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

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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.

JEL classification: E32, E62

Keywords: fiscal consolidation, public wage bill, zero lower bound, unemployment

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1 Introduction

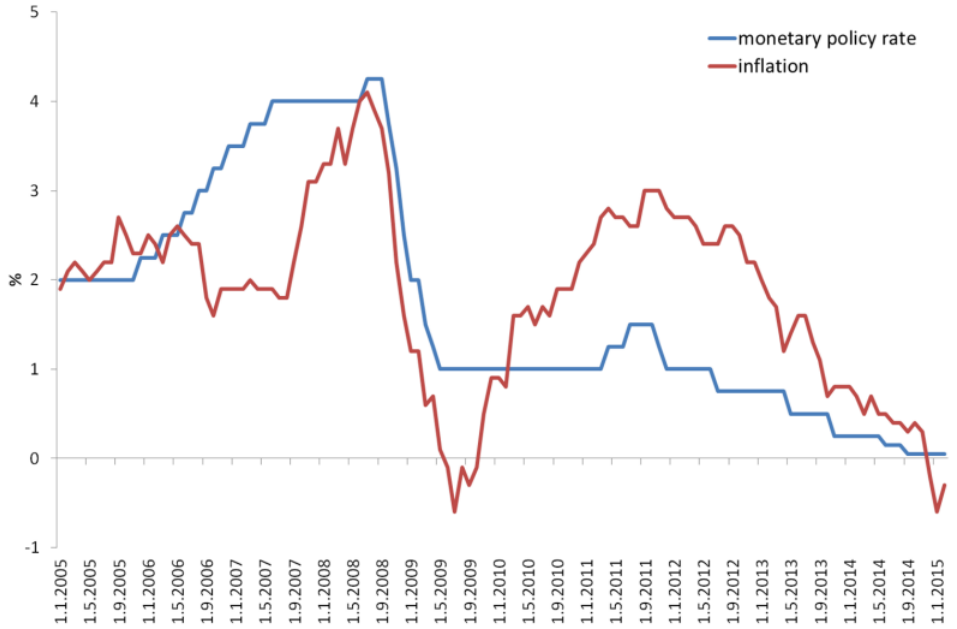
An important feature of the current economic conditions in the EU, which challenges the design and implementation of macroeconomic policy, is inflation uncertainty. With monetary policy constrained by the zero lower bound (ZLB henceforth), inflation in the euro area has remained below the ECB's medium-run 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 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

Figure 1: Inflation and Interest Rates in the Euro Area *Source: ECB, Eurostat*



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, Ilzetzki 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 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 2, the government wage bill before the crisis accounted, on average, for almost a quarter

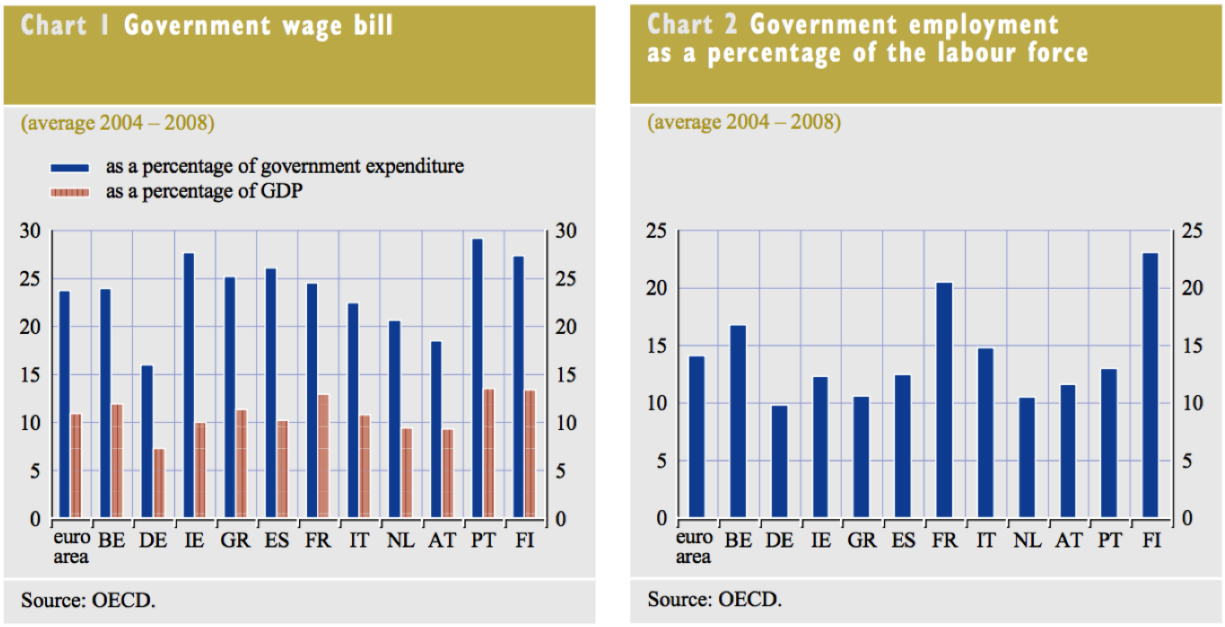


Figure 2: Public Wage Bill and Public Employment Before the Crisis *Source: Holm-Hadulla et al. (2010)*

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). Cuts in public sector wages have been widely implemented in countries like Ireland, Cyprus, Portugal (see Figure 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 par-

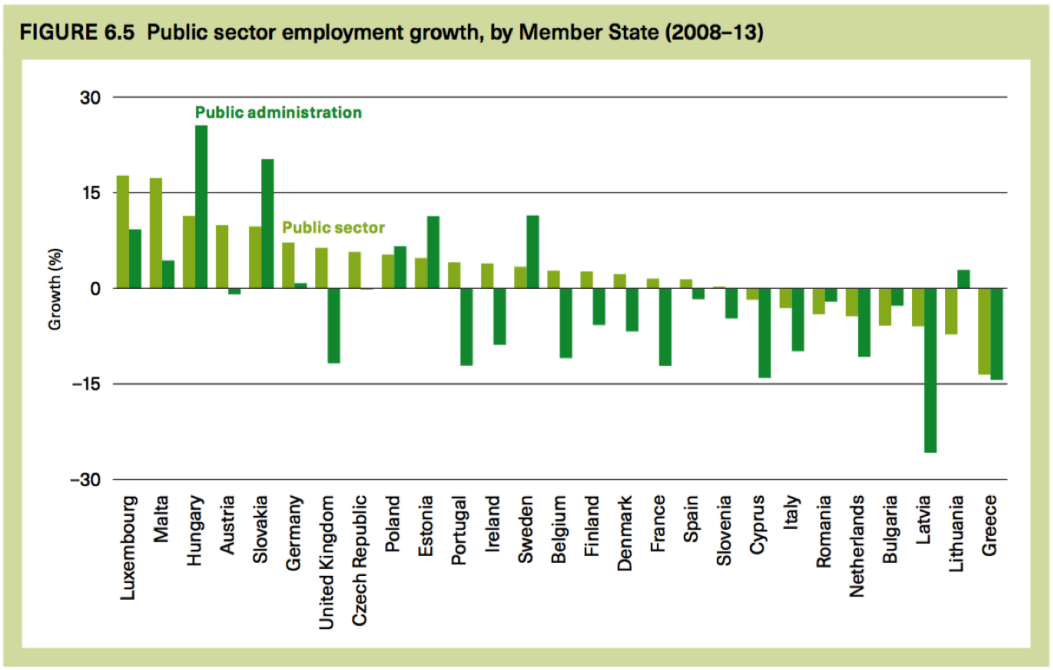


Figure 3: Changes in Public Sector Employment Following the Crisis *Source: Gama et al. (2015)*

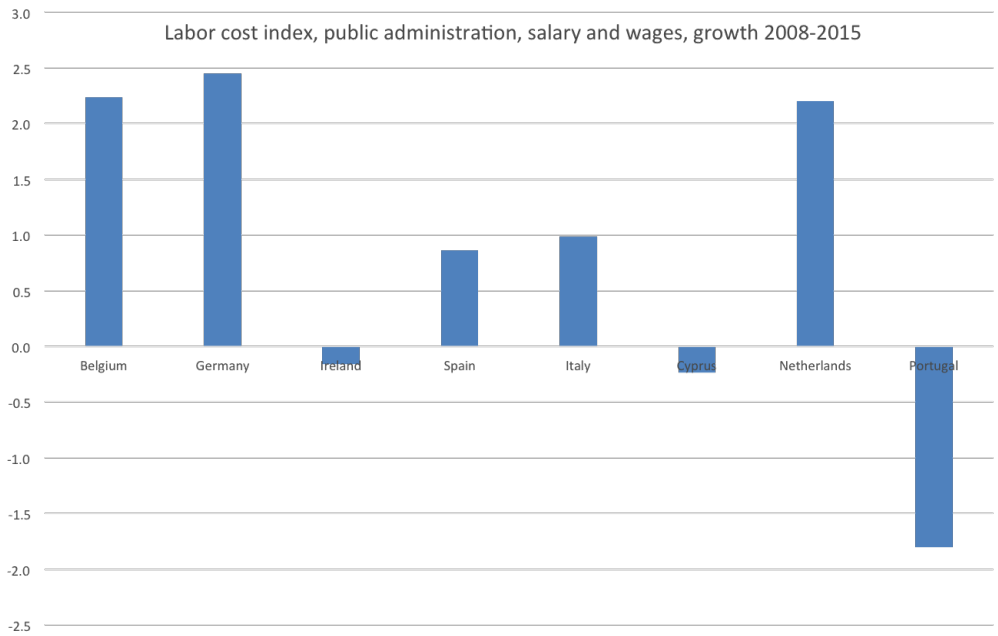


Figure 4: Changes in Public Sector Wages Following the Crisis *Source: Eurostat*

ticipation 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 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 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.

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

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.

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:

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

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

The new matches are given by:

$$m_t^j = \rho_m^j (v_t^j)^\alpha (u_t^j)^{1-\alpha} \tag{2}$$

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}:

$$\psi_t^{hj} \equiv \frac{m_t^j}{u_t^j} \tag{3}$$

$$\psi_t^{fj} \equiv \frac{m_t^j}{v_t^j} \tag{4}$$

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 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 $\Upsilon > 0$ andξ 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, l_t, so that:

$$n_t^p + n_t^g + u_t + l_t = 1 \tag{5}$$

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

[1]For simplicity, we will abstract from variable labour effort in the public sector.

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

$$k_{t+1}^p = \left[1 - \frac{\omega}{2}\left(\frac{i_t^p}{i_{t-1}^p} - 1\right)^2\right] i_t^p + (1-\delta^p)\, k_t^p \tag{6}$$

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

$$\begin{aligned}(1+\tau_c)\, c_t + i_t^p + b_{g,t+1} + e_t r_{f,t-1} b_{f,t} &\leq \left[r_t^p - \tau_k\left(r_t^p - \delta^p\right)\right] k_t^p + r_{t-1} b_{g,t} + e_t b_{f,t+1} \\ &+ (1-\tau_n)\left(w_t^p n_t^p x_t + w_t^g n_t^g\right) + \mathrm{b} u_t + \Pi_t^p + T_t\end{aligned} \tag{7}$$

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 in 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

$$r_t = \frac{R_t}{\pi_{t+1}} \tag{8}$$

where π_t is the gross consumer inflation rate.

Thus the problem of the household is to choosec_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, (7), the law of motion of employment in each sector, (1), the law of motion of capital, (6),

and the composition of the household, (5). The resulting first order conditions are provided in an online appendix. For use below, we define the marginal value of an additional private sector employee as:

$$\begin{aligned} V^H_{n^p t} &= \lambda_{ct} w^p_t x_t (1-\tau_n) - \Phi l^{\varphi}_t + (1-\sigma^p)\lambda_{n^p t} \\ &= \lambda_{ct} w^p_t x_t (1-\tau_n) - \Phi l^{\varphi}_t + (1-\sigma^p)\beta E_t(V^H_{n^p t+1}) \end{aligned} \tag{9}$$

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.

2.3 Production

2.3.1 Intermediate goods firms

Intermediate goods are produced with a Cobb-Douglas technology:

$$y^p_t = (A_t n^p_t x_t)^{1-\phi} (k^p_t)^{\phi} (y^g_t)^{\nu} \tag{10}$$

where A_t is a labour augmenting productivity factor, k^p_t and n^p_t 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^g_t, 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^p_t, is taken as given and the employment decision concerns the number of vacancies posted in the current period, v^p_t, so as

to employ the desired number of workers next period, n^p_{t+1}.[2] Firms also decide the amount of the private capital, k^p_t, to be rented from the household at rate r^p_t. The problem of an intermediate firm with n^p_t currently employed workers consists of choosing k^p_t and υ^p_t to maximize:

$$Q^p(n^p_t) = \max_{k^p_t, \upsilon^p_t} \left\{ p_{x,t}(A_t x_t n^p_t)^{1-\phi}(k^p_t)^{\phi}(y^g_t)^{\nu} - w^p_t n^p_t x_t - r^p_t k^p_t - \kappa \upsilon^p_t + E_t \left[\Lambda_{t,t+1} Q^p(n^p_{t+1}) \right] \right\} \tag{11}$$

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:

$$n^p_{t+1} = (1 - \sigma^p) n^p_t + \psi^{fp}_t \upsilon^p_t \tag{12}$$

The first-order conditions are:

$$p_{x,t} \phi \frac{y^p_t}{k^p_t} = r^p_t \tag{13}$$

$$\frac{\kappa}{\psi^{fp}_t} = E_t \Lambda_{t,t+1} [p_{x,t+1}(1-\phi)\frac{y^p_{t+1}}{n^p_{t+1}} - w^p_{t+1} x_{t+1} + (1-\sigma^p)\frac{\kappa}{\psi^{fp}_{t+1}}] \tag{14}$$

According to (13) and (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.

[2]Firms 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.

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

$$V^F_{n^p t} \equiv \frac{\partial Q^p(n^p_t)}{\partial n^p_t} = p_{x,t}(1-\phi)\frac{y^p_t}{n^p_t} - w^p_t x_t + \frac{(1-\sigma^p)\kappa}{\psi^{fp}_t} \tag{15}$$

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_{it} be the quantity of output sold by retailer i. The final consumption good can be expressed as:

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

where $\epsilon > 1$ is the constant elasticity of demand for 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

$$y_{i,t} = \left(\frac{P_{i,h,t}}{P_{h,t}}\right)^{-\epsilon} y^r_t \tag{16}$$

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

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

subject to the demand schedule (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

$$\frac{p^*_{h,t}}{p_{h,t}} = \frac{\epsilon}{(\epsilon-1)}\frac{\mathcal{N}_t}{\mathcal{D}_t} \tag{17}$$

where

$$\mathcal{N}_t = p_{x,t}y^r_t + \beta\chi\Lambda_{t,t+1}\left(\pi_{h,t+1}\right)^{\epsilon}\mathcal{N}_{t+1} \tag{18}$$

$$\mathcal{D}_t = p_{h,t}y^r_t + \beta\chi\Lambda_{t,t+1}\left(\pi_{h,t+1}\right)^{\epsilon-1}\mathcal{D}_{t+1} \tag{19}$$

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

$$P_{h,t} = \chi\left(P_{h,t-1}\right)^{\epsilon-1} + (1-\chi)\left(P^*_{h,t}\right)^{1-\epsilon} \tag{20}$$

Retail goods are sold domestically and abroad. In aggregate,

$$y^r_t = y_{h,t} + y^\star_{h,t} \tag{21}$$

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

$$p_{h,t} = e_t p^\star_{h,t} \tag{22}$$

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

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

where $\overline{\tau} \equiv (1-n)/n$ 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 $y_t - p_{h,t} y_{h,t} - p_{f,t} \overline{\tau} y_{f,t}$ each period. Solving for the optimal demand functions gives

$$y_{h,t} = \varpi (p_{h,t})^{-\gamma} y_t \tag{23}$$

$$y_{f,t} = (1-\varpi) (p_{f,t})^{-\gamma} \frac{n}{1-n} y_t \tag{24}$$

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

$$P_t = \varpi (P_{h,t})^{1-\gamma} + (1-\varpi) (P_{f,t})^{1-\gamma} \tag{25}$$

2.4 Government

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

$$y_t^g = (A_t n_t^g)^{1-\mu} (\bar{k^g})^{\mu} \tag{26}$$

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:

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

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:

$$b_{g,t} + DF_t = \frac{b_{g,t+1}}{r_t} \tag{27}$$

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 it's 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):

$$\Psi_t = \Psi^{(1-\beta_{\Psi 0})} \ \Psi_{t-1}^{\beta_{\Psi 0}} \left[\left(\frac{b_t}{b_t^*} \right)^{\beta_{\Psi 1}} \ \left(\frac{\Delta b_{t+1}}{\Delta b_{t+1}^*} \right)^{\beta_{\Psi 2}} \right]^{(1-\beta_{\Psi 0})} \tag{28}$$

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

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

where ε_t^b is a white noise shock representing a fiscal consolidation.[3]

2.5 Closing the model

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:

$$R_t^\star = \text{Max}\left\{1, \rho R_{t-1}^\star + (1-\rho)\,\rho_\pi \tilde{\pi}_t\right\} \tag{29}$$

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

$$\frac{\pi_{h,t}}{\pi_t} = \frac{p_{h,t}}{p_{h,t-1}} \tag{30}$$

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

$$\frac{e_t}{e_{t-1}} = \frac{\pi_t^\star}{\pi_t} \tag{31}$$

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:

$$r_{f,t} = r_t^\star exp\left\{\Gamma \bar{\tau} e_t \frac{b_{f,t+1}}{rgdp_t}\right\} \tag{32}$$

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

[3]Notice 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.

2.5.2 Resource constraint

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

$$y_t = c_t + i_t^p + \kappa \upsilon_t^p + \kappa \upsilon_t^g \tag{33}$$

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

$$rgdp_t = p_{x,t} y_t^p + w_t^g n_t^g \tag{34}$$

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

$$e_t \left(r_{f,t-1} b_{f,t} - b_{f,t+1} \right) = nx_t \tag{35}$$

and where nx_t are net exports defined as:

$$nx_t = p_{h,t} y_{h,t}^{\star} - p_{f,t} \overline{\tau} y_{f,t} \tag{36}$$

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:

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

where $V^H_{n^p t}$ and $V^F_{n^p t}$ have been defined above. The optimization problem leads to the following solution for w^p_t:

$$w^p_t x_t = (1-\vartheta) p_{x,t}(1-\phi)\frac{y^p_t}{n^p_t} + \frac{\vartheta}{(1-\tau_n)\lambda_{c,t}}\Phi l^{\varphi}_t \tag{37}$$

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.[4]

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. When considering the ZLB, which is a non-linear constraint, we use the Occbin toolkit provided by Guerrieri and Iacoviello (2015).

Table 1 shows some of the key parameters and steady-state values targeted in our calibration. Full details of the calibration strategy are provided in the online appendix.

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, υ^g and w^g. We then consider the same shock in a low inflation environment. Following the literature, this environment is induced by assuming a positive shock to the household's discount rate, β, which causes inflation to fall, driving the nominal interest rate to its lower bound.[5]

[4] See the online appendix for the full derivation.

[5] We assume that the shock decays with auto-regressive parameter 0.5.

Table 1: Calibration of Parameters and Steady-State Values

Parameter/Variable	Description	Value
Preferences:		
β	Household discount factor	0.99
η	Intertemporal Elasticity of Substitution	1
φ	Inverse Frisch Elasticity of Labour	4
Labour Market:		
$(1-l)$	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%
Production:		
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
Policy Parameters:		
ρ_π	Taylor-rule inflation targeting parameter	2.5
ρ_1, ρ_2	Debt-target law of motion	0.85, 0.0001
b	Steady-state debt-to-GDP ratios	50%

To further investigate the results, we also show the role of the different mechnisms 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.

3.1 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.

3.1.1 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 Figure 5. We see that the cut in public vacancies causes a fall in public employment, and hence both the public wage bill and public output fall with a lag. Eventually, some of the jobseekers leaving the public sector move sluggishly towards the private sector, causing 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. This, plus the fall in private wages, crowds out private investment and leads to a reduction in private capital. Yet, private output increases due to the availability of cheaper labour, 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.

3.1.2 Price-based Measures: Public Wage Cuts

Figure 6 depicts the case in which fiscal consolidation is achieved through cuts in the public wage. The public wage cut causes a significant fall in the fraction of jobseekers in the public sector. As before, this causes a movement of jobseekers towards the private sector, and boosts private employment. In the case of wage cuts, 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. Due to the fall in public wages and the increase in demand in the private sector, unemployed shift their supply of labour towards the private sector. Hence, public employment is also decreasing, as in the case of vacancy cuts, but

for different reasons. Differently from before, the adjustment is less sluggish, as labour force participation also rises, and private wages are reduced soon after the public wage cut. As a result, private vacancies increase on impact and this leads to increases in both private employment and capital. 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. It is also important to note that the consolidation is much more successful in the case of public wage cuts, with the debt-to-GDP ratio falling to its new target after 12 quarters. Total GDP falls also in the case of public wage cuts but less persistently relative to the case of vacancy cuts.

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 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.

3.2 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.

3.2.1 Quantity-based Measures: Public Vacancy Cuts

Figure 7 shows the impulse response functions when public vacancies are the active consolidation instrument in a low inflation environment. For comparabilty purposes,

the blue solid line depicts 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 red line depicts the responses in a low inflation environment induced by the shock to the household's discount rate, when imposing the ZLB constraint. Here we see that the nominal and the real interest rates fall sharply. Yet, the gross nominal rate reaches its lower bound and cannot fall more than 1% in deviations from its steady state value since in that case it hits the ZLB. With the negative demand shock, we observe a fall in private consumption and an increase in private investment compared to the baseline case. The latter leads to increases in private capital. However, despite the rise in capital, the demand contraction leads to a fall in private labour demand and, hence, private employment. The negative wealth effect is so strong that agents increase further their participation, leading to a considerable increase in unemployment. 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.

In contrast, in the absence of a ZLB constraint, depicted by the green dashed lines, the economic effects of the shock would be much more moderate. In such a case, since the nominal rate can sufficiently offset the fall in inflation, the real rate falls more and mitigates the contraction in the private sector, actually expanding private investment. In this scenario, in fact, the debt-to-GDP target is reached almost immediately due to the significant fall in the interest rate and after the first two periods the consolidation is reversed.[6]

[6]In experiments we do not present here for economy of space we show that without the consolidation shock, this economy would suffer very little from the discount shock and if anything the consolidation intensifies the effects of the shock by crowding out private employment since it is reversed.

3.2.2 Price-based Measures: Public Wage Cuts

Figure 8 plots impulse responses for the case of public wage cuts. Again, the blue continuous lines depict the baseline responses presented in subsection 3.1.2, red lines show responses when the ZLB constraint is binding and the economy is hit by a discount rate shock and the green lines show the unrestricted responses in the presence of the deflationary shock. Responses look very similar with the responses of the vacancy cut case: When the interest rate is not bounded by the zero constraint, its fall allows the government to achieve consolidation very fast and actually after two periods 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 lower value of the real rate. On the other hand, public output expands so much that total real GDP increases after the first 4 quarters.[7]

Moving to the more interesting case of the equilibrium in which the ZLB constraint is imposed, we see that the fall in the nominal interest rate is not enough to bring inflation back to equilibrium. The fall in the real rate expands investment more than in the baseline case, but consumption contracts significantly due to the demand shock. Firms can hire workers for a lower wage as in the benchmark case, but demand is contracted. Private vacancies do not increase that much on impact, leading to a fall in private employment and tax revenues, making the consolidation much more difficult to achieve in this environment.

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

[7]Again, in experiments we do not present here for economy of space we demonstrate that the economy can recover even faster from the deflationary shock in the absence of the consolidation shock.

negative effect on private output, hence they are no longer obviously preferable to vacancy cuts.

3.3 Sensitivity Analysis I: Fiscal and Monetary Policy

3.3.1 The Role of the Consolidation Shock

To understand better how consolidation affects the economy at the ZLB in this subsection we analyse the dynamics of the economy at the ZLB when consolidation is imposed (continuous lines) and when it is not (crossed lines) in Figures 9 and 10 for vacancy cuts and wage cuts, respectively.

For the case of vacancy cuts, the presence or not 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 (28), the public vacancies react even without the consolidation shock. Yet, apart from the obvious effects the consolidation has on public vacancies and the public wage bill and its immediate effect on public employment and output, the presence or not of a consolidation shock changes very little the dynamics of the private sector. Private employment seems to react a bit faster in the presence of a consolidation shock, but this differentiated response does not seem to affect significantly the dynamics of the private-sector economy.

The picture is, however, different when we look at public wage cuts in Figure 10. The consolidation in this case does help the faster recovery of the private sector by leading to stronger positive reactions of investment and private employment and increases in private vacancies. As a result, private output falls less under this scenario, making the recovery of the economy following the combined shocks faster.

3.3.2 The Speed of Adjustment during Consolidation

In Figures 11 and 12 we examine how our conclusions would change if we considered a faster speed of adjustment for the fiscal consolidations in the case of vacancy cuts and wage cuts, respectively. 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 (especially for vacancy cuts). Nonetheless, faster debt adjustment seems to imply that for both fiscal instruments the recovery of the private sector is somewhat faster. Since the debt consolidation shocks can undo the negative effects of the deflationary shock in the economy, requiring the instruments to adjust faster implies a stronger reaction of private employment, and hence smaller detrimental effects of the deflationary shock on private output. This of course comes at the cost of a higher public output and wage bill adjustment that results in a more negative response of real GDP.

3.3.3 The Strength of Monetary Policy

In Figures 13 and 14 we examine the sensitivity of our results to the conduct of monetary policy at the union level. The circled lines depict responses of the economy when we assume a more lax monetary policy (ρ_π=1,1), while continuous lines depict responses in our baseline model. Responses for the two instruments differ significantly in this case. For price-based measures (public wage cuts) implementing debt consolidation when the ZLB constraint is binding in such a monetary policy environment implies that the economy will suffer from deflation and lower demand for a longer period. As a result, the consolidation has to be more pronounced, leading to significant falls in both private output and total GDP. On the other hand, in the case of quantity-based measures (vacancy cuts) deflation does not persist and as a result the differences between the case of stricter or more lax monetary policy are minimal. This is a crucial difference between the two consolidation instruments:

wage cuts prolong the deflationary periods, while vacancy cuts as a quantity-based measure have little effects on inflation and their efficacy is independent of the stance of monetary policy.

3.3.4 Independent Monetary Policy

Finally, in Figures 15 and 16 we compare the responses of the economy to a fiscal consolidation when the ZLB binds after a discount factor shock in the case of independent monetary policy (dashed lines), using a closed economy setup, and common monetary policy, using the previous monetary union setup (continues lines). Confirming the results of Erceg and Linde (2013) about spending cuts, a fiscal consolidation in a monetary union is much more detrimental relative to the case of independent monetary policy in a closed economy. This is evident from the responses of private output, real GDP and the unemployment rate both for public vacancy cuts and public wage cuts. 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. Interestingly, when we compare the closed and open economy versions of our baseline model (without the discount factor shock), we can see in Figures 17 and 18 that the effects of public vacancy cuts are more adverse, at least for five quarters, with independent monetary policy (closed economy).

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.

3.4.1 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 19 and 20 depict the responses of the baseline model with continuous lines, while circled lines represent the model economy responses when we assume a higher productivity of the public good in private production (we set ν= 0.15 in this experiment). 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.

3.4.2 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 21 and 22 where we plot the responses of the economy when we increase the adjustment cost parameter from 0.5 to 3. 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.

3.4.3 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 23 and 24 we compare the responses of the model economy we shut the participation margin (circled lines) with the baseline responses (continuous lines) for vacancy and wage cuts, respectively.

When agents are not allowed to adjust their participation, private vacancies react less to the shock relative to the case of endogenous participation and, as a result, private employment reacts more negatively to the shock, reducing the reaction of private output and making it more difficult for the fiscal authorities to achieve the debt target.

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 rise in the 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. These negative effects are mitigated when monetary policy is conducted independently (in a closed economy setup). The differences between the two instruments appear less pronounced in a low inflation environment; yet public wage cuts lead to a reduction in the long-run unemployment rate, 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. We know, for example, that the reallocation of workers from the public to the private sector is key for our results, as is the assumption of flexible wages. In future versions of this paper we plan to extend our sensitivity analysis to these and other primitives of our model.

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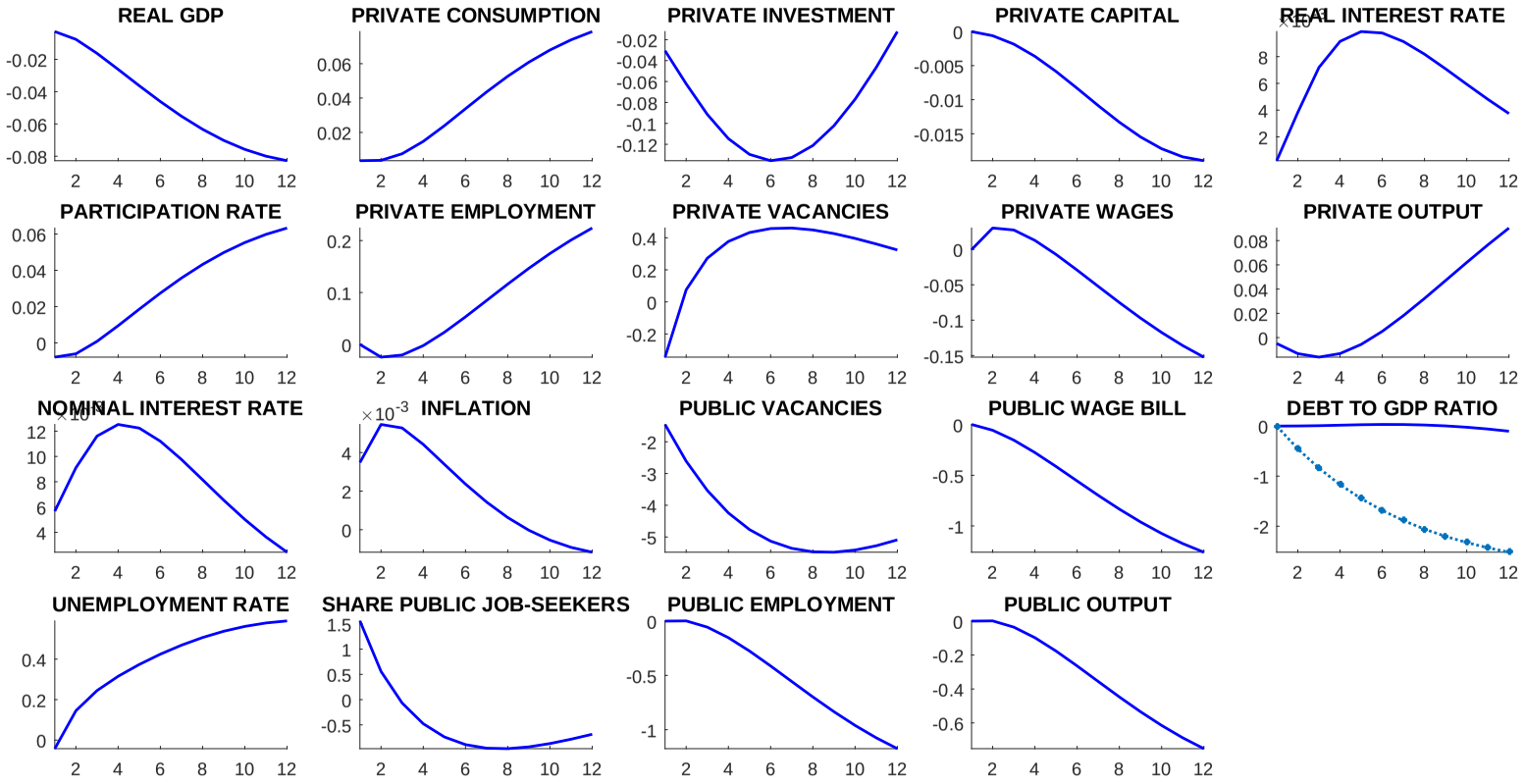

Figure 5: Fiscal Consolidation with Public Vacancy Cuts

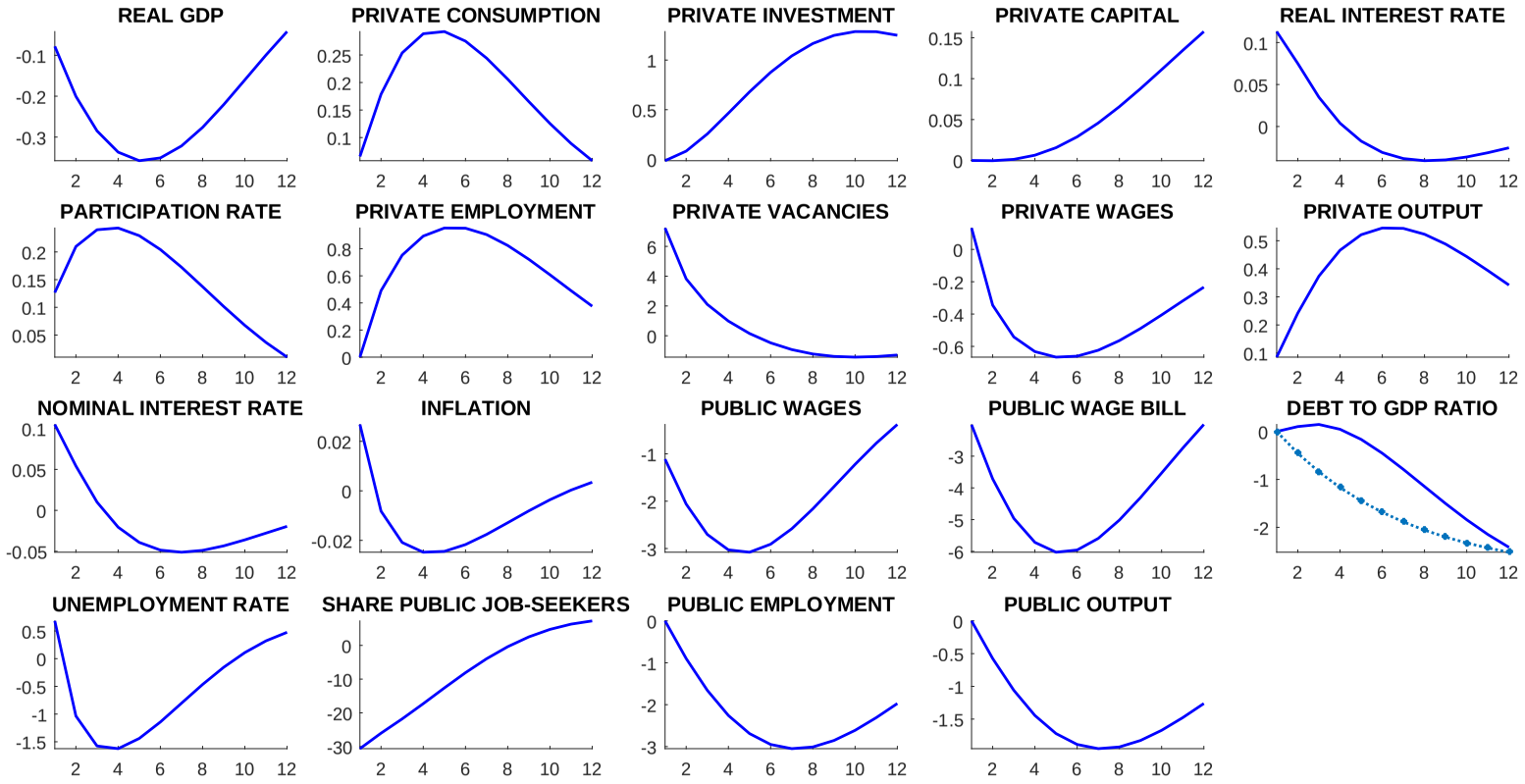

Figure 6: Fiscal Consolidation with Public Wage Cuts

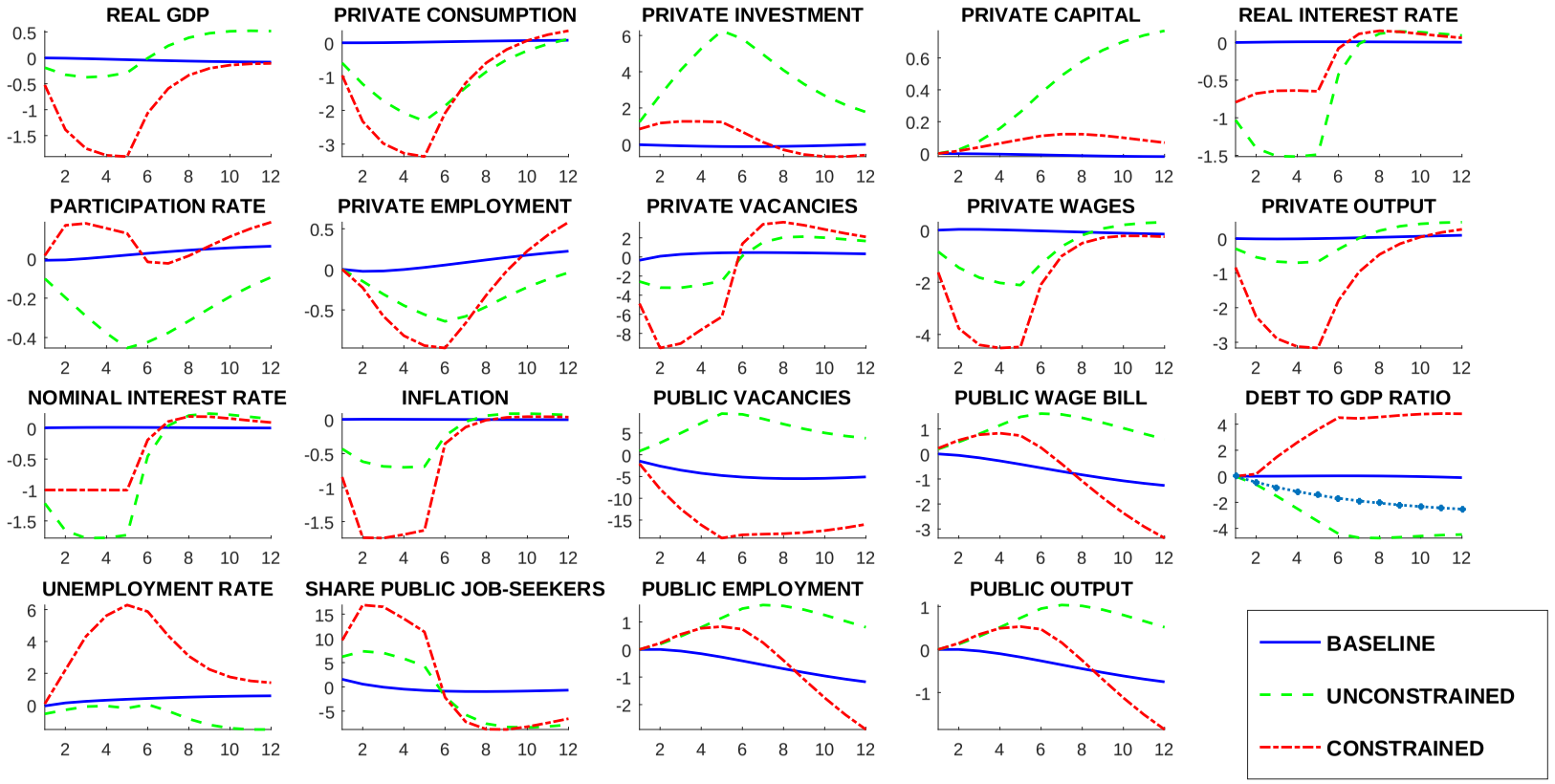

Figure 7: Fiscal Consolidation in a Low Inflation Environment: Public Vacancy Cuts

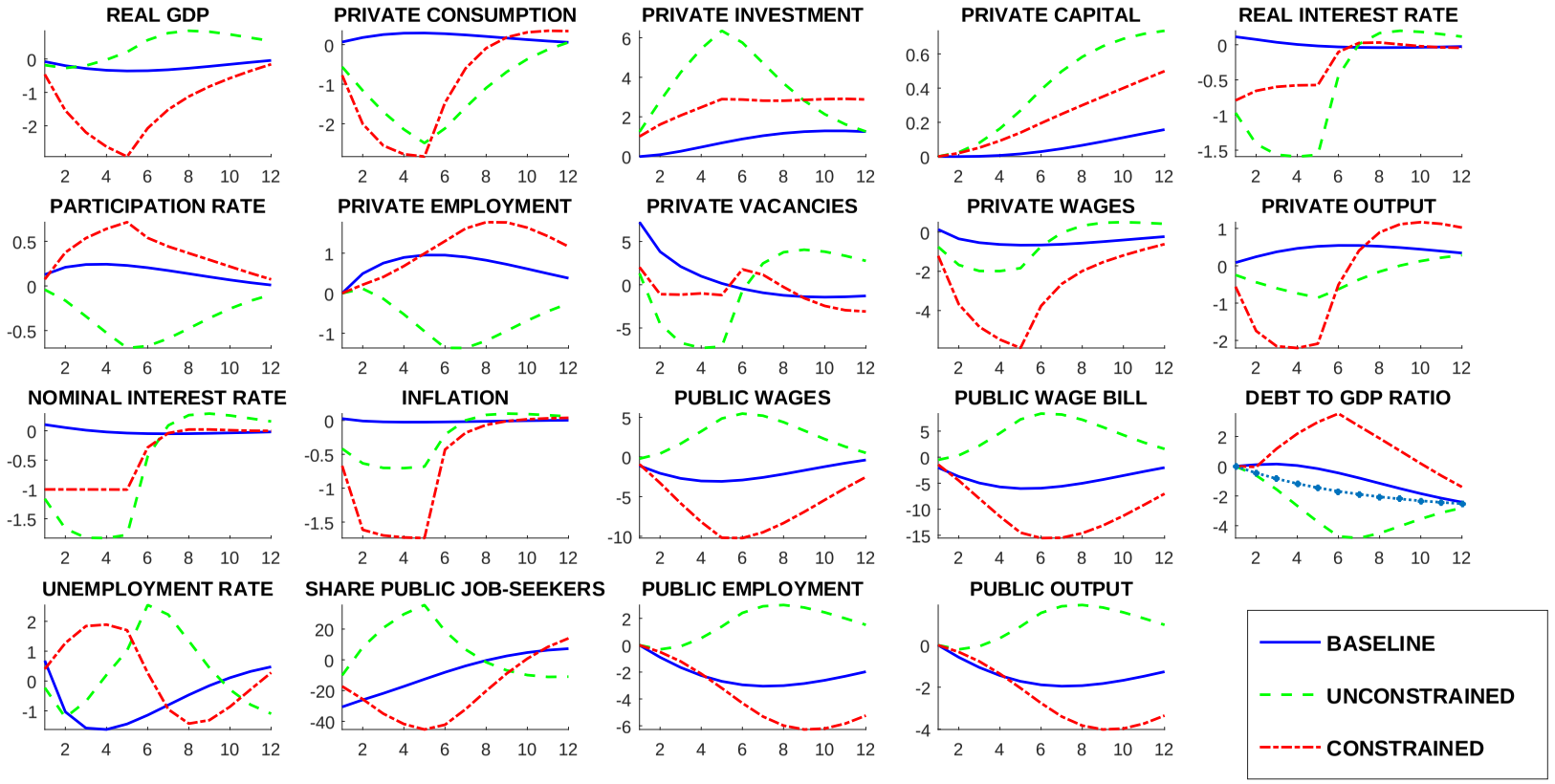

Figure 8: Fiscal Consolidation in a Low Inflation Environment: Public Wage Cuts

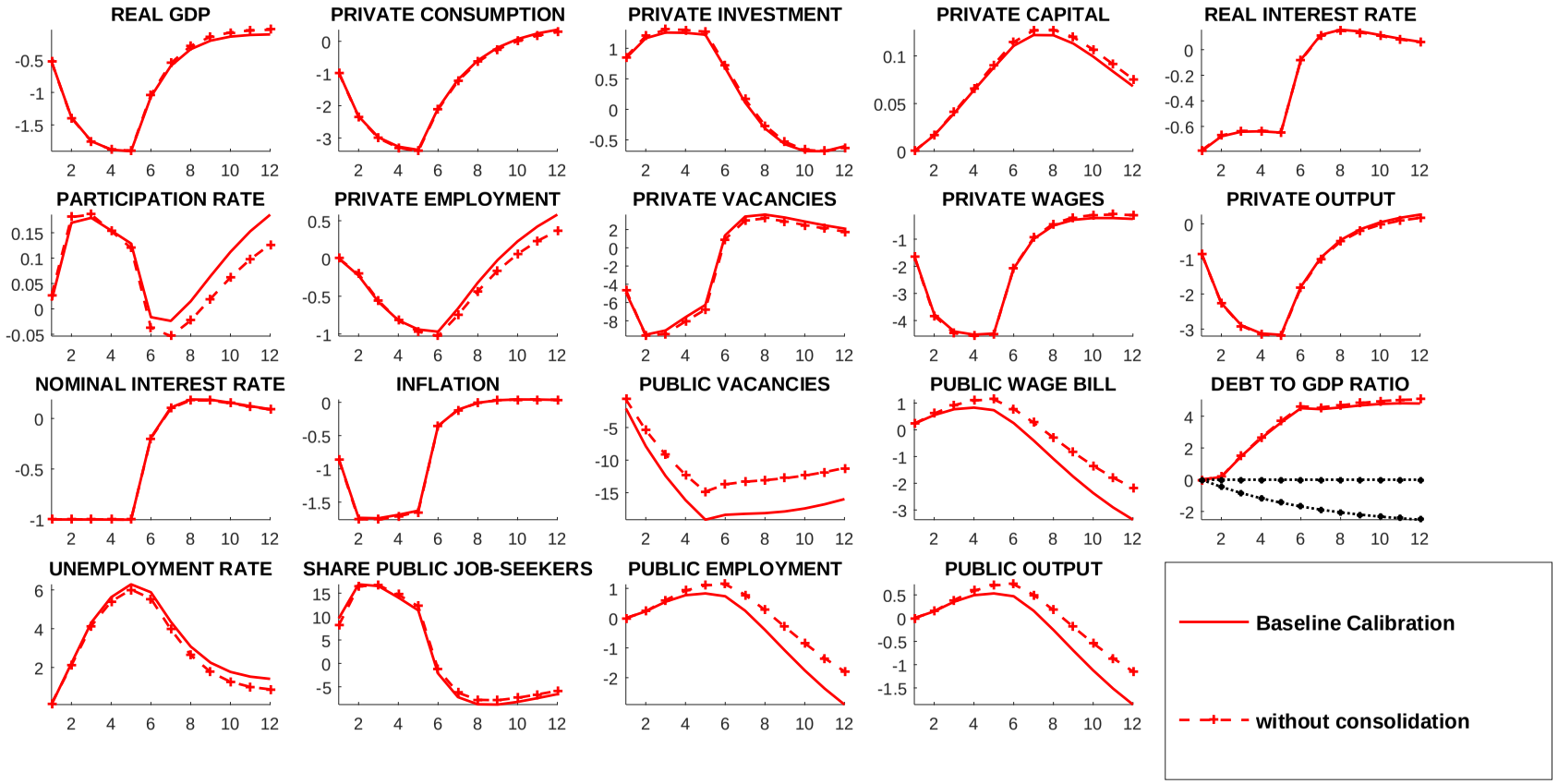

Figure 9: Public Vacancy Cuts in a Low Inflation Environment: the Role of Consolidation

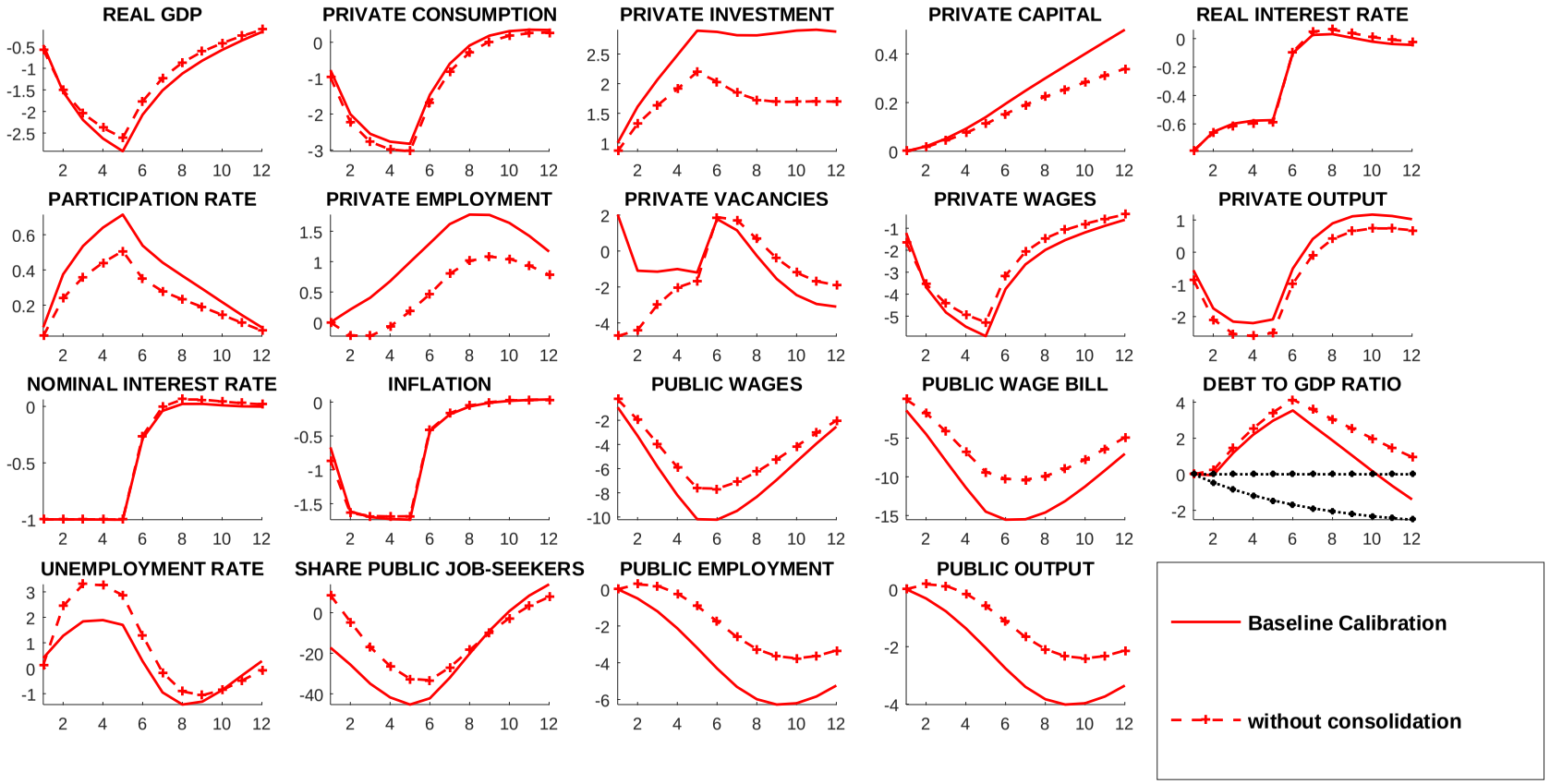

Figure 10: Public Wage Cuts in a Low Inflation Environment: the Role of Consolidation

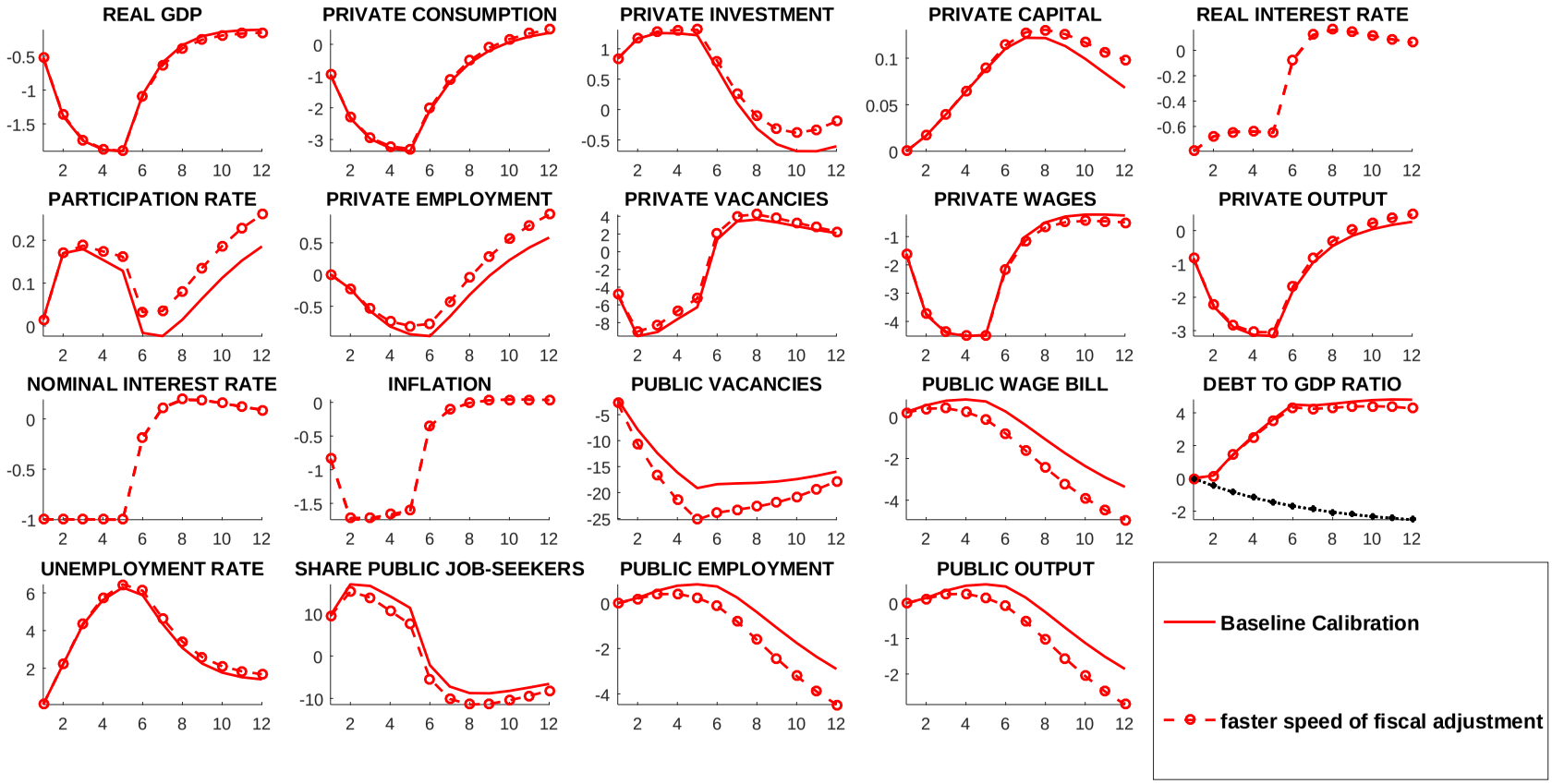

Figure 11: Public Vacancy Cuts in a Low Inflation Environment: the Speed of Consolidation

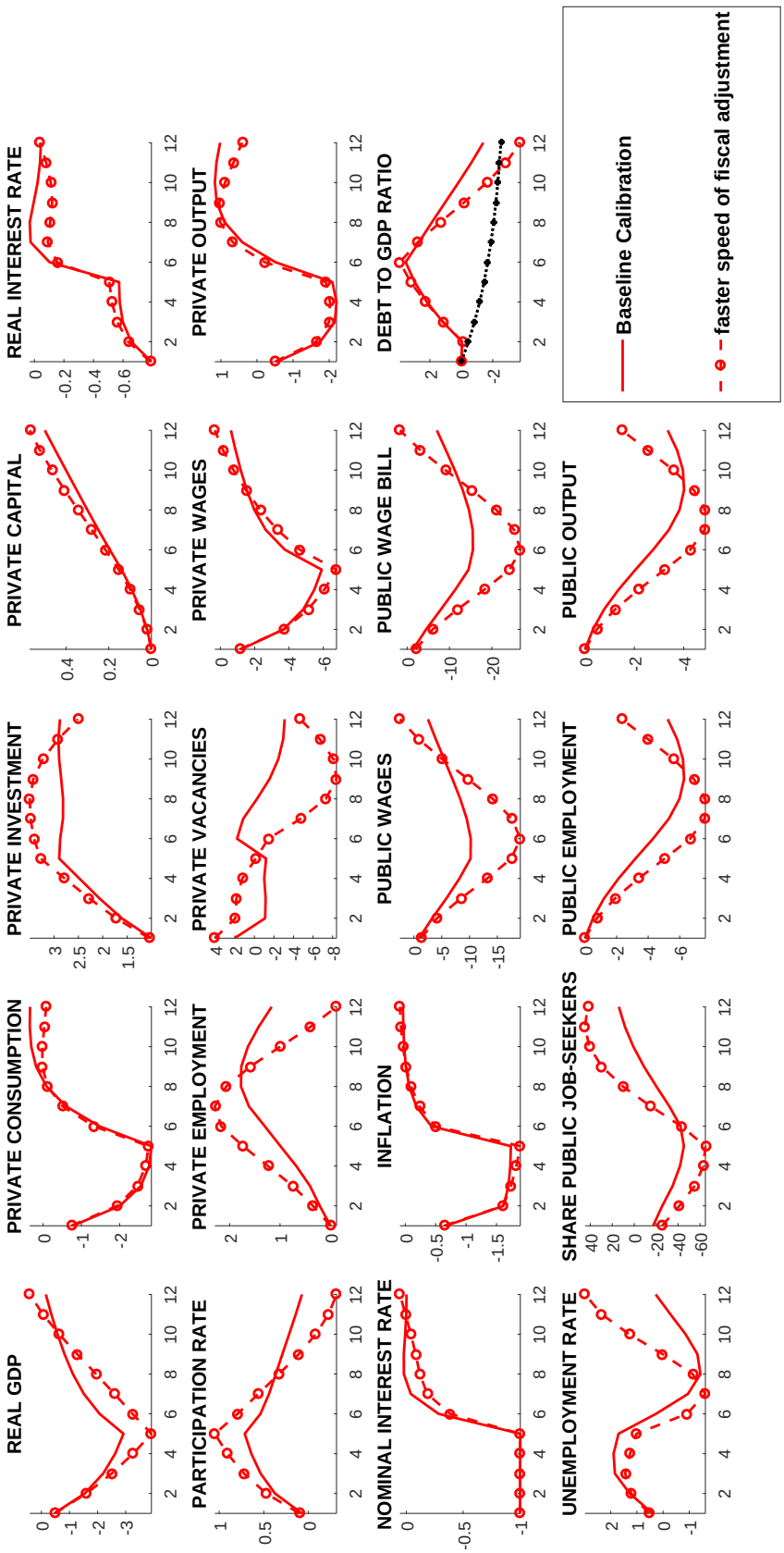

Figure 12: Public Wage Cuts in a Low Inflation Environment: the Speed of Consolidation

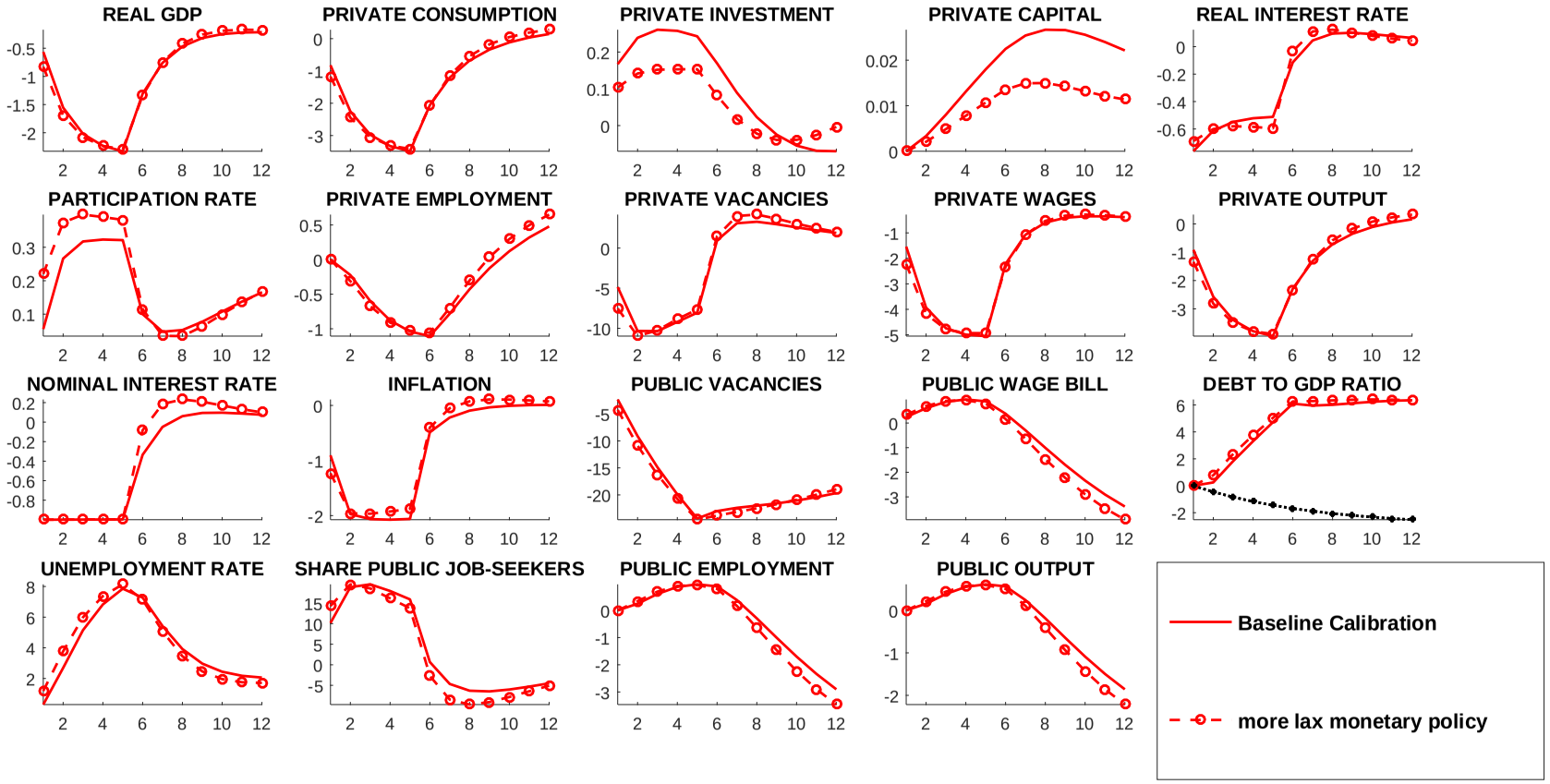

Figure 13: Public Vacancy Cuts in a Low Inflation Environment: the Role of Monetary Policy Strength

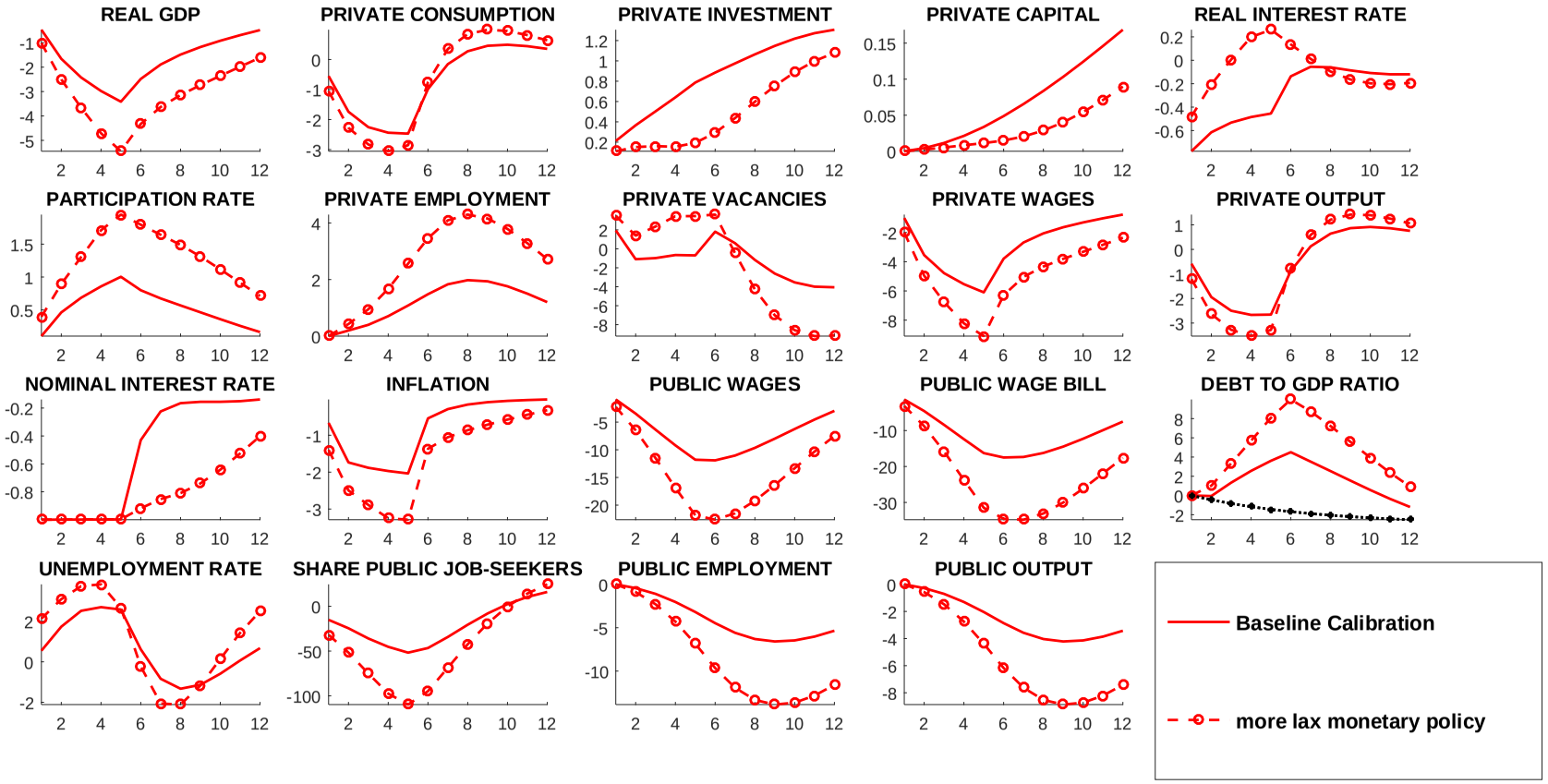

Figure 14: Public Wage Cuts in a Low Inflation Environment: the Role of Monetary Policy Strength

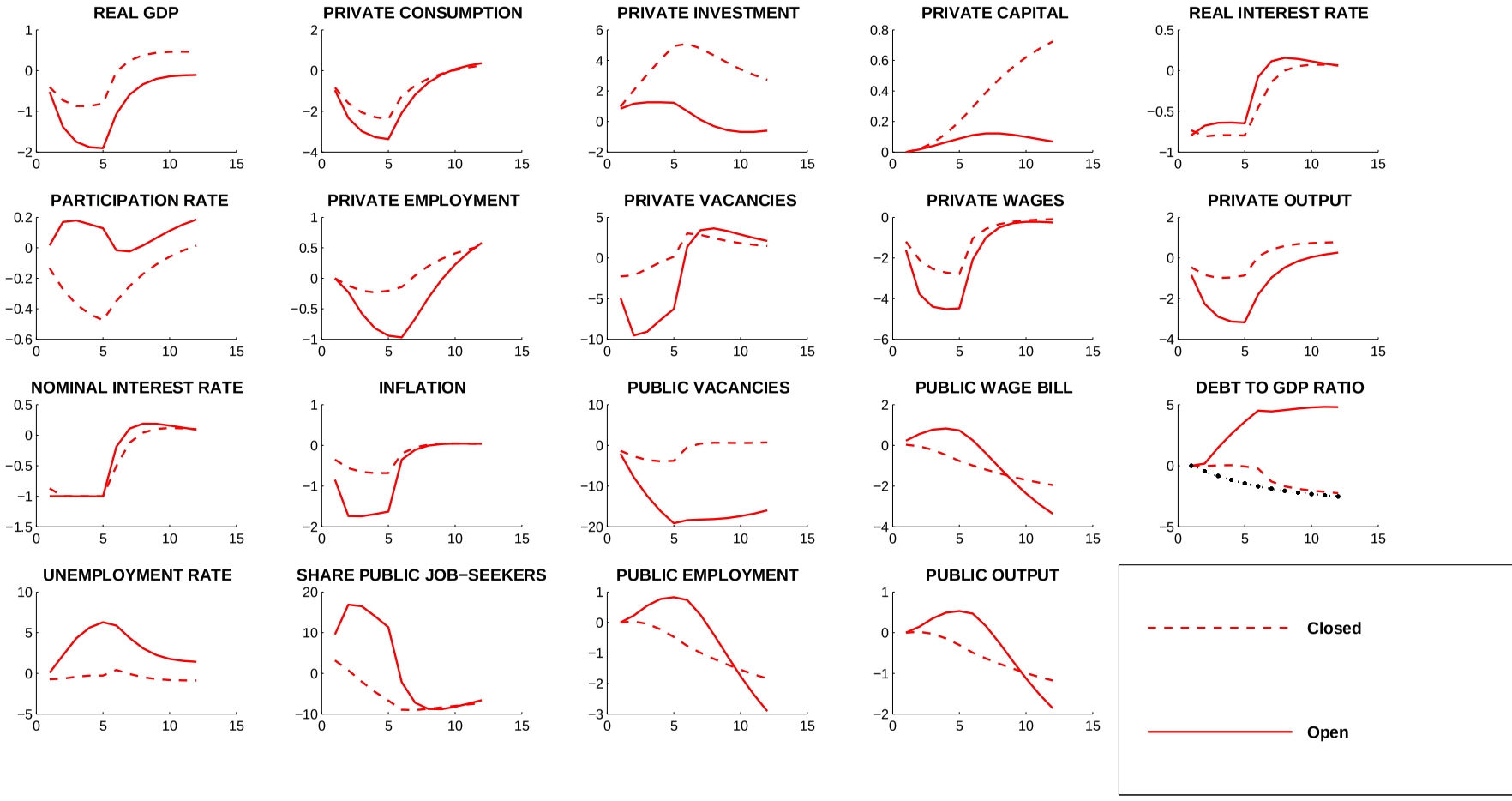

Figure 15: Public Vacancy Cuts in a Low Inflation Environment: Closed versus Open Economy

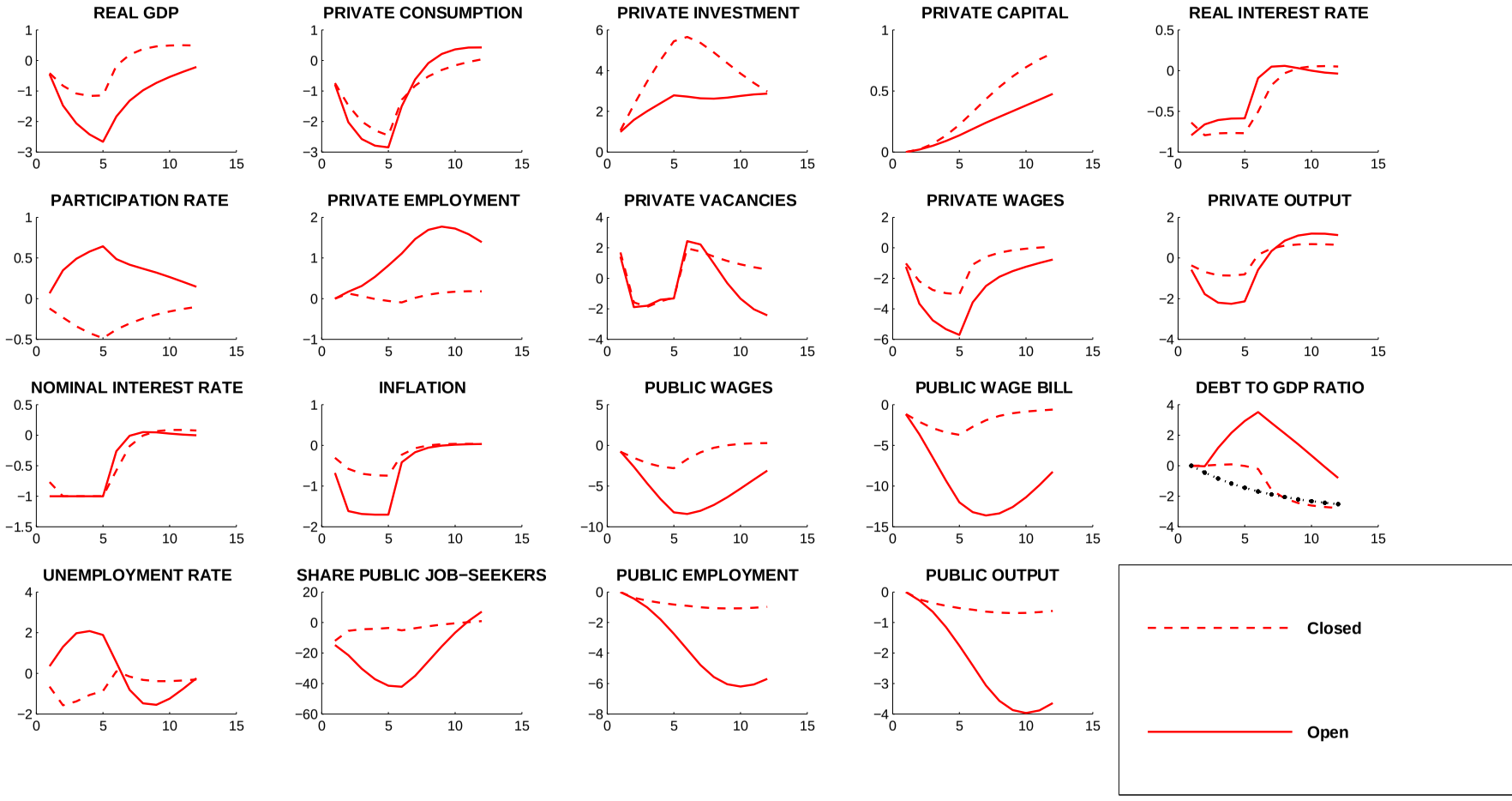

Figure 16: Public Wage Cuts in a Low Inflation Environment: Closed versus Open Economy

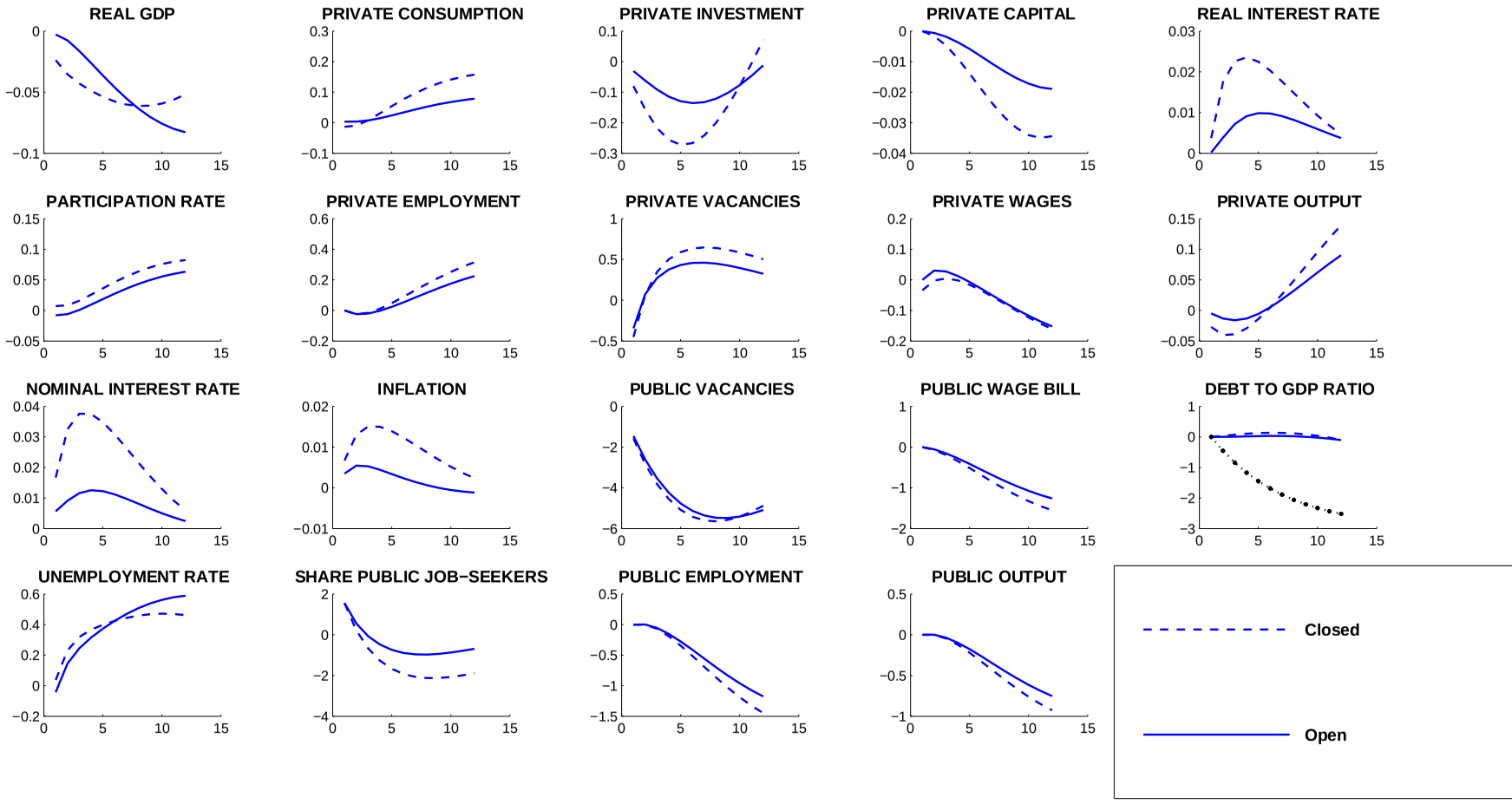

Figure 17: Public Vacancy Cuts in Normal Times: Closed versus Open Economy

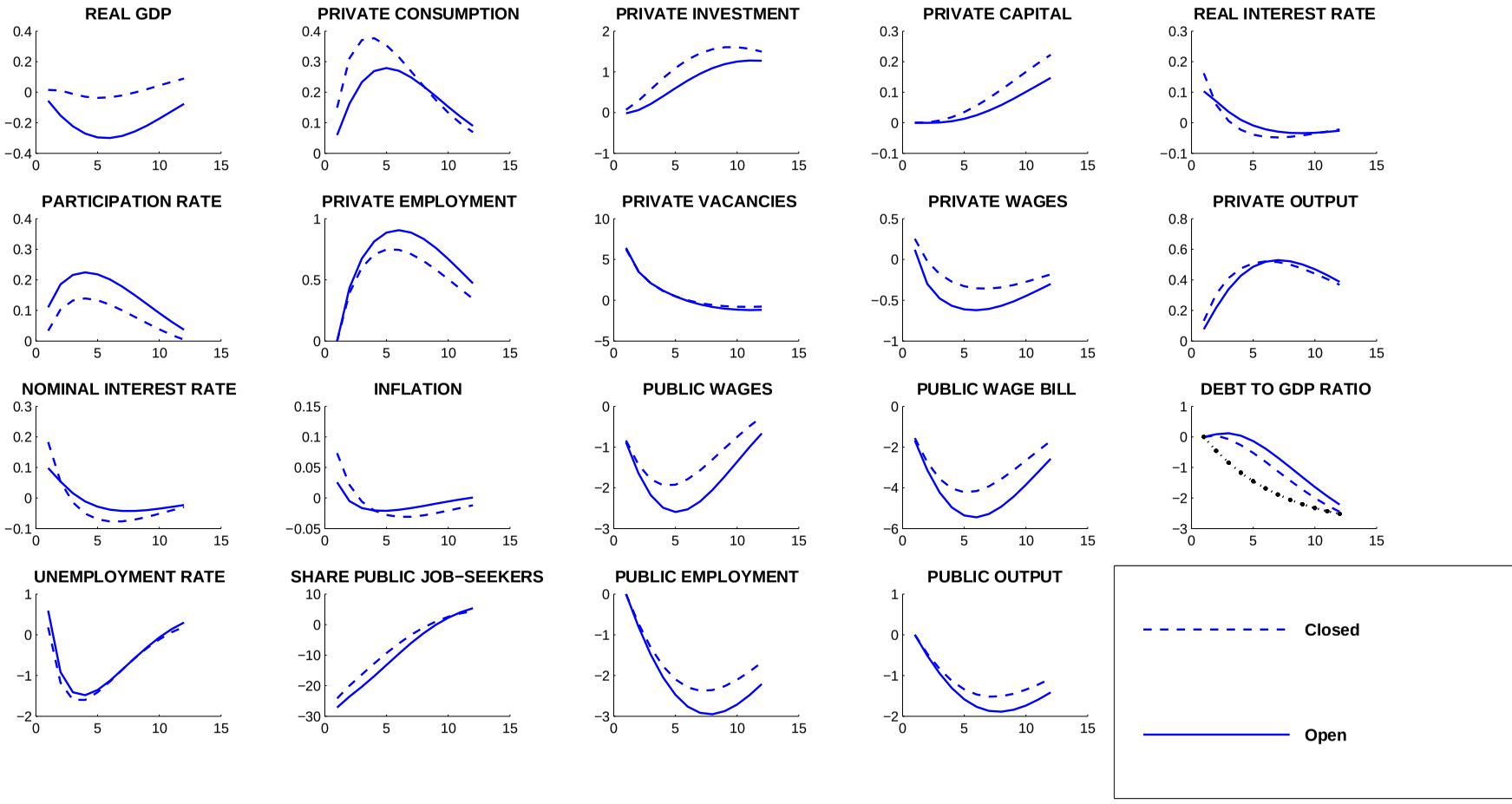

Figure 18: Public Wage Cuts in Normal Times: Closed versus Open Economy

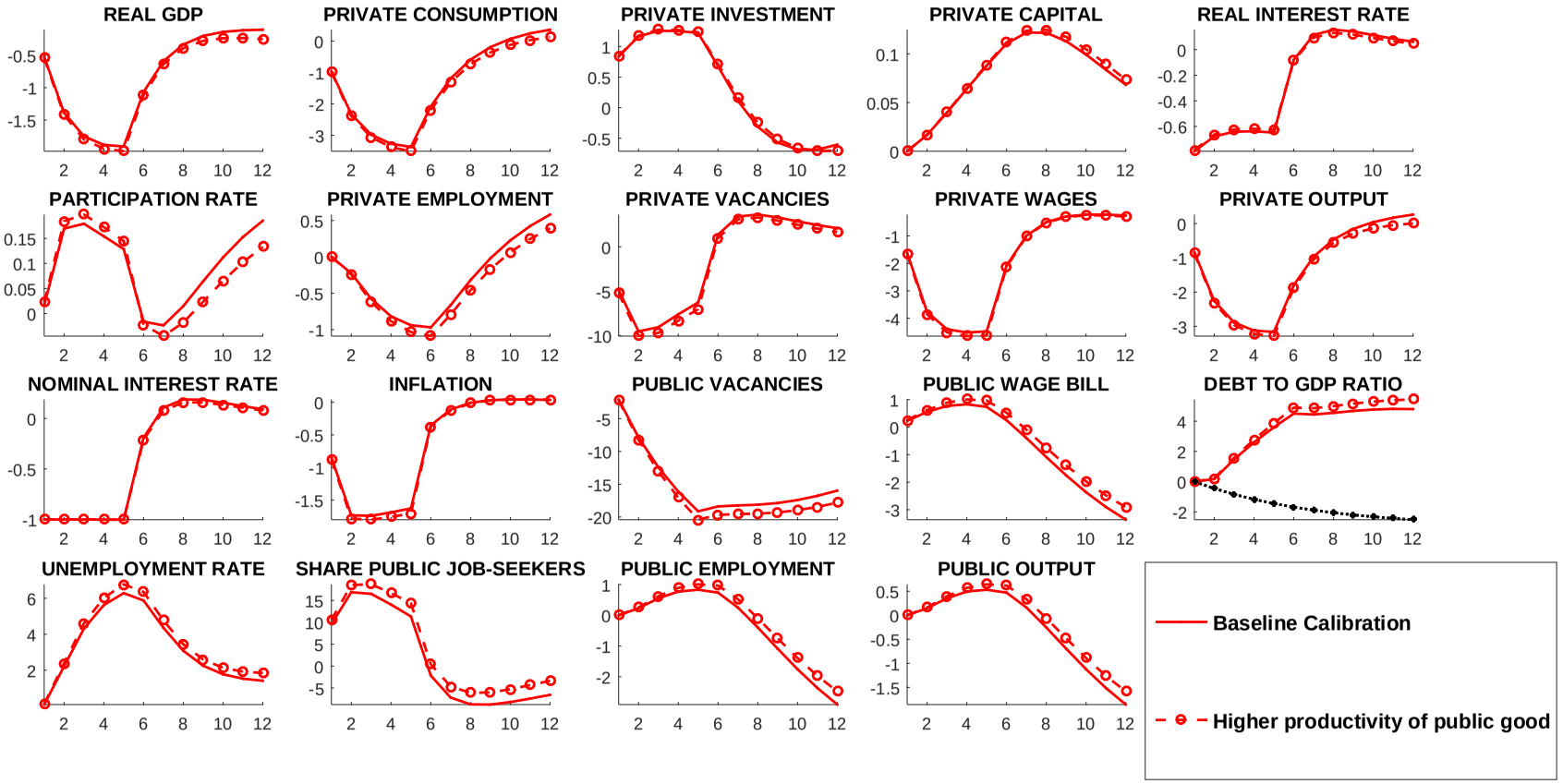

Figure 19: Public Vacancy Cuts in a Low Inflation Environment: the Productivity of Public Output

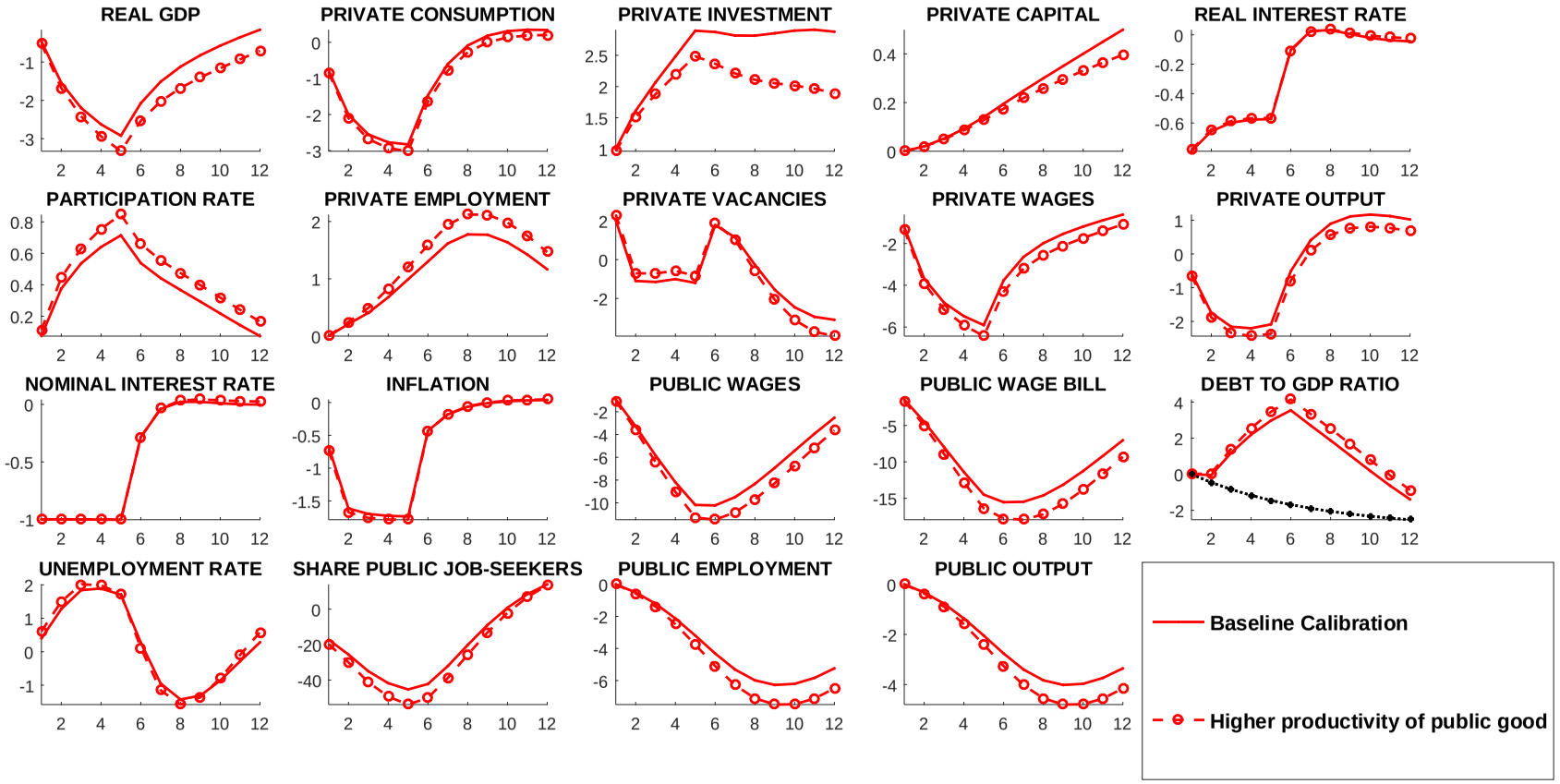

Figure 20: Public Wage Cuts in a Low Inflation Environment: the Productivity of Public Output

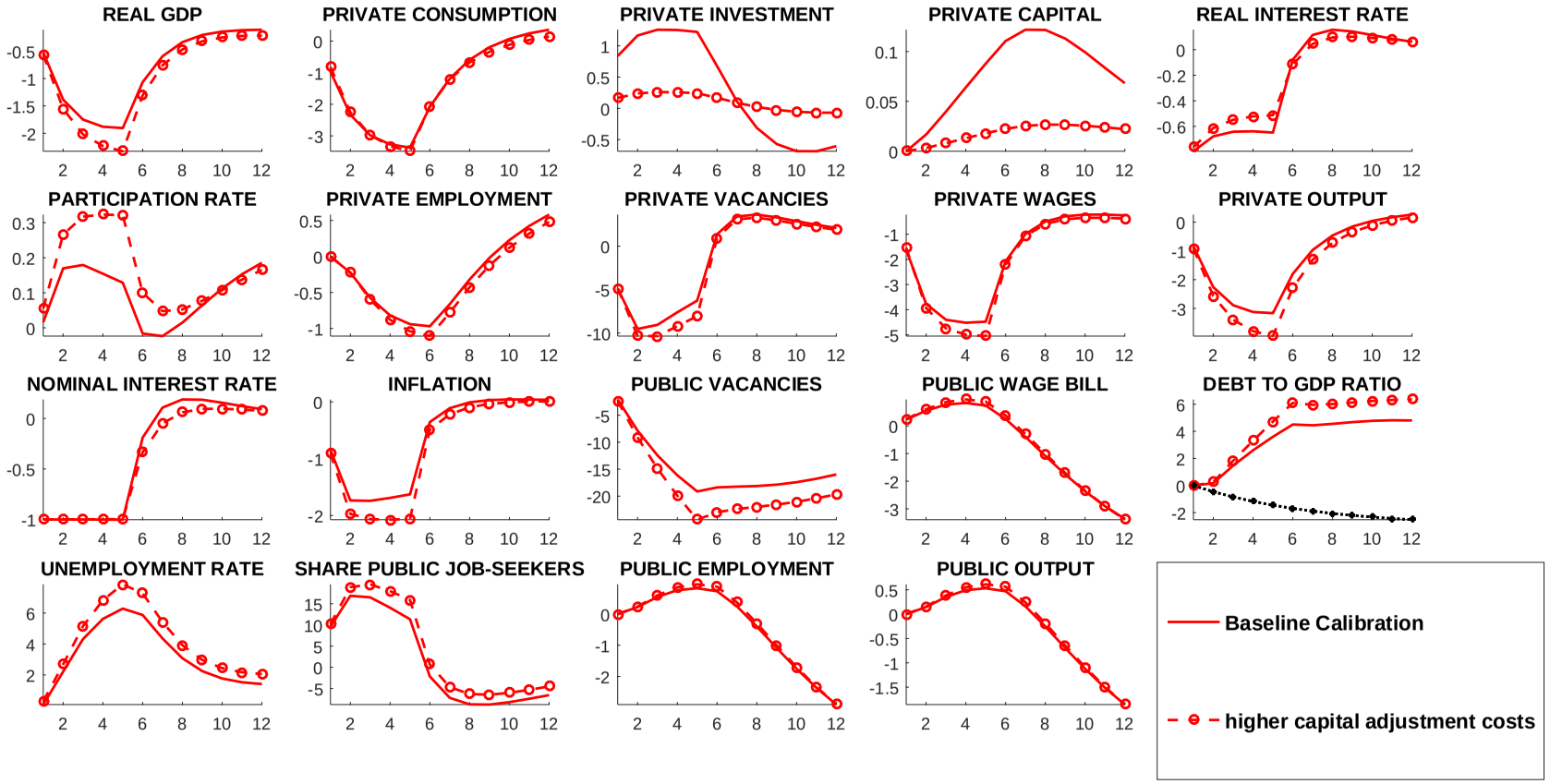

Figure 21: Public Vacancy Cuts in a Low Inflation Environment: Investment Adjustment Costs

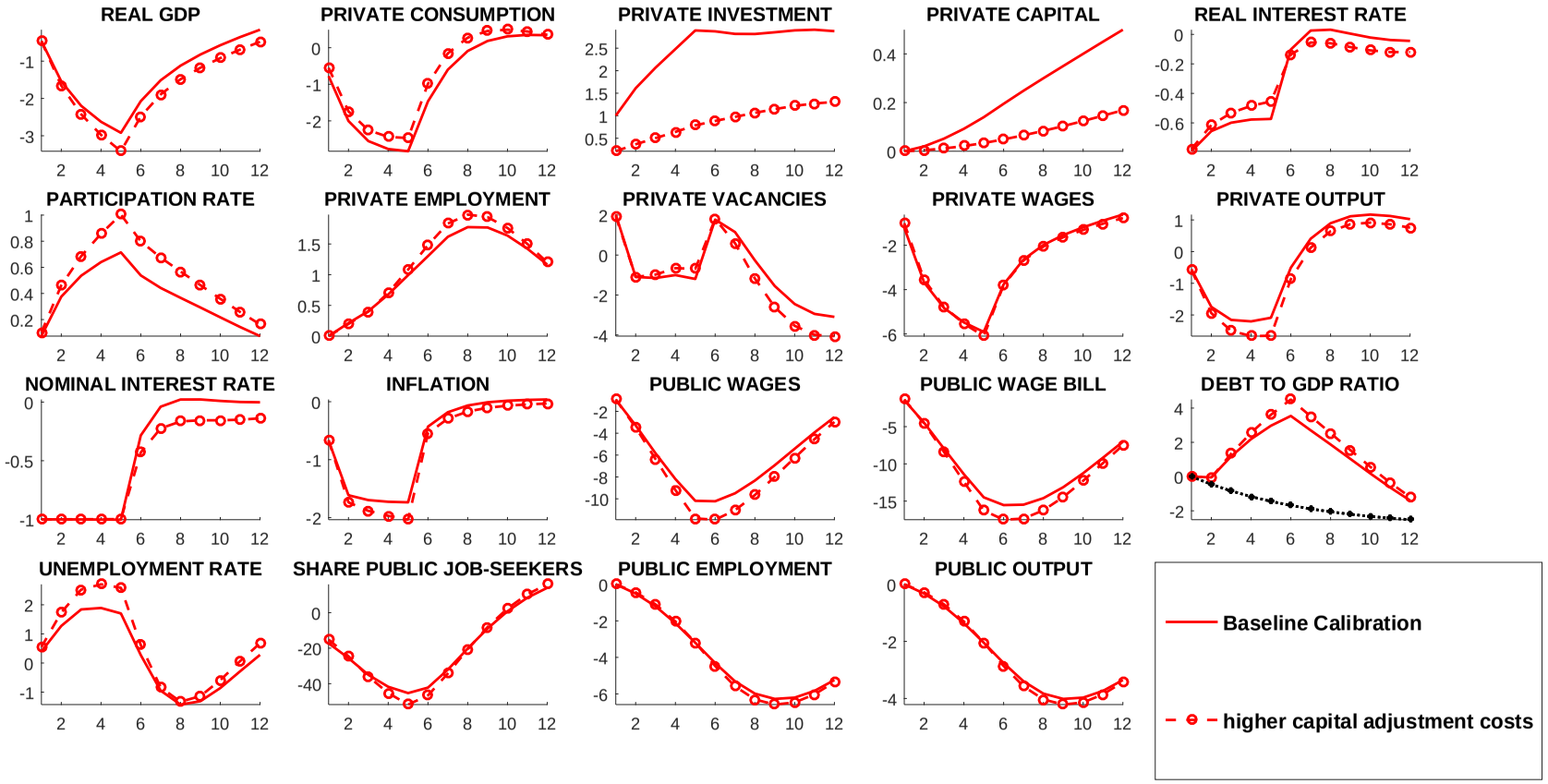

Figure 22: Public Wage Cuts in a Low Inflation Environment: Investment Adjustment Costs

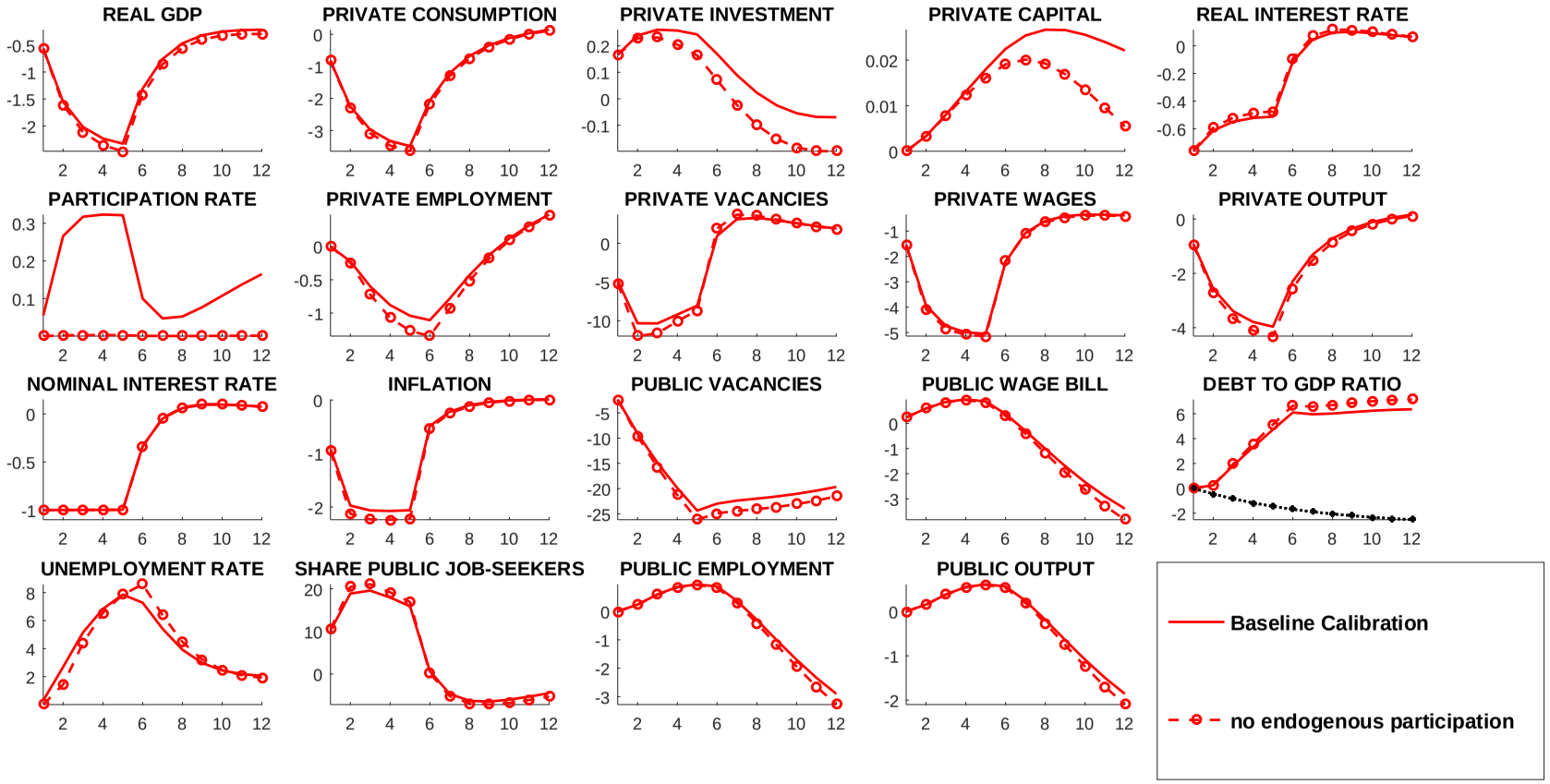

Figure 23: Public Vacancy Cuts in a Low Inflation Environment: Endogenous Labour Force Participation

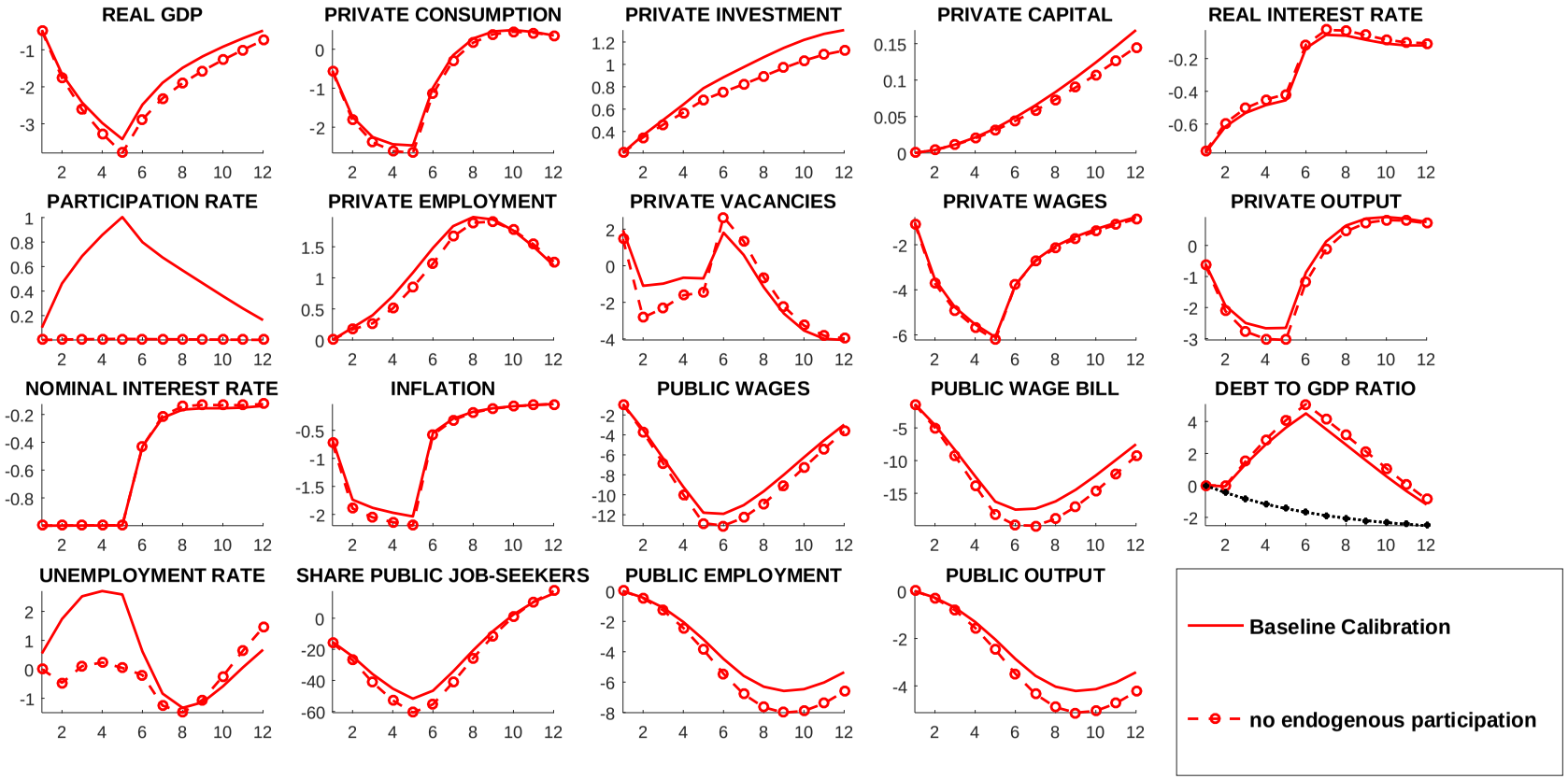

Figure 24: Public Wage Cuts in a Low Inflation Environment: Endogenous Labour Force Participation