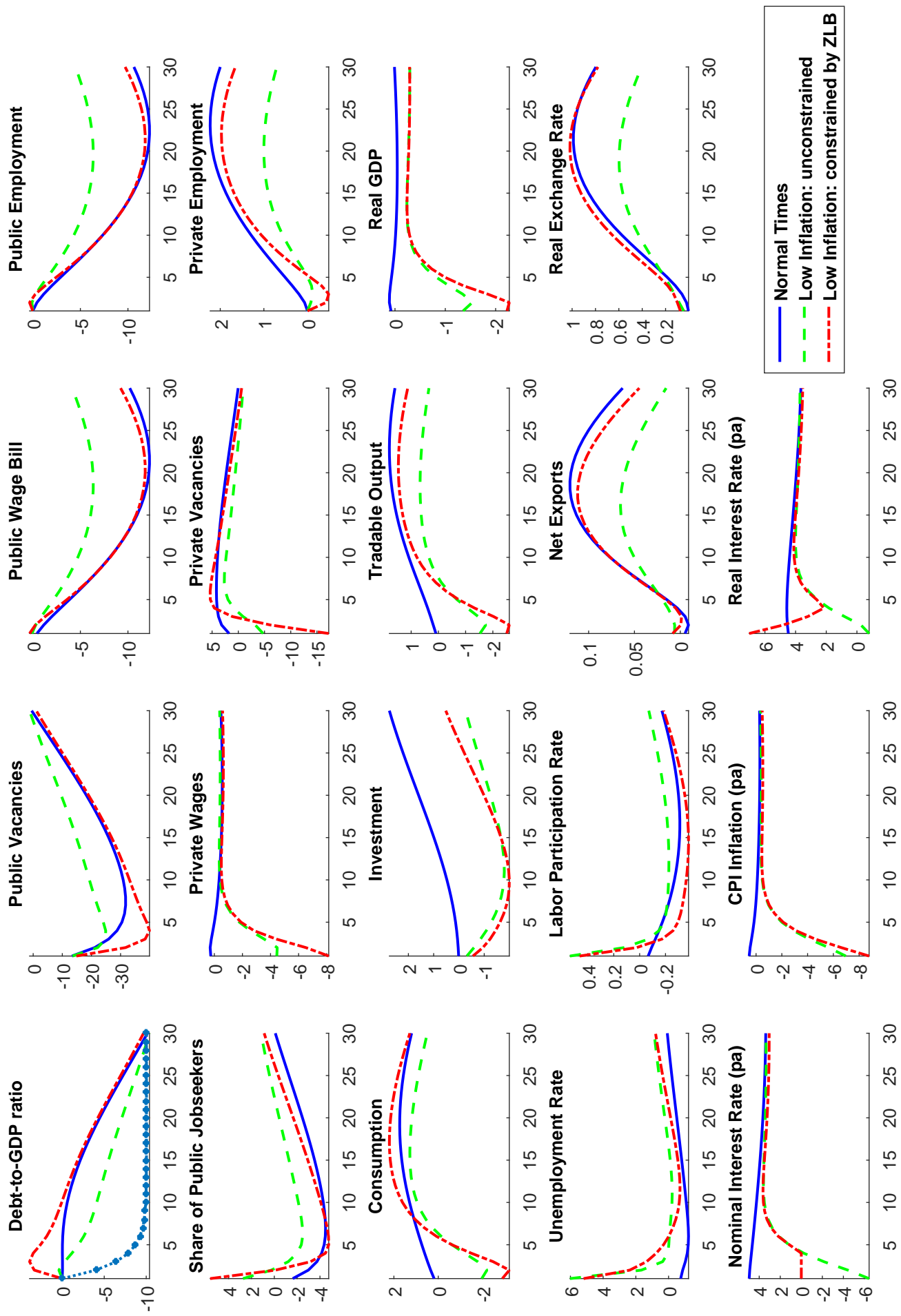


Figure 4: Normal Times vs. Low Inflation Environment: Public Vacancy Cuts

Responses are in percent deviations from steady state, except for interest rates and inflation, which are in annualized levels, the share of public jobseekers, which is in percentage point deviation from steady state, and net exports, which are in levels. The line with diamond markers on the top-left panel reports the path for the debt-to-GDP target.

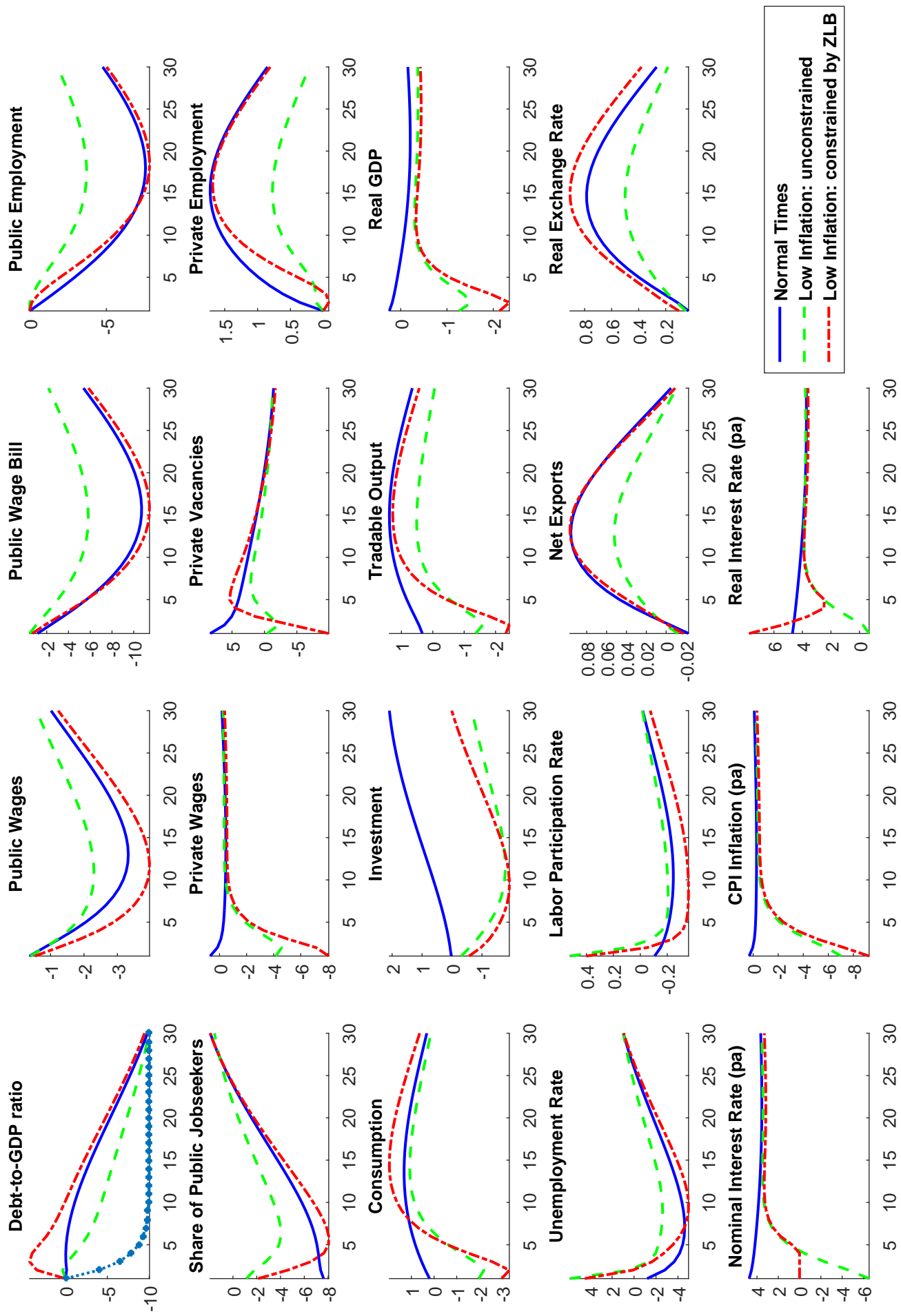


Figure 5: Normal Times vs. Low Inflation Environment: Public Wage Cuts

Responses are in percent deviations from steady state, except for interest rates and inflation, which are in annualized levels, the share of public jobseekers, which is in percentage point deviation from steady state, and net exports, which are in levels. The line with diamond markers on the top-left panel reports the path for the debt-to-GDP target.

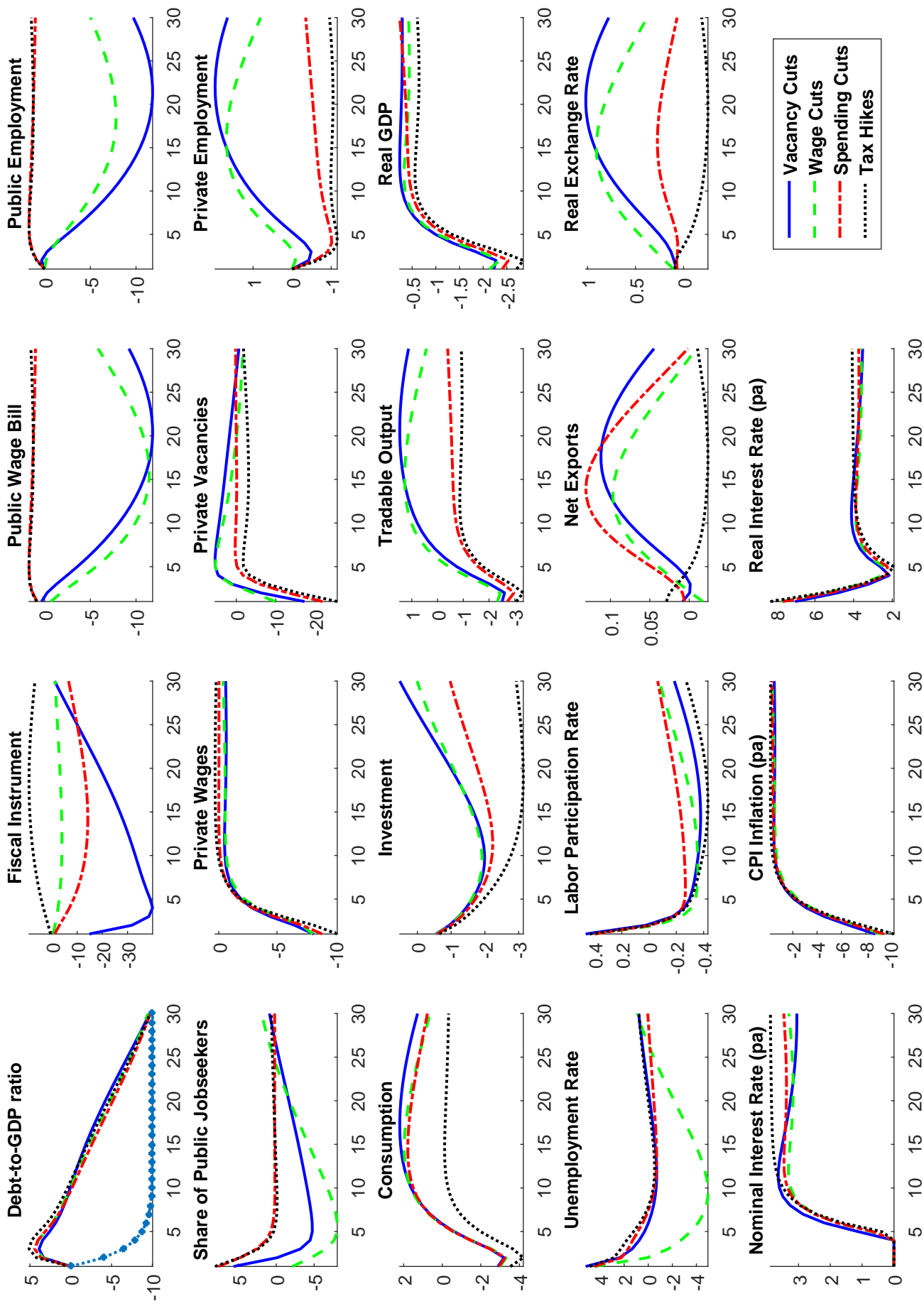


Figure 6: Low Inflation Environment: Comparison of Fiscal Instruments

Responses are in percent deviations from steady state, except for interest rates and inflation, which are in annualized levels, the share of public jobseekers, which is in percentage point deviation from steady state, and net exports, which are in levels. The line with diamond markers on the top-left panel reports the path for the debt-to-GDP target.

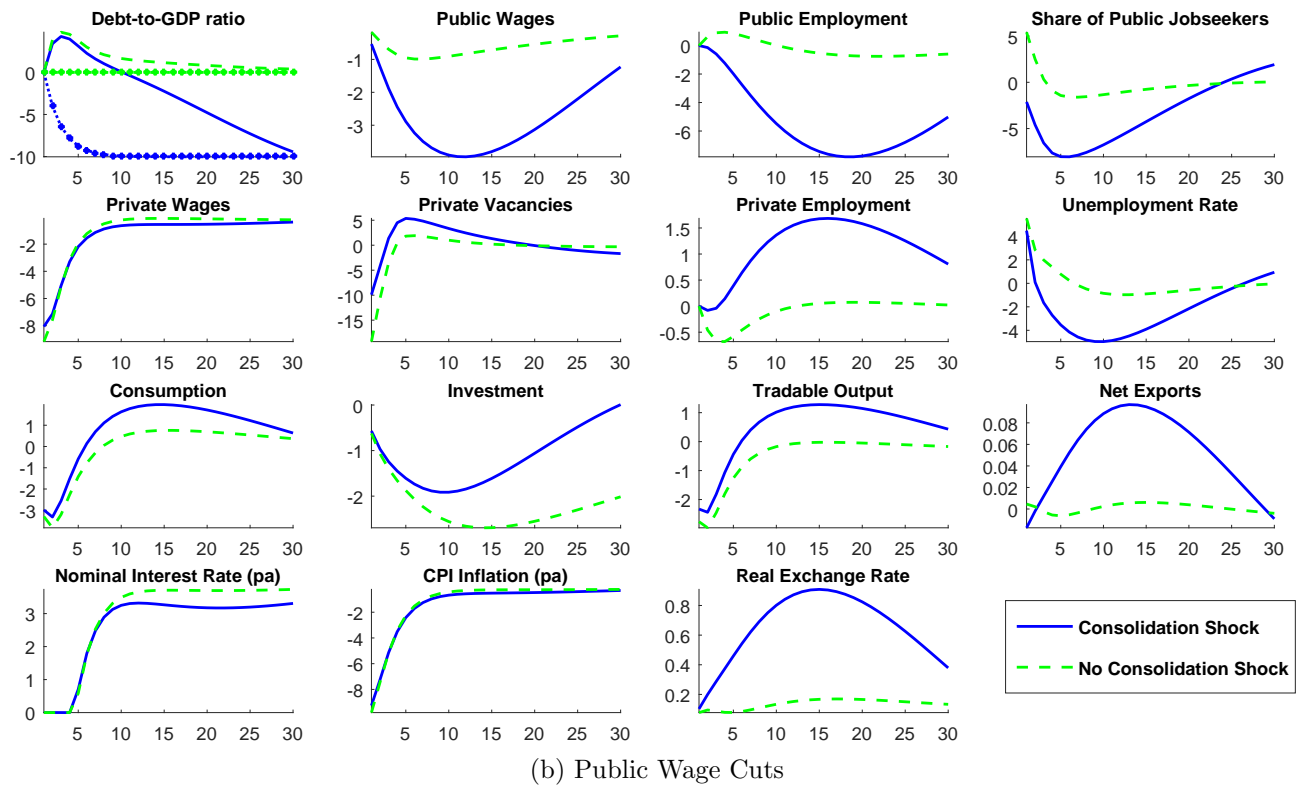
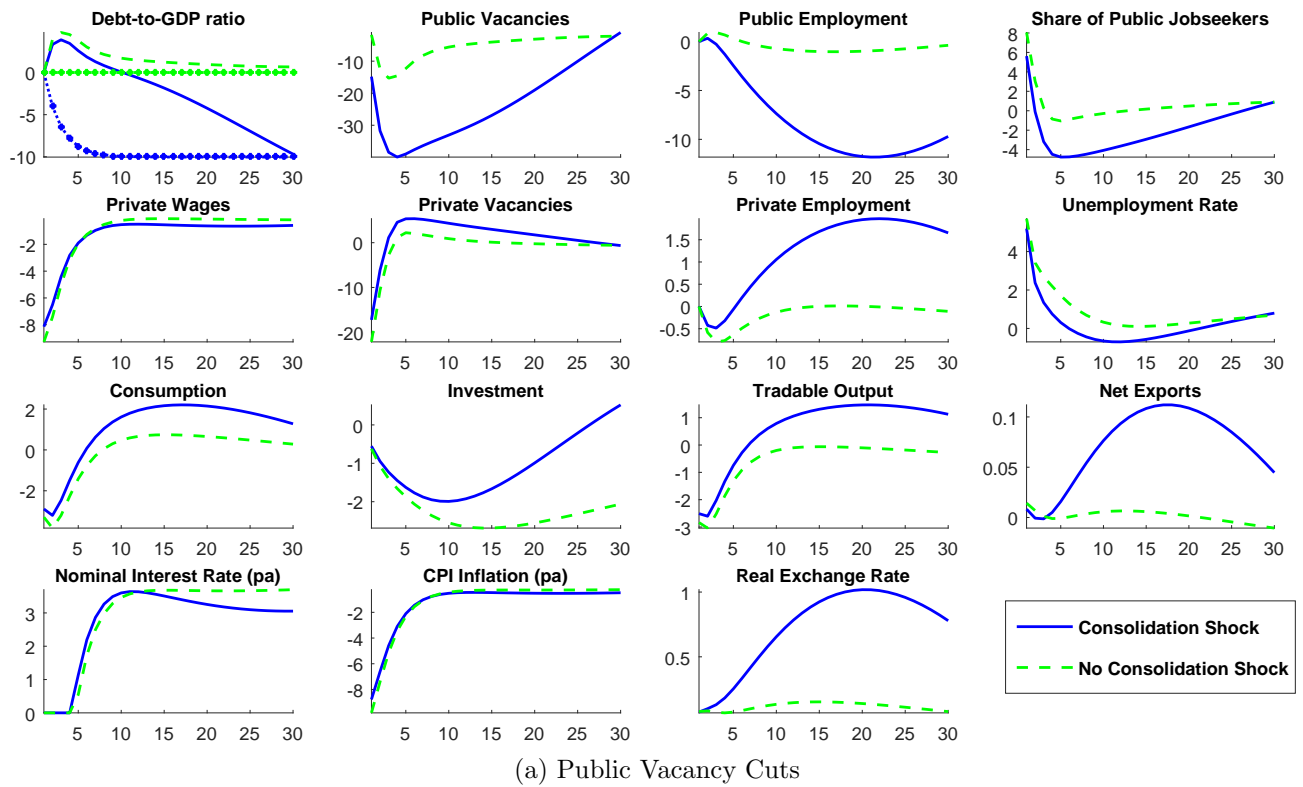
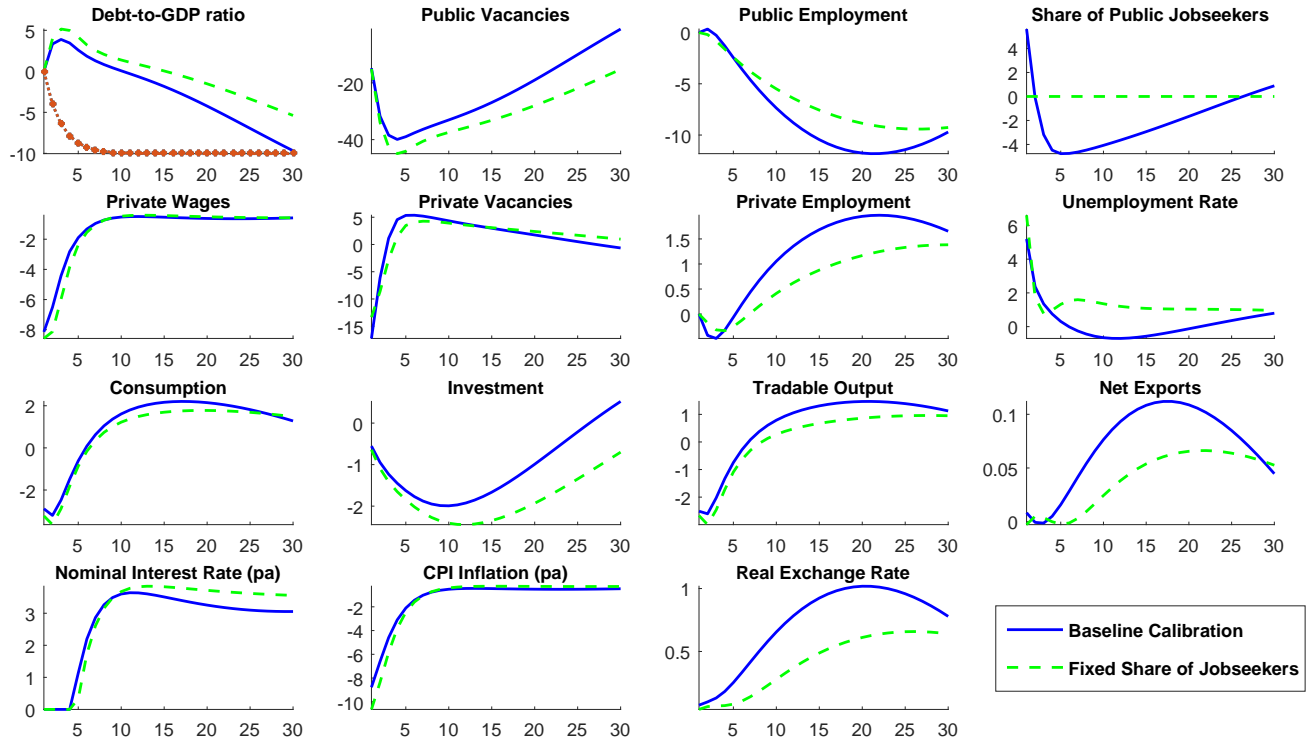
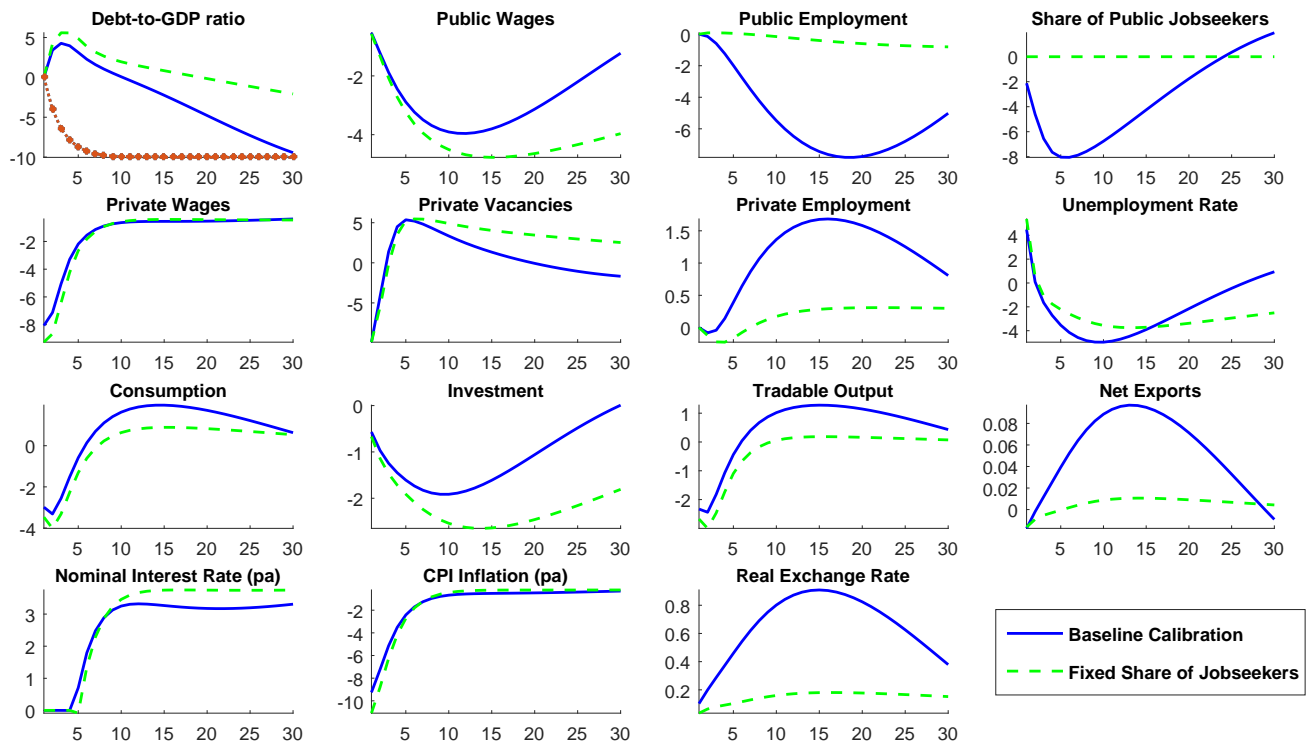


Figure 7: The Role of Consolidation at the Zero Lower Bound

Responses are in percent deviations from steady state, except for interest rates and inflation, which are in annualized levels, the share of public jobseekers, which is in percentage point deviation from steady state, and net exports, which are in levels. The lines with diamond markers on the top-left panels report the path for the debt-to-GDP target.



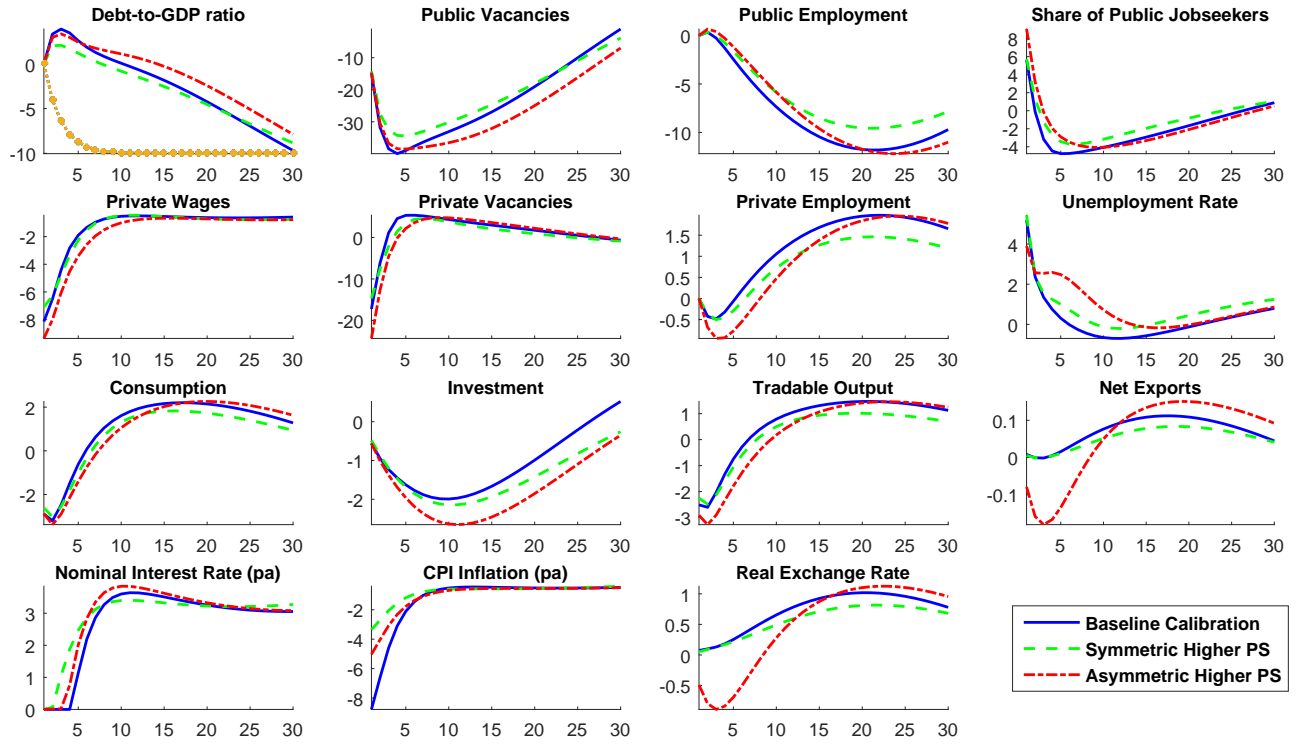
(a) Public Vacancy Cuts



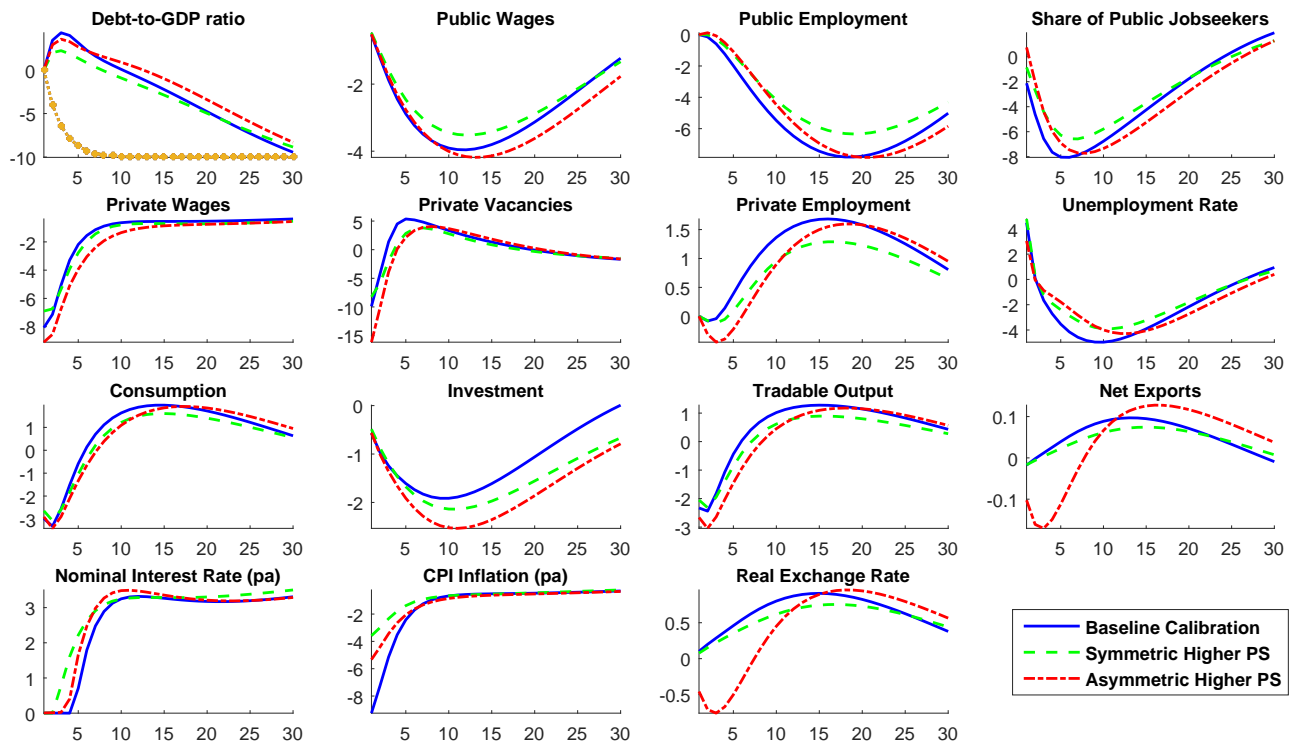
(b) Public Wage Cuts

Figure 8: Labor Market Rigidities at the Zero Lower Bound

Responses are in percent deviations from steady state, except for interest rates and inflation, which are in annualized levels, the share of public jobseekers, which is in percentage point deviation from steady state, and net exports, which are in levels. The line with diamond markers on the top-left panels reports the path for the debt-to-GDP target.



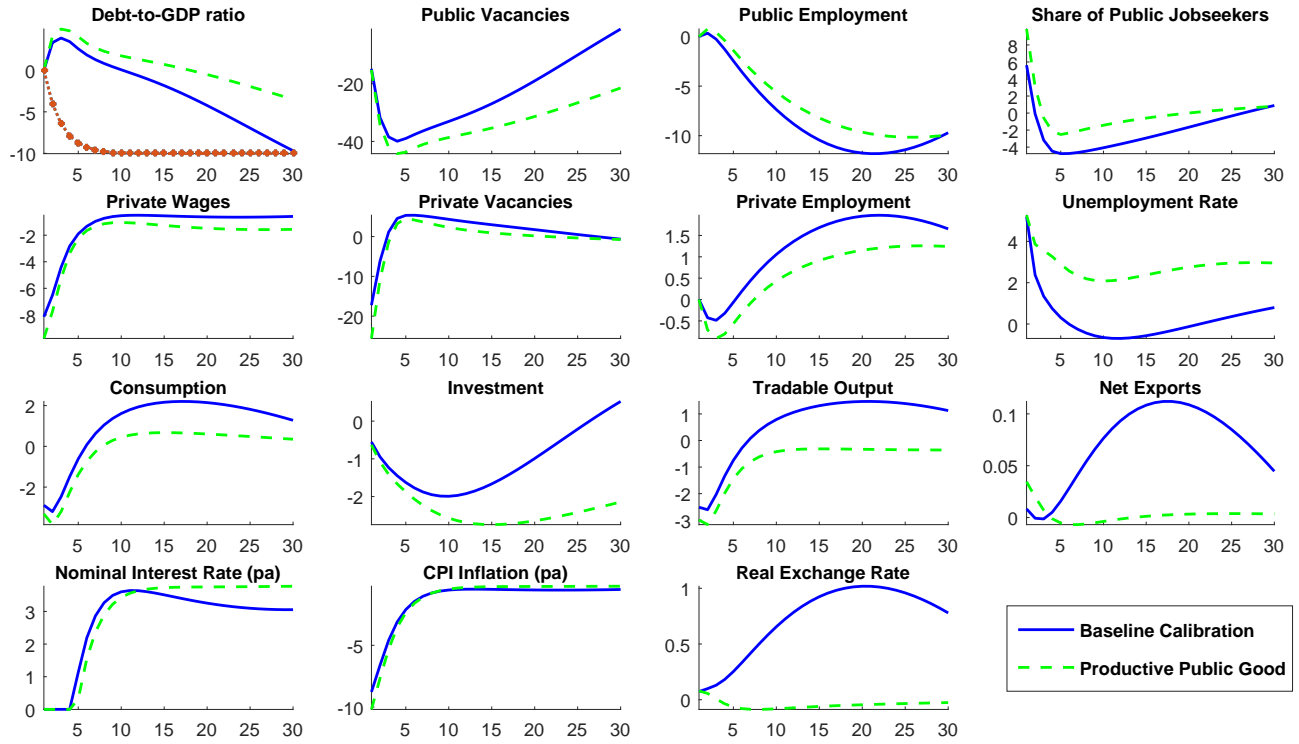
(a) Public Vacancy Cuts



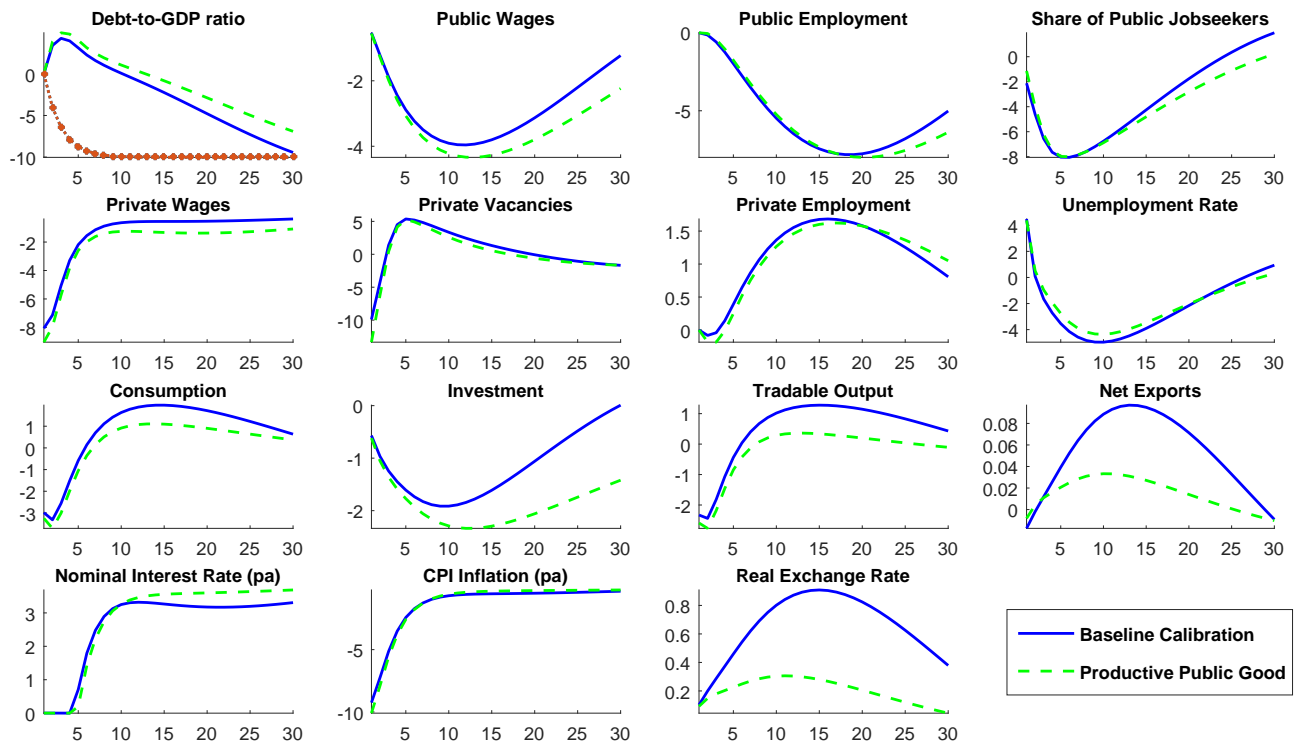
(b) Public Wage Cuts

Figure 9: Higher Price Stickiness (PS) at the Zero Lower Bound

Responses are in percent deviations from steady state, except for interest rates and inflation, which are in annualized levels, the share of public jobseekers, which is in percentage point deviation from steady state, and net exports, which are in levels. The line with diamond markers on the top-left panels reports the path for the debt-to-GDP target.



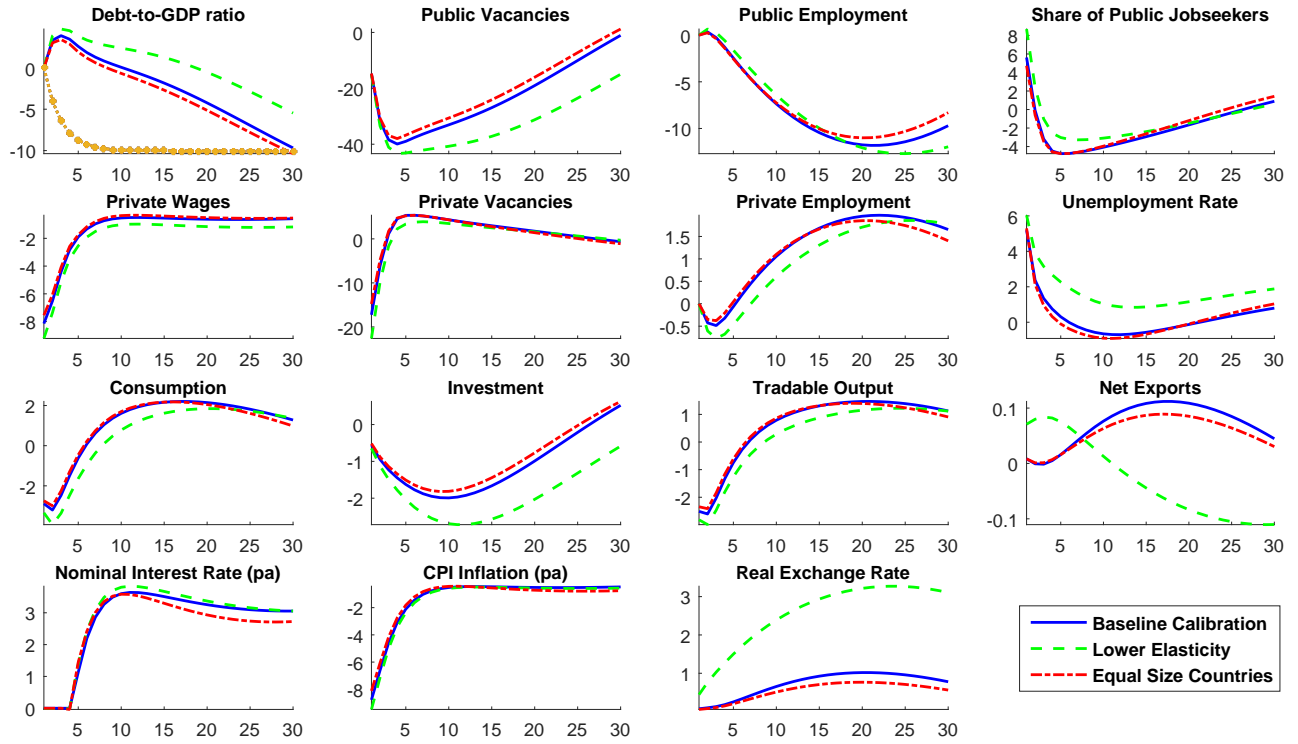
(a) Public Vacancy Cuts



(b) Public Wage Cuts

Figure 10: The Role of the Public Good at the Zero Lower Bound

Responses are in percent deviations from steady state, except for interest rates and inflation, which are in annualized levels, the share of public jobseekers, which is in percentage point deviation from steady state, and net exports, which are in levels. The line with diamond markers on the top-left panels reports the path for the debt-to-GDP target.



(a) Public Vacancy Cuts



(b) Public Wage Cuts

Figure 11: The Role of Openness at the Zero Lower Bound

Responses are in percent deviations from steady state, except for interest rates and inflation, which are in annualized levels, the share of public jobseekers, which is in percentage point deviation from steady state, and net exports, which are in levels. The line with diamond markers on the top-left panels reports the path for the debt-to-GDP target.