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Spillover effects in a monetary union: Why fiscal policy instruments matter ?*

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Abstract: Using a two-country DSGE model, we analyze the spillover effects of fiscal policy in a monetary union. Based on a non-Walrasian labor market and a detailed fiscal sector, our analysis focuses on the relative cross-border effects of different kinds of fiscal instruments (expenditure side and revenue side). We show that different fiscal instruments produce quite different *qualitative* effects on the foreign economy. For instance, a public consumption expansion or a cut in social protection tax triggers a decrease in foreign GDP and an increase in foreign unemployment. On the contrary, an increase in transfers to households or a decrease in VAT leads to an increase in foreign GDP and a decrease in foreign unemployment. Moreover, we demonstrate that the choice of the fiscal instrument strongly affects the size of the spillover effects, meaning that different fiscal instruments also produce different *quantitative* effects on the foreign economy.

Keywords : Fiscal policy, spillover effects, new-Keynesian model, labor market, unemployment

JEL classification : E62, F41, F42, F 45, J20

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1 Introduction

Since the Eurozone was launched in 1999, inter-relations between national economies have strengthened. In such an integrated context, damaging effects of non-coordinated national fiscal policies may potentially be very high. However, despite the growing role of the European Commission in the monitoring of national budgets, fiscal policy remains a national area of competence. A deep knowledge of the effects of a national fiscal policy on the other Member States of the monetary union is fundamental to reach an effective fiscal policy at the monetary union level. Actually, economists have long established that expansionary fiscal policies have tangible effects on the other partner countries. These are the so-called "spillover effects" or "cross-border effects" of fiscal policy.

For instance, positive spillover effects may cause a coordination problem. Moreover, moral hazard could appears between Member States. In this case, some countries could benefit from expansionary fiscal policies conducted in other countries without creating deficit themselves. On the contrary, if spillover effects are negative, it militates for the suitability of the recent restrictive fiscal policies conducted within the Euro Area. In this case, it could partly explain the weakness of GDP growth within the Euro Area, each national restrictive fiscal policy decreasing GDP growth in the other member states.[1] In this context, both sign and size of spillover effects are to be taken into account.

A very extensive literature has investigated the cross-border effects of fiscal policy. Despite abundance of studies on this subject, both the sign and the size of these spillover effects remain uncertain.

Two main transmission channels have been underlined. Firstly, the so-called "trade chanel": a rise in public expenditure in one country triggers increased imports in this country and symmetrically increased exports in the foreign economy. In the Euro Area, such an effect should be high since national markets, notably for goods and services, have become more and more integrated over time. In a monetary union, a second transmission channel appears: the "interest rate channel". When one country implements an expansionary fiscal policy, it tends to create inflation pressures so that

[1] This may be an explanation of the underestimation of fiscal multiplier in the recent Adjustment programmes financed by IMF and the EC and implemented in some European countries like Hungary, Latvia and Greece among other. See, for instance, Blanchard & Leigh (2013).

the central bank may react by raising its interest rate. The consequence is a crowding-out effect on private demand in the whole union. This effect could be important and even exceed the positive spillover effect of the trade channel.

For example, Beetsma, Giuliodori & Klaassen (2006) investigate the trade transmission channel by estimating a panel VAR reduced form with a panel trade model for 14 European countries from 1965 to 2004. The authors argue for significantly positive effects of an expansionary fiscal policy on foreign exports and GDPs of the cross-border economies. A rise in public expenditure in Germany corresponding to 1% of GDP would increase foreign exports in other countries by 2.2% in one year. This effect would have a final effect of 0.13% on foreign GDP. In the case of a tax cut of the same size, the authors find weaker effects, with a rise in foreign exports of 0.8% and a rise in GDP of 0.07%. Hollmayr (2012) built a multi-country DSGE model (for seven initial members of the Euro-Area) coupled with a GVAR methodology in order to assess the trade weights between the different economies. He finds that both transmission channels exist (trade and interest rate channels) but the negative spillover effect induced by the rise in interest rate is predominant. The model thus produces a slightly negative total spillover effect. In the same veine, European Commission (2014) focuses on the key factors determining the cross-border effects in the Euro Zone. Moreover, Auerbach & Gorodnichenko (2013) deal specifically with spillover effects for several OECD countries. This is an empirical paper, which shows that the spillovers are more important (and positive) when the economy which sets up the expansionary fiscal policy is in recession.[2].

Although many studies assess the spillover effects of fiscal policy, they generally neglect the labor market *i.e.* the responses of employment, real wages and labor force participation to a fiscal policy shock.[3] One of the aim of this analysis is to fill this gap. The added value of this paper is twofold. First, we explicitly take into consideration the effects of fiscal policy on labor market (labor force participation, real wages and employment) using a micro-founded labor market with a non-Walrasian labor market where unemployment is an observable variable following Gali, Smets & Wouters (2012). In this paper, we do not focus only on GDP and inflation, we also look into labor market

[2]See also Betti & Coudert (2015) for an analysis of the effects of fiscal policy on the labor market over the Business Cycle.

[3]For example, Stähler & Thomas (2012) offer an interesting model of labor market in a monetary union but are not interested in spillover effects between countries belonging to the union.

dynamic and especially the response of unemployment rate. Second, we assess the impact of different fiscal policy instruments. Indeed, different forms of fiscal spending and taxes could cause different effects on both the home and foreign economy.

More precisely, we study the spillover effects of a domestic fiscal policy in a monetary union on output, inflation and employment in the foreign economy according to the fiscal instrument used. We use a two-country DSGE model of monetary union and introduce six different fiscal instruments. We assume that each country in the union contains two different production sectors (tradable and non-tradable goods sectors) and that two kinds of households coexist (Ricardian and non-Ricardian households). In this monetary union, the single central bank sets the nominal interest rate in the union following a traditional Taylor rule. As to governments, they have at their disposal various fiscal policy instruments, both in terms of public expenditure and taxation. On the expenditure side, we analyze the effects of public consumption, public investment and transfers to households. On the revenue side, we consider three taxes, namely VAT, a labor revenue tax paid by households and a social protection tax paid by firms. We will see throughout this analysis that these different fiscal components trigger quite heterogeneous effects on key macroeconomic variables.

This study shows that both sign and size of the spillover effects of fiscal policy widely depend on which expenditure component or tax is considered.The interest rate channel appears stronger than the trade channel in all cases except in the case of an increase in transfers to households or a reduction in VAT. Interestingly, fiscal expansions affecting the demand side and those affecting the supply side of the economy have inverse trade and interest rate channels. This may be a reason why studies estimating the spillover effects of an exhaustive public spending shock find weak spillover effects since the different expenditure components partly compensate each other.

The rest of this paper is organized as follows. Section 2 presents the analytical framework. Section 3 proposes an in-depth analysis of spillover effects of a domestic fiscal policy on foreign activity, inflation and employment by focusing both on the sign and the size of the spillover effects. Finally, we conclude in section 4.

2 The monetary union framework

In this model, we consider a monetary union composed of two countries. The introduction of the price index and the real exchange rate follows Rabanal (2009). It is assumed that each country contains two different production sectors: one producing non-tradable goods and one producing perfectly tradable goods. Within the four different production sectors, the technology is assumed to be identical and the production functions incorporate private capital, domestic labor and public capital. All firms are monopolistic suppliers of differentiated goods and thus set their price following a standard Calvo price setting[4]. Moreover, the model includes two kinds of households: Ricardian households and non-Ricardian households that do not have access to financial markets.

2.1 Monetary union, price index and real exchange rate

Two structurally similar countries form a monetary union. The monetary union is normalized to 1. The size of the home country is s and the size of the foreign country is $(1-s)$. The variables denoted by "H" are for the home country while those denoted by "F" are for the foreign country. The exponent "EMU" is used for the union-wide variables.

Each country produces two kinds of goods: perfectly tradable (within the union) goods and non-tradable goods. Thus, each kind of households of the monetary union typically purchases three types of goods: the tradable goods produced in the two countries and the non-tradable goods produced in his home country.

Let C_t^i define the total consumption of households in country i for $i, j = H, F$ with $i \neq j$. This aggregate consumption is a basket of goods represented by a standard CES function such as:

$$C_t^i = [\gamma^{\frac{1}{\epsilon}}(C_t^{T,i})^{\frac{\epsilon-1}{\epsilon}} + (1-\gamma)^{\frac{1}{\epsilon}}(C_t^{NT,i})^{\frac{\epsilon-1}{\epsilon}}]^{\frac{\epsilon}{\epsilon-1}} \tag{1}$$

with:

$$C_t^{T,i} = [\lambda^{\frac{1}{\nu}}(C_t^{i,i})^{\frac{\nu-1}{\nu}} + (1-\lambda)^{\frac{1}{\nu}}(C_t^{i,j})^{\frac{\nu-1}{\nu}}]^{\frac{\nu}{\nu-1}} \tag{2}$$

$C_t^{T,i}$ defines the consumption of tradable goods by the households in country i, $C_t^{NT,i}$ the consumption of non-tradable goods and finally $C_t^{i,i}$ and $C_t^{i,j}$ define respectively the home consumption of home and foreign tradable goods.

[4]See Calvo (1983).

Moreover, $\gamma \in [0;1[$ denotes the share of tradable goods, $\epsilon \in [0;1[$ the elasticity of substitution between tradable and non-tradable goods, $\lambda \in [0;1[$ the share of home-produced goods in the total basket of tradable goods and $\nu \in [0;1[$ the elasticity of substitution between home and foreign tradable goods.

P_t^i corresponds to the consumer price index in country i for $i, j = H, F$ with $i \neq j$ (the index introduced in the maximization process of households) and is expressed as:

$$P_t^i = [\gamma (P_t^{T,i})^{1-\epsilon} + (1-\gamma)(P_t^{NT,i})^{1-\epsilon}]^{\frac{1}{1-\epsilon}} \tag{3}$$

with:

$$P_t^{T,i} = [\lambda (P_t^{i,i})^{1-\nu} + (1-\lambda)(P_t^{j,i})^{1-\nu}]^{\frac{1}{1-\nu}} \tag{4}$$

$P_t^{T,i}$ defines the price index of tradable goods for the consumer in country i, $P_t^{NT,i}$ the price index of non-tradable goods and finally $P_t^{i,i}$ and $P_t^{j,i}$ define respectively the price index of home and foreign tradable goods bought by households in country i.

Finally, we can express the union-wide price index as:

$$P_t^{EMU} = (P_t^H)^s (P_t^F)^{(1-s)} \tag{5}$$

where s (respectively $(1-s)$) corresponds to the weight of country H (respectively country F) in the monetary union's GDP ($s \in [0;1]$).

The real exchange rate defined as a prices ratio between the two countries can be expressed as:

$$S_t = \frac{P_t^F}{P_t^H} \tag{6}$$

Thus, a decrease in S_t corresponds to a loss of competitiveness for domestic economy and, on the contrary, a gain of competitiveness for foreign country.

2.2 Households

In each country for $i, j = H, F$ with $i \neq j$, households are distributed in $[0;1]$. Two kinds of households coexist, namely time-optimizing Ricardian households distributed in $[0;n^R]$ and "hand-to-mouth" non-Ricardian households distributed in $]n^R;1]$ that do not have access to financial markets.

Households consume a basket of goods composed of home non-tradable goods, home tradable goods and foreign tradable goods. Ricardian households within the monetary union do not face credit constraint. Thus, they decide, for each period, their total consumption, labor supply, savings through the holding of a riskless asset, invest in capital and then loan it to firms in the spirit of Smets & Wouters (2007) for instance. The preferences for consumption and labor are introduced *à la* Jaimovich & Rebelo (2009) allowing for a smooth wealth effect of consumption on labor supply. These preferences can be seen as a generalization of additively separable preferences with the King, Plosser & Rebelo (1988) preferences and the Greenwood, Hercowitz & Huffman (1988) preferences as polar cases. Non-Ricardian households do not optimize their level of consumption over time. They simply consume their current disposable income. However, they choose their labor force participation intertemporally in the same way that Ricardian households do.

2.2.1 Ricardian households

Each Ricardian household l with $l \in [0; n^R]$ maximizes the following utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t U_t^{R,i}(l) = E_0 \sum_{t=0}^{\infty} \beta^t \left(log\tilde{C}_t^{R,i}(l) - \frac{\Delta_t^{R,i}(l) N_t^{R,i}(l)^{1+\phi}}{1+\phi} \right) \tag{7}$$

where:

$$\tilde{C}_t^{R,i}(l) = C_t^{R,i}(l) - h\bar{C}_{t-1}^{R,i}(l) \tag{8}$$

$$\Delta_t^{R,i}(l) = Z_t^{R,i}(l)/\tilde{C}_t^{R,i}(l) \tag{9}$$

$$\text{with} \quad Z_t^{R,i}(l) = (Z_{t-1}^{R,i}(l))^{1-\nu}(C_t^{R,i}(l) - hC_{t-1}^{R,i}(l))^{\nu} \tag{10}$$

$\tilde{C}_t^{R,i}$ corresponds to the adjusted consumption with $\bar{C}_{t-1}^{R,i}$ the aggregate past consumption representing a consumption index over the continuum of differentiated households and $C_t^{R,i}$ the consumption before adjustment. Parameter $h \in [0, 1[$ denotes the degree of habit formation for consumption. $N_t^{R,i}$ defines employment and $\phi > 1$ denotes the Frisch elasticity of substitution of labor.[5] $\Delta_t^{R,i}$ introduces the smoothed wealth effect of consumption on labor.

[5]Named after Frisch (1932), the Frisch elasticity of labor supply measures the substitution effect of a change in the wage rate on labor supply.

We now express the utility function for a representative Ricardian household in country i assuming that there is a perfect risk sharing within households for the level of consumption in the spirit of Merz (1995). Furthermore, defining aggregate employment for Ricardian households as $N_t^{R,i} = \int_0^{n^R} N_t^{R,i}(l)\,\mathrm{d}l$ allows us to rewrite the optimization program for the representative household as:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(log\tilde{C}_t^{R,i} - \frac{\Delta_t^{R,i}(N_t^{R,i})^{1+\phi}}{1+\phi} \right) \tag{11}$$

Budget constraint and capital accumulation equation are given by:

$$(1+\tau_t^{c,i})P_t^i C_t^{R,i} + P_t^i I_t^{R,i} + \frac{E_t B_{t+1}^i}{1+R_t} \leq (1-\tau_t^{w,i})W_t^i N_t^{R,i} + B_t^i + R_t^{K,i} K_{t-1}^{R,i} + Tr_t^i \tag{12}$$

$$K_t^{R,i} = (1-\delta)K_{t-1}^{R,i} + \left[1 - S\left(\frac{I_t^{R,i}}{I_{t-1}^{R,i}} \right) \right] I_t^{R,i} \tag{13}$$

with:

$$S\left(\frac{I_t^{R,i}}{I_{t-1}^{R,i}} \right) = \frac{\kappa}{2}(I_t^{R,i}/I_{t-1}^{R,i} - 1)^2 \tag{14}$$

In this economy, as shown by equation (12), two taxes are paid by households: VAT $\tau_t^{c,i}$ and labor income tax $\tau_t^{w,i}$. Also, $I_t^{R,i}$ defines private investment, $K_t^{R,i}$ the capital stock, B_t^i the stock of riskless assets held at the period t and W_t^i the nominal wage in country i. Since households loan capital to firms, they are compensated at a rate $R_t^{K,i}$. Moreover, households receive Tr_t^i as social transfers.

Concerning the capital accumulation given by equation (61), $\delta \in [0;1[$ denotes the depreciation of private capital. Following Christiano, Eichenbaum & Evans (2005) and Smets & Wouters (2007), we assume that the cost function related to changes on investment decisions is given by (14) where $\kappa > 1$ corresponds to a fixed cost to change the level of investment.

In each country i, maximizing the utility function of a Ricardian household given by (11) subject to budget constraint (12) and capital accumulation

constraint (61) with respect to $C_t^{R,i}$, B_t^i, $I_t^{R,i}$ and $K_t^{R,i}$ yields the following first order conditions where $\mu_t^{R,i}$ and $\Omega_t^{R,i}$ are respectively the Lagrangian multipliers corresponding to the budget constraint and the capital accumulation constraint:

$$\mu_t^{R,i} = \frac{\beta^t U_{C,t}^{R,i}}{P_t^i(1+\tau_t^{c,i})} \quad \text{with} \quad U_{C,t}^{R,i} = \frac{\partial U_t^{R,i}}{\partial C_t^{R,i}} \tag{15}$$

$$\mu_t^{R,i} = \frac{\mu_{t-1}^{R,i}}{1+R_{t-1}} \tag{16}$$

$$\begin{aligned}\mu_t^{R,i} P_t^i = \Omega_t^{R,i} \left(1 - S\left(\frac{I_t^{R,i}}{I_{t-1}^{R,i}}\right) - S'\left(\frac{I_t^{R,i}}{I_{t-1}^{R,i}}\right)\left(\frac{I_t^{R,i}}{I_{t-1}^{R,i}}\right)\right) \\ +\beta E_t \Omega_{t+1}^{R,i} \left(S'\left(\frac{I_{t+1}^{R,i}}{I_t^{R,i}}\right)\left(\frac{I_{t+1}^{R,i}}{I_t^{R,i}}\right)^2\right)\end{aligned} \tag{17}$$

$$\Omega_t^{R,i} = \beta E_t[\mu_{t+1}^{R,i} R_{t+1}^{K,i} + \Omega_{t+1}^{R,i}(1-\delta^p)] \tag{18}$$

Including (16) in (15) allows us to obtain the consumption Euler equation:

$$\frac{U_{C,t-1}^{R,i}}{U_{C,t}^{R,i}} = \beta(1+R_{t-1})\frac{P_{t-1}^i(1+\tau_{t-1}^{c,i})}{P_t^i(1+\tau_t^{c,i})} \tag{19}$$

Notice that we do not define at this stage the labor supply decision for Ricardian households. Actually, we introduce employment $N_t^{R,i}$ and not the labor supply $L_t^{R,i}$ in the utility function. Indeed, labor demand defines employment since we assume a positive unemployment rate at the steady-state thus labor demand is the short side of the market. However, there is a labor force participation decision that is described in the labor market section.

2.2.2 Non-Ricardian households

Non-Ricardian households do not optimize their level of consumption over time. They simply consume all their disposable income, composed of their labor revenue and of government transfers, such as:

$$(1+\tau_t^{c,i})P_t^i C_t^{NR,i} = (1-\tau_t^{w,i})W_t^i N_t^{NR,i} + Tr_t^i \tag{20}$$

However, we consider that non-Ricardian households decide to participate or not in the labor market in the same manner than Ricardian households. The labor force participation decision is described in the labor market section. In order to define a labor force participation decision for these households, we can already introduce their utility function. Then, similarly to Ricardian households, the utility function for hand-to-mouth households is expressed as:

$$U_t^{NR,i} = log\tilde{C}_t^{NR,i} - \frac{\Delta_t^{NR,i}(N_t^{NR,i})^{1+\phi}}{1+\phi} \tag{21}$$

2.2.3 Consumption functions

Consumption functions for the four types of goods produced in the monetary union depend on relative prices and on both elasticities of substitution between tradable and non-tradable goods and between home tradable goods and foreign tradable goods.

In each country i for $i, j = H, F$ with $i \neq j$, demands addressed by households to firms are represented by the following equations:

$$C_t^{i,i} = \lambda\gamma \left(\frac{P_t^{i,i}}{P_t^{T,i}}\right)^{-\nu} \left(\frac{P_t^{T,i}}{P_t^i}\right)^{-\epsilon} C_t^i \tag{22}$$

$$C_t^{i,j} = (1-\lambda)\gamma \left(\frac{P_t^{i,j}}{P_t^{T,i}}\right)^{-\nu} \left(\frac{P_t^{T,i}}{P_t^i}\right)^{-\epsilon} C_t^i \tag{23}$$

$$C_t^{NT,i} = (1-\lambda)\gamma \left(\frac{P_t^{NT,i}}{P_t^i}\right)^{-\epsilon} C_t^i \tag{24}$$

$C_t^{i,i}$ and $C_t^{i,j}$ respectively define the home consumption of home and foreign tradable goods and $C_t^{NT,i}$ the consumption of non-tradable goods by households in country i.

2.3 Firms

In this economy, tradable and non-tradable sectors share the same technology. For each sector, a continuum of firms produce differentiated goods in a monopolistic way and use a Calvo-style price setting mechanism. Moreover, we assume that the nominal wage is similar in both sectors. However, prices can differ across sectors. Besides, we assume that in both sectors firms use the same type of capital. Consequently, the aggregate capital accumulated by home households K_t^i is allocated in both sectors such as $K_t^i = K_t^{T,i} + K_t^{NT,i}$.

2.3.1 The tradable sector

In the tradable sector of each country i for $i, j = H, F$ with $i \neq j$, all firms share the same technology and the production function is given by:

$$Y_t^{T,i} = \xi_t^{A,T,i}(K_t^{T,i})^{\alpha}(N_t^{T,i})^{1-\alpha}(K_{t-1}^{g,i})^{\alpha_g} \tag{25}$$

where $K_t^{T,i}$ is the private capital used in production, $N_t^{T,i}$ the level of labor and $\alpha \in]0;1[$ the share of private capital used in the production process.

$K_{t-1}^{g,i}$ defines public capital accumulated by the government *via* public investment. We suppose that public capital puts a period before becoming really effective and therefore it puts a period before increasing the productivity of firms. We assume that public capital has the same productivity effect in both sectors. The size of the productivity effect of public capital on the production process is expressed by the parameter α^g.

$\xi_t^{A,T,i}$ is the total factor productivity shock (TFP), common to all firms in the home tradable sector. The TFP exogenous innovation is defined as an AR(1) process:

$$\xi_t^{A,T,i} = (\xi_{t-1}^{A,T,i})^{\rho^{A,i}} exp(\epsilon^{A,T,i}) \tag{26}$$

with $\rho^{A,i}$ defining the duration of the productivity shock.

The profit of the representative firm in nominal terms is given by:

$$\Pi_t^{T,i} = P^{T,i}Y_t^{T,i} - (1 + \tau_t^{sp,i})W_t^i N_t^{T,i} - R_t^{K,i}K_t^{T,i} \tag{27}$$

with $\tau_t^{sp,i}$ denoting the social protection tax paid by firms. We assume that the government does not differentiate the level of taxation between both sectors.

Maximizing the profit function (27) with respect to $N_t^{T,i}$ and $K_t^{T,i}$ according to (25) yields the following first order conditions for labor and capital:

$$\frac{\partial \Pi_t^{T,i}}{\partial N_t^{T,i}} = 0 \Leftrightarrow \nabla_t^{T,i}(1-\alpha)\xi_t^{A,T,i}(K_t^{T,i})^{\alpha}(N_t^{T,i})^{-\alpha}(K_{t-1}^{g,i})^{\alpha_g} = (1+\tau_t^{sp,i})W_t^i \quad (28)$$

$$\frac{\partial \Pi_t^{T,i}}{\partial K_t^{T,i}} = 0 \Leftrightarrow \nabla_t^{T,i}\alpha\xi_t^{A,T,i}(K_t^{T,i})^{\alpha-1}(N_t^{T,i})^{1-\alpha}(K_{t-1}^{g,i})^{\alpha_g} = R_t^{K,i} \quad (29)$$

where $\nabla_t^{T,i}$ is the Lagrangian multiplier associated with the function production and equals marginal cost $MC_t^{T,i}$.

By rearranging equations (28) and (29), we find the demand function for each input, such as:

$$K_t^{T,i} = \frac{\alpha}{1-\alpha}(1+\tau_t^{sp,i})\frac{W_t^i}{R_t^{K,i}}N_t^{T,i} \quad (30)$$

Also from equations (28) and (29), marginal cost of firm $MC_t^{T,i}$ can be expressed as:

$$\nabla_t^{T,i} = MC_t^{T,i} = \frac{((1+\tau_t^{sp,i})W_t^i)^{1-\alpha}(R_t^{K,i})^{\alpha}}{\xi_t^{A,T,i}\alpha^{\alpha}(1-\alpha)^{1-\alpha}(K_{t-1}^{g,i})^{\alpha_g}} \quad (31)$$

We can observe that public capital negatively affects the marginal cost of firms. We can thus expect that a public investment shock decreases inflation. Furthermore, assumptions about a common nominal wage and different price dynamics across sectors allow us to introduce different real marginal costs across sectors.

2.3.2 The non-tradable sector

The non-tradable sector is modelized in a very similar way as the tradable one. Therefore, in the non-tradable sector in each country i for $i, j = H, F$ with $i \neq j$, the production function is:

$$Y_t^{NT,i} = \xi_t^{A,NT,i}(K_t^{NT,i})^{\alpha}(N_t^{NT,i})^{1-\alpha}(K_{t-1}^{g,i})^{\alpha_g} \quad (32)$$

$$\text{with} \quad \xi_t^{A,NT,i} = (\xi_{t-1}^{A,NT,i})^{\rho^{A,i}} exp(\epsilon^{A,NT,i}) \quad (33)$$

The profit of the representative firm in nominal terms can be expressed as follows:

$$\Pi_t^{NT,i} = P_t^{NT,i} Y_t^{NT,i} - (1+\tau_t^{sp,i}) W_t^i N_t^{NT,i} - R_t^{K,i} K_t^{NT,i} \tag{34}$$

As in the tradable sector, the profit maximization of firm in the non-tradable sector leads to the following optimal input choice and the following marginal cost:

$$K_t^{NT,i} = \frac{\alpha}{1-\alpha}(1+\tau_t^{sp,i}) \frac{W_t^i}{R_t^{K,i}} N_t^{NT,i} \tag{35}$$

$$MC_t^{NT,i} = \frac{((1+\tau_t^{sp,i}) W_t^i)^{1-\alpha} (R_t^{K,i})^{\alpha}}{\xi_t^{A,NT,i} \alpha^{\alpha} (1-\alpha)^{1-\alpha} (K_{t-1}^{g,i})^{\alpha_g}} \tag{36}$$

2.3.3 Price setting

In each country i for $i, j = H, F$ with $i \neq j$, firms set their price in each period constrained by a certain degree of rigidity introduced *à la* Calvo (1983). In each period, only a fraction $(1-\theta^p)$ are allowed to reset their price. Firms maximise their price taking into account their mark-up over the marginal cost and constrained by a specific demand function. Then, we present the price setting for the home tradable firms but the process is quite similar in the non-tradable sector and in the foreign economy. Following Christiano, Eichenbaum & Evans (2005) or Smets & Wouters (2007), the maximisation process can be expressed as:

$$\max_{\tilde{P}_t^{T,i}(l)} E_t \sum_{k=0}^{+\infty} \theta^p \frac{\beta \mu_t^{R,i}}{\mu_{t+k}^{R,i}} [\tilde{P}_t^{T,i}(l)(\pi_{k=1}^{T,i} \pi_{t+k-1}^{T,i}) - MC_{t+k}^{T,i}(l)] Y_{t+k}^{T,i}(l) \tag{37}$$

$$\text{s.t.} Y_{t+k}^{T,i}(l) = Y_{t+k}^{T,i} G'^{-1} \left(\frac{P_t^{T,i}(l) \pi_{k=1}^{T,i} \pi_{t+k-1}^{T,i}}{P_{t+k}^{T,i}} m_{t+k} \right) \tag{38}$$

with $m_t = \int_0^1 G' \left(\frac{Y_t^{T,i}(l)}{Y_t^{T,i}} \right) \frac{Y_t^{T,i}(l)}{Y_t^{T,i}} \, , \mathrm{d}l$ which yields the following FOC:

$$E_t \sum_{k=0}^{\infty} \theta^p \frac{\beta P_t^{T,i}}{P_{t+k}^{T,i}} Y_{t+k}^{T,i}(l)[X] = 0 \tag{39}$$

where $X = \pi_{k=1}^{T,i}\pi_{t+k-1}^{T,i}\tilde{P}_t^{T,i}(l)+((\tilde{P}_t^{T,i}(l)\pi_{k=1}^{T,i}\pi_{t+k-1}^{T,i}-MC_{t+k}^{T,i}(l))\frac{1}{G'^{-1}(z_{t+k})}\frac{G'(x_{t+k})}{G''(x_{t+k})}$

with $x_t = G'^{-1}(z_t)$ and $z_t = \frac{P_t^{T,i}(l)}{P_t^{T,i}}m_t$.

Finally, the aggregate price index is expressed as:

$$P_t^{T,i} = (1-\theta^p)\tilde{P}_t^{T,i}(l)G'^{-1}\left[\frac{P_t^{T,i}(l)m_t}{P_t^{T,i}}\right]+\theta^p\pi_{k=1}^{T,i}\pi_{t+k-1}^{T,i}P_{t-1}^{T,i}G'^{-1}\left[\frac{\pi_{k=1}^{T,i}\pi_{t+k-1}^{T,i}P_{t-1}^{T,i}m_t}{P_t^{T,i}}\right] \tag{40}$$

2.4 Labor force participation and wage setting

We assume labor immobility across countries. Within each country, households supply their labor to firm from both tradable and non-tradable sectors. On the demand side, the different types of firms formulate their own labor demand. As mentioned previously, we assume that the nominal wage is common to all firms, independently of the sector. Nevertheless, employment can differ across firms since they do not face the same demand for their specific goods.

The labor market and especially the introduction of the unemployment rate follow closely Gali, Smets & Wouters (2012). In our two-sector model, assuming a similar nominal wage across all firms of a same country allows us to simplify the equilibrium conditions for the labor market. In fact, the real wage for households will be the same regardless of whether they work in tradable sector or in non-tradable sector. Thus, the unemployment rate is defined as the difference between the total labor force participation formulated by households and the aggregate labor demand addressed by firms from both sectors. For the nominal wage setting, we apply the standard Erceg, Henderson & Levin (2000) framework, assuming than each worker is the supplier of a specific kind of work. In this monopolistic framework, workers (or unions representing the workers) set their wage in a Calvo-style price setting. Like in Gali, Smets & Wouters (2012), we relate the wage mark-up included in the wage setting equation to the unemployment rate.

Labor force participation decision As previously mentioned, both sorts of agents make labor supply decision. We describe the equations relative

to Ricardian households but calculations for non-Ricardian households are similar. Following Gali, Smets & Wouters (2012), we assume that a worker l will accept to participate in the labor market if his utility for labor revenue is higher than his disutility for work. In the case of a Ricardian agent, this is expressed as:

$$\left(\frac{1}{C_t^{R,i} - hC_{t-1}^{R,i}}\right)(1-\tau_t^{w,i})\left(\frac{W_t^i(l)}{P_t^i}\right) \geq \Delta_t^{R,i}(L_t^{R,i})^{\phi}(l) \tag{41}$$

where $L_t^{R,i}(l)$ denotes the labor supply for a Ricardian worker (l) in the country i.

Re-expressing equation (41) and saturating the condition, the aggregate labor force participation is defined by:

$$(1-\tau_t^{w,i})\frac{W_t^i}{P_t^i} = Z_t^{R,i}(L_t^{R,i})^{\phi} \tag{42}$$

Definition of the labor force participation is similar in the case of a non-Ricardian household such as we obtain:

$$(1-\tau_t^{w,i})\frac{W_t^i}{P_t^i} = Z_t^{NR,i}(L_t^{NR,i})^{\phi} \tag{43}$$

Even if the definitions for the labor force participation are similar across households, both labor force participations can have a different dynamic. Consumption for Ricardian and non-Ricardian households is likely to differ, and accordingly the labor force participation is likely to differ as well because of the effect of consumption on the labor supply decision.

Total labor force participation noted L_t^i is then aggregated such as:

$$L_t^i = L_t^{R,i} + L_t^{NR,i} \tag{44}$$

Finally, once we have described total employment and the aggregate labor force participation, unemployment noted U_t^i is simply defined as:

$$U_t^i = L_t^i - N_t^i \tag{45}$$

Wage setting We assume that both Ricardian and non-Ricardian households receive the same wage bargained by a representative union. Following Calvo (1983), workers can only reoptimize their nominal wage in each period with a probability $(1-\theta^w)$, regardeless the number of periods since they last

reoptimized. In this model, when a worker cannot reoptimize his nominal wage, there is a partial indexation of the nominal wage on past inflation, the degree of indexation being defined by the parameter γ^w. Wage in the period k of a worker who has not reoptimized his wage since the period t is of the form $W^i_{t+k/t} = W^i_{t+k-1/t}(\Pi^{p,i}_{t-1})^{\gamma^w}(\Pi^{p,i})^{1-\gamma^w}$ with $\Pi^{p,i}$ inflation at the steady-state. Since we assume a zero inflation steady-state such as $\Pi^{p,i} = 1$, nominal wages are only indexed on past inflation.

The sequence of isolelastic demand schedules is defined such as:

$$N^i_{t+k/t} = \left(\frac{W^i_{t+k/t}}{W^i_{t+k}}\right)^{-\epsilon^w} N^i_{t+k} \tag{46}$$

The first condition for the optimizing process is expressed as:[6]

$$\sum_{k=0}^{\infty}(\beta\theta_w)^k E_t\left[\left(\frac{N^i_{t+k/t}}{C^i_{t+k}}\right)\left(\frac{W^{*i}_{t+k/t}}{P^i_{t+k}} - \frac{\epsilon^w}{\epsilon^w - 1}MRS^i_{t+k/t}\right)\right] = 0 \tag{47}$$

with W^{*i}_t the optimal nominal wage, MRS^i_t the marginal rate of substitution between consumption and labor and where $\frac{\epsilon^w}{\epsilon^w-1}$ corresponds to the wage mark-up desired by the workers.

The last step is to introduce the previous condition in the following law of motion of the aggregate nominal wage that takes into account for the automatic indexation of the nominal wage on past inflation, that is:

$$W^i_t = [\theta_w(W^i_{t-1}(\Pi^{p,i}_{t-1})^{\gamma_w})^{1-\epsilon^w} + (1-\theta_w)(W^{*i}_t)^{1-\epsilon^w}]^{\frac{1}{1-\epsilon^w}} \tag{48}$$

Basically, the wage inflation dynamic is based on fluctuation of the effective mark-up in relation to the natural mark-up $\frac{\epsilon^w}{\epsilon^w-1}$. In this case, the effective markup noted MU^i_t is expressed as:

$$MU^i_t = \frac{W^i_t}{P^i_t} - MRS^i_t \tag{49}$$

The marginal rate of substitution between consumption and labor given by MRS^i_t is defined as:

$$MRS^i_t = -\frac{U^i_{N,t}}{U^i_{C,t}} = Z^i_t N^{i\phi}_t \tag{50}$$

[6] A total derivation of this step can be found in Erceg, Henderson & Levin (2000).

After simplification, we find that:

$$\frac{W_t^i}{P_t^i} - MRS_t^i = \phi U_t^i \tag{51}$$

Thus nominal wages are driven by the unemployment rate. This modelling is interesting since it introduces a microfoundation of the original Phillips curve, i.e. the link between nominal wages and unemployment.

2.5 Aggregate variables and market clearing conditions

In each country i for $i, j = H, F$ with $i \neq j$, we can define aggregate variables and give market clearing conditions.

Total employment noted N_t^i is defined as:

$$N_t^i = N_t^{T,i} + N_t^{NT,i} \tag{52}$$

Total consumption given by C_t^i is:

$$C_t^i = C_t^{R,i} + C_t^{NR,i} \tag{53}$$

Total demand for goods addressed to tradable firms noted $Y_t^{T,i}$ and to non-tradable firms noted $Y_t^{NT,i}$ are defined as:

$$Y_t^{T,i} = C_t^{T,i} + C_t^{T,j} + C_t^{g,T,i} + I_t^{T,i} + I_t^{g,i} \tag{54}$$

$$Y_t^{NT,i} = C_t^{NT,i} + C_t^{g,NT,i} + I_t^{NT,i} + I_t^{g,i} \tag{55}$$

where $C_t^{g,T,i}$ and $C_t^{g,NT,i}$ are public consumption by the home government in both sectors and $I_t^{g,i}$ is public investment. Private investment by Ricardian households are splited across both production sectors such as:

$$I_t^R = I_t^{T,i} + I_t^{NT,i} \tag{56}$$

Total output noted Y_t^i is defined as:

$$Y_t^i = Y_t^{NT,i} + Y_t^{T,i} \tag{57}$$

Finally, in the monetary union as a whole, total output noted Y_t^{EMU} is defined as:

$$Y_t^{EMU} = Y_t^H + Y_t^F \tag{58}$$

2.6 The economic policy

On the monetary policy side, for the monetary union as a whole, we assume a central bank setting its nominal interest rate following this version of the Taylor rule:

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho^r} \left(\frac{Y_t^{EMU}}{\bar{Y}^{EMU}}\right)^{\rho^y} \left(\frac{\Pi_t^{EMU}}{\bar{\Pi}^{EMU}}\right)^{\rho^\pi} \tag{59}$$

where the nominal interest rate R_t deviates from its steady-state value $\bar{R}$ by reacting to changes of output and inflation in the whole union from their steady-state value ($\bar{Y}^{EMU}$ and $\bar{\Pi}^{EMU}$).

On the fiscal policy side, we consider the fiscal policy in each country i for $i, j = H, F$ with $i \neq j$. We represent the behavior of the different fiscal components as an exogenous process, in order to investigate the cross-border effects of a domestic fiscal policy in the foreign economy. More precisely, we consider six fiscal policy instruments: public consumption, social transfers to households, public investment on the public expenditure side, consumption tax (VAT), labor income tax and social protection tax on the tax side.

The budget constraint in nominal terms of each government in the union is expressed as:

$$\tau_t^{c,i}(P_t^i C_t^i) + (\tau_t^{w,i} + \tau_t^{sp,i})(W_t^i N_t^i) + D_t^i = C_t^{g,T,i} + C_t^{g,NT,i} + I_t^{g,i} + Tr_t^i \tag{60}$$

As for private capital accumulation, public capital accumulation is defined as follows:

$$K_t^{g,i} = (1-\delta)K_{t-1}^{g,i} + \left[1 - S\left(\frac{I_t^{g,i}}{I_{t-1}^{g,i}}\right)\right] I_t^{g,i} \tag{61}$$

where $\delta \in [0; 1[$ denotes the depreciation of public capital.

Each fiscal variable is defined as an AR(1) process, such as:

$$C_t^{g,T,i} = (C_{t-1}^{g,T,i})^{\rho^g} + \exp(\xi^{Cg,T,i}) \tag{62}$$

$$C_t^{g,NT,i} = (C_{t-1}^{g,NT,i})^{\rho^g} + \exp(\xi^{Cg,NT,i}) \tag{63}$$

$$I_t^{g,i} = (I_{t-1}^{g,i})^{\rho^g} + \exp(\xi^{Ig,i}) \tag{64}$$

$$Tr_t^i = (Tr_{t-1}^i)^{\rho^g} + \exp(\xi^{Tr,i}) \tag{65}$$

$$\tau_t^{c,i} = (\tau_{t-1}^{c,i})^{\rho^g} + \exp(\xi^{\tau^c,i}) \tag{66}$$

$$\tau_t^{w,i} = (\tau_{t-1}^{w,i})^{\rho^g} + \exp(\xi^{\tau^w,i}) \tag{67}$$

$$\tau_t^{sp,i} = (\tau_{t-1}^{sp,i})^{\rho^g} + \exp(\xi^{\tau^{sp},i}) \tag{68}$$

with ρ^g defining the duration of the fiscal shock.

Equation (60) shows that the government is allowed to finance an expansionary fiscal policy with a deficit D_t^i. In some papers dealing with fiscal policy in DSGE models, taxes are often introduced as reacting to a degradation of the deficit. This is not the case here: our intention is simply to extract from this model the effects of fiscal policy shocks without investigating the potential distorting effects of taxes.[7]

3 Spillover effects of a domestic fiscal policy

The aim of this analysis is to focus on the spillover effects of a domestic fiscal policy on activity, inflation and also employment in the foreign economy.

3.1 Calibration and comments

For structural parameters of the model, we use the estimates of Smets, Warne & Wouters (2013) for the euro zone.[8] Table 1 sums up the initial calibration for the model.

Table 1: Initial calibration of the structural parameters of the model

Parameter	Value	Parameter	Value
γ	0.5	ϵ	0.75
λ	0.5	ν	0.4
s	0.5	h	0.8
ϕ	2	β	0.997
δ	0.05	κ	2.8
α	0.18	$\rho^{A,i}$	0.9
θ^p	0.5	γ^p	0.5
θ^w	0.5	γ^w	0.16
ϵ^w	6.5		

[7] For such an analysis, see, for instance, Barbier-Gauchard & Betti (2015).

[8] Smets, Warne & Wouters (2013) estimate the Gali, Smets & Wouters (2012) model for the euro zone.

For monetary policy parameters, we also used the estimates of Smets, Warne & Wouters (2013). As a consequence, for the Taylor rule, $\rho^r = 0.9$ defines the degree of inertia of the interest rate. For the remaining parameters characterising the response of the central bank to output and inflation differentials, we give usual values to monetary parameters with $\rho^y = 0.5$ and $\rho^\pi = 1.5$. Table 2 gathers these values.

Fiscal policy parameters are also given by Table 2. As discussed in Leeper, Walker & Yang (2010), we do not have clear evidence concerning the size of the productivity effect of public capital. We set $\alpha^g = 0.015$ which seems to be a reasonable and medium value according to empiricial studies at both the macro and micro level. However, giving another value to α^g would trigger different effects of public investment on the economy. This is one weakness of the DSGE modelling when we attempt to adress the effects of public investment. Public investment will have a demand effect similarly to public consumption for instance. However, public investment has a supply effect since it affects the production process of firms. Thus, α^g captures the supply-side effects of public investment. For simplicity sake, we suppose the same duration for each fiscal shock with $\rho^g = 0.6$. With this parameter value, we assume a temporary fiscal shock with a fiscal tool that deviates from its steady-state value for a few quarters. The goal of this paper is not to analyze the respective effects of temporary vs. permanent fiscal shocks.

Table 2: Initial calibration of the economic policy parameters of the model

Parameter	Value	Parameter	Value
ρ^r	0.9	α^g	0.015
ρ^y	0.4	ρ^g	0.6
ρ^π	1.25		

3.2 Sign of spillover effects

This section summarizes the results concerning the cross-border effects in the foreign country of different kinds of spending and taxes occuring in the domestic economy.[9] In the recent literature, two main transmission channels for an expansionary fiscal policy in a monetary union have been highlighted *i.e* a positive trade effect *via* a rise in imports in the domestic economy and a negative interest rate effect *via* a rise in the interest rate at the union level. The total effect on the foreign activity thus depends on the relative size of the two transmission channels.

Table 3 summarizes the signs of the spillover effects according to the different fiscal shocks for foreign GDP, foreign unemployment, foreign inflation and real exchange rate. The Impulse Response Functions (IRF) given in Appendix A illustrate these effects for each fiscal policy instrument. For example, a rise in domestic public consumption leads to a decrease in foreign activity, an increase in foreign unemployment, in foreign inflation and a depreciation of real exchange rate inducing a gain of competitiveness for foreign economy.

Table 3: Signs of spillover effects according to different domestic fiscal shocks

	$C_t^{g,H}$	Tr_t^H	$I_t^{g,H}$	$\tau_t^{sp,H}$	$\tau_t^{c,H}$	$\tau_t^{w,H}$
Y_t^F	-	+	+	-	+	+
U_t^F	+	-	-/+	+	-	-/+
Π_t^F	+	+	-	-	+	-
S_t	-	-	+	+	-	+

[9]See Betti (2014) for an assessment of the effects of public expenditure shocks on domestic economy in the Euro Area and more especially on labor market.

A first assessment is that spillover effects widely differ according to the fiscal shock. A rise in transfers to households and in public investment or a cut in VAT or in labor revenue tax all produce positive spillover effects on the foreign GDP. On the contrary, a cut in social protection tax causes an effect on foreign GDP that is close to 0 (slightly negative). Finally, a rise in public consumption has a negative impact on foreign GDP.

According to the results, it appears more relevant to isolate fiscal policy instruments with demand-side effects (public consumption, social transfers and VAT) on the one hand and those with supply-side effects (social protection tax paid by firms) on the other, than to make a distinction between expenditure and taxes. Cross-border effects of labor revenue tax cut and public investment are investigated separately as they can be seen as particular cases.

The cases of public consumption, social transfers and VAT

We first considered alternatively a rise in transfers to households and a VAT cut. We observe in figures (2) and (4) that these fiscal instruments produce a total positive spillover effect on foreign GDP. Transfers to households and VAT directly and positively affect private consumption. Since home households (both Ricardian and hand-to-mouth households) consume home goods but also a share of tradable foreign goods, activity of foreign firms in the tradable sector increases. This trade channel is well-known in the literature focusing on the open-economy effects of the policy. This rise in imports in the home economy is a leakage that diminishes the fiscal multiplier in this economy and produces a positive demand effect in the other. Secondly, we observe that inflation increases in both economies but inflation pressures are stronger in the home economy, due to a significant increase in marginal cost for home firms *via* a rise in real wages. The real exchange rate therefore decrease, inducing a positive price competitiveness effect for foreign goods. Total demand therefore turns towards foreign goods to the detriment of home goods. Thus, the trade channel is the combination of two effects : a rise in imports due to the composition of the household basket of goods and a loss of competitiveness for the home economy. Thirdly, the nominal interest rate increases in response to the rise in inflation at the union level. The Euler equation for consumption indicates that private demand decreases following the interest rate rise. This is the negative transmission channel of fiscal policy in a monetary union already highlighted in the literature. Finally, in case of VAT and transfers, positive trade effects prevail over the interest rate channel; therefore, foreign GDP increases following these two shocks.

Public consumption produces similar demand-side effects with one important exception as shown in figure (1). In the model we assume that the home government only purchases home-produced goods. On the contrary, a rise in private consumption induced by either transfers or VAT changes causes a rise in purchases of both home and foreign goods. Public consumption increases therefore the home activity more than transfers or VAT. The leakage present in the case of an expansive fiscal policy in an open economy due to an automatic rise in home imports does not exist here. However, public consumption also causes a degradation of the real exchange rate for the home economy; therefore, there is a positive spillover effect *via* a price competitiveness effect for the foreign country as in the cases of transfers and VAT. The interest rate rise is also present in response to the increase in prices in the whole union. Since the trade channel is weaker with public consumption, the total spillover effect is negative with an interest rate channel prevailing on a reduced trade channel as compared to transfers or VAT changes.

The case of social protection tax and public investment

Both economies respond quite differently in case of a rise in public investment and a cut in social protection tax. An interesting point here is that with these two fiscal instruments, the two transmission channels (trade and interest rate) operate in opposite direction.

When the social protection tax paid by firms decreases, the direct effect is a drop in labor costs and therefore in the global marginal cost of home firms. As shown in the impulse response functions in figure (5), prices diminish and production rises. Prices also drop in the foreign economy but to a lesser extend. In this case, the trade channel is present but in the opposite direction: the real exchange rate increases and foreign economy suffers from a negative price competitiveness effect. Furthermore, the interest rate decreases following the drop in inflation; therefore, the interest rate channel becomes positive for the foreign economy that takes advantage of a rise in union-wide private demand. Total effect on foreign GDP is close to 0 and very slightly negative. Foreign activity hikes just after the shock with a rise in union-wide private demand but decreases after a few periods due to the progressive rise in real exchange rate.

A rise in public investment is a special case since this shock has direct effects on both the demand and supply sides of the economy as shown in figure (3). Indeed, public investment enters into demand functions addressed to firms and public capital is present in the production function and in the

marginal cost of firms. Supply-side effects of public capital are similar to the TFP shock commonly introduced in DSGE models: a rise in public capital enhances firms productivity and reduces total marginal cost. The size of these supply effects is defined by the parameter α^g as discussed in the calibration section. We set initially $\alpha^g = 0.015$, which can be seen as a low value. A rise in public capital triggers a drop in marginal cost and therefore a drop in inflation. In this case and similarly to a social protection tax cut, the interest rate decreases and the union-wide private consumption increases. The interest rate channel in this case generates a positive spillover effect on foreign GDP. The significant drop in inflation in the home country induces a rise in real exchange rate leading to a negative price competitiveness effect for the home country. The total effect on the foreign country is however positive, as shown in the IRFs given in Appendix A.

Nevertheless, there is an uncertainty concerning the value of α^g. We simulate the model with a higher value $\alpha^g = 0.05$. [10] With this alternative calibration, the supply-side effects of public investment are higher. On the home economy, effects on GDP and inflation are greater. However, on labor market the effect is more ambiguous. This fiscal policy shock generates a large increase in real wages increasing the labor force participation. With a strong productivity effect, the response of employment is weak and the total response of unemployment is close to 0. On the foreign economy, the spillover effect remains positive on GDP. The two channels are enhanced: the drop in the central bank interest rate is higher and more long-lasting and the price competitiveness effect due to the increase in home price is also magnified. As in the case with $\alpha^g = 0.015$, the total effect on foreign GDP is positive, with an interest rate channel prevailing on the negative trade effect for the foreign economy. With $\alpha^g = 0.05$, the positive spillover effect is even greater. In a polar case in which we assume no productivity effect of public capital, that is with $\alpha^g = 0$, the effects of a public investment shock on both economies are similar to the public consumption shock. Indeed, only transmission channels of the rise on home private demand (for capital produces by the private sector) are present. Thus, in this case, total spillover on foreign GDP is negative, like in the case of public consumption. Two comments has to be done. Firstly, even if we can be doubtful about the value of this parameter, we show that the highest the value of this parameter, the largest the positive spillover effect on foreign GDP. Secondly, and similarly to the public consumption shock, the assumption of demand for capital by government towards only home firms could be too strong. It is likely that

[10] We do not report the IRFs but they can be sent upon request.

in the building process of public infrastructures, one share of the inputs used originate from other countries. In our model, if we assume that public investment is partly produced by foreign firms, the spillover effect would be also greater, generating an higher leakage for home fiscal policy.

The case of labor revenue tax

Figure (6) gives the impulse response functions of macroeconomic variables in the foreign economy. A labor revenue tax reduction produces a higher labor revenue for households. Therefore, they increase their labor force participation. Consumption of non-Ricardian households increases. Thus, demand to home firms increases and employment rises in the home economy. However, the rise in labor force participation is stronger than the rise in employment; accordingly the unemployment rate increases. With the wage setting introduced in the model, nominal and real wages both drop. This causes a drop in the marginal cost for home firms, thus inflation decreases. As a consequence, the interest rate diminishes increasing private demand in the whole union. Thus, as in the cases of public investment and social protection tax, there is a positive spillover on the activity of the foreign economy *via* the interest rate channel. Inflation also drops in the foreign economy but to a lesser extend than in the home economy. The real exchange rate therefore increases, which leads to a negative price competitiveness effect for the foreign country. However, the interest rate channel prevails over the trade channel. Thus, the final spillover effect on the foreign economy is positive.

The labor revenue tax cut is an interestingly as a demand-enhancing instrument that increases the disposable income of consumers. However, paradoxically, we show that cross-border effects are more similar to those induced by supply instruments like social protection tax reduction or rise in public investment. This result arises from what happens on the labor market. The strong rise of the labor force participation and therefore the rise of unemployment causes a drop in real wages, in contrary to the other "demand-oriented" fiscal instruments like public consumption, transfers and VAT. The drop in inflation and the rise in unemployment rate makes the labor revenue tax cut a demand-side fiscal instrument that produces responses of the economies that resemble those observed in the case of supply shocks.

Main results in a nutshell

In this analysis, we do not focus only on GDP but also on the dynamic of the labor market and especially the response on unemployment rate. At this stage, we can summarize our main findings in two major ideas. Firstly, the signs of transmission channels can change widely according to the nature of the spending or the tax. Secondly, the interest rate channel is stronger than the trade channel in all cases except in the case of transfers to households increase and to VAT reduction. It's worth noting that fiscal expansions affecting the demand side and those affecting the supply side of the economy have inverse trade and interest rate channels. This can explain why studies on the spillover effects of an exhaustive public spending shock find weak spillover effects since the different expenditure components partly compensate each other.

Concerning the effects of home fiscal expansions on the foreign labor market, transfers to households, public investment, labor revenue tax cut and VAT cut decrease foreign unemployment rate. On the contrary, increase in public consumption or cut in social protection tax increase foreign unemployment rate. Like the effects on GDP, the rise in transfers and the cut in VAT have similar effects on the foreign labor market. The positive effect on the foreign output causes a rise in foreign employment. The inflationary pressures in the foreign economy triggers a slight drop of real wages but the drop in foreign private consumption eventually induces a weak rise of the labor force participation since we introduce a smoothed wealth effect on the labor force participation decision in households' preferences. For both transfers increase and VAT cut, the foreign unemployment rate is reduced.

The case of a rise in public consumption is slightly different, due to a negative spillover effect on the foreign GDP as seen previously. The drop in foreign activity leads to a negative response of employment thus the unemployment rate increases in this case. However, the effects of a home fiscal expansion on the foreign real wages are similar to the case of a rise in transfers and a cut in VAT, namely foreign real wages decrease.

The social protection tax cut has no significant effects on foreign GDP as seen previously. The response of foreign employment is therefore close to 0 if we compute the total variation of employment over time. On the supply side of the labor market, the rise in real wages prevails over the rise in consumption on the labor force participation that rises therefore. The total effect on the unemployment rate is in this case slightly positive.

Public investment significantly enhances foreign activity, and accordingly increases employment. The strong rise in real wages induced by the drop in inflation in the foreign economy increases labor force participation. The total effect on the unemployment rate is in this case negative due to a strong rise in employment.

Finally, a labor revenue tax cut in the home economy leads to a weak drop of foreign unemployment rate. Since this fiscal tool induces a positive spillover effect on foreign GDP, foreign employment increases. Furthermore, the rise in foreign real wages induces a positive response of foreign labor force participation. The total effect on unemployment rate is however slightly negative.

3.3 The major role of the size of spillover effects

While in the previous section we investigate the sign of the spillover effects and the transmission channels behind these results, another important feature of the open-economy effects of fiscal policy is the size of these spillover effects. We compute the absolute value of the ratio of the home fiscal multiplier over the fiscal multiplier of the home expenditures on foreign GDP, such as, in the case of public consumption for instance:

$$\left| \frac{\sum_{t=0}^{k} \beta^t \frac{\Delta Y_t^F}{\Delta C_t^{g,T,H}}}{\sum_{t=0}^{k} \beta^t \frac{\Delta Y_t^H}{\Delta C_t^{g,T,H}}} \right| \tag{69}$$

This ratio represents the size of spillover effects on the foreign economy expressed in percentage of fiscal multiplier in the home economy. Table 4 summarizes the value of this ratio for the foreign GDP (Y_t^F) and unemployment (U_t^F) in relation to the six fiscal instruments investigated.

Table 4: Spillover multiplier for GDP and unemployment according to the different fiscal instruments

	$C_t^{g,H}$	Tr_t^H	$I_t^{g,H}$	$\tau_t^{sp,H}$	$\tau_t^{c,H}$	$\tau_t^{w,H}$
Y_t^F	0.11	0.24	0.21	0.05	0.15	0.13
U_t^F	0.04	0.2	0.7	7	0.18	0.05

This table means that a rise in public consumption in the home economy induces a rise in the foreign GDP equal to 11 % of the fiscal multiplier on the GDP in the home economy. We observe that the amplitude of the spillover effects highly depends on the fiscal instrument considered. Concerning the foreign GDP, the lower spillover effect is in the case of a social protection tax cut with a ratio equal to 0.05. Since the total effect on the foreign GDP is close to 0 while the home GDP is significantly increased, the ratio is very low. Excluding this low value, the other fiscal shocks have a ratio between 0.11 and 0.24. The literature generally observes low spillover effects but following our results, we argue that they are not insignificant. Transfers to households induce the higher ratio that can be easily explained by the resulting spending since recipient households spend both home and foreign produced goods. This is the well-known leakage of fiscal policy, which is sizeable in our model.

The heterogeneity of the ratios is clearly stronger in the case of unemployment. Public consumption shock and labor revenue tax cut create a low dynamic of unemployment in the foreign economy. Transfers and VAT induce a higher effect with a spillover multiplier of respectively 0.2 and 0.18. Public investment has a very strong ratio equals to 0.7 since it causes a large decline of unemployment in the foreign economy and a significant but limited drop of home unemployment because of an ambiguous effect on home employment. The most surprising result is the ratio obtained in the case of a social protection tax cut. The positive effect on foreign unemployment is 7 times greater than the effect on home unemployment. This ratio is explained by the low response of home unemployment, which is strongly reduced when the shock occurs but eventually increases after a few quarters. The total effect over time is therefore low. On the contrary, foreign unemployment clearly increases even if the amplitude of the effect is ultimately rather low (peaking at 0.25 % after a few periods).

4 Conclusion

In a monetary union, we focused on spillover effects of a domestic fiscal policy in a monetary union on foreign activity, inflation and unemployment. We assumed that each country in the union contains two different production sectors (tradable and non-tradable goods sectors) and that two kinds of households coexist (Ricardian and non-Ricardian households). In this monetary union, the single central bank sets the nominal interest rate following

a Taylor rule. As to governments, they have at their disposal various fiscal policy instruments, both in terms of public expenditure and taxation. More precisely, we consider six possible fiscal policy instruments: public consumption, social transfers to households, public investment on the public expenditure side; consumption tax (VAT), labor income tax and social protection tax on the revenue side.

The added value of this study is twofold. First, we explicitly take into consideration the effects on the labor market (labor force participation, real wages and employment) of fiscal policy using a micro-founded labor market with a non-Walrasian labor market. Second, we assess the impact of different fiscal policy instruments.

This paper shows that spillover effects of fiscal policy widely depend on what expenditure component or tax is considered. Furthermore, we demonstrate that it is more relevant to split the different fiscal instruments according to the side of the economy they affect (demand or/and supply) rather than splitting the fiscal components between types of taxes and expenditure. Based on the classical transmission channels already highlighted in the literature, we show that the different types of expenditure/taxes produce quite different spillover effects of different sign and size.

As a consequence, policy makers in the EMU should give more consideration to these heterogeneities in fiscal policy instruments if they wish to better coordinate fiscal policies in a monetary union like the Euro Area. The implementation of the European Economic Recovery Plan and of the American Recovery and Reinvestment Act in the aftermath of the global financial crisis was based on the "3T", namely, *timely, temporary and targeted*. In the case of the EMU, in which the Member States had to implement this recovery plan in a coordinated way, the European policy makers should also promote fiscal measures that have positive spillover effects in Member States instruments in order to produce large fiscal multipliers at the monetary union level.

Nevertheless, the assumption relative to purchases by government of goods only produced in the home government may be too strong. Besides, investigating the potential distortion effects of the financing of these expansionary policies, by assuming taxes which increase following an increase in spending for instance, may also be an interesting case to study.

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5 Appendix

A Impulse response functions (IRF) for the different domestic fiscal shocks

Figure 1: Increase in domestic public consumption

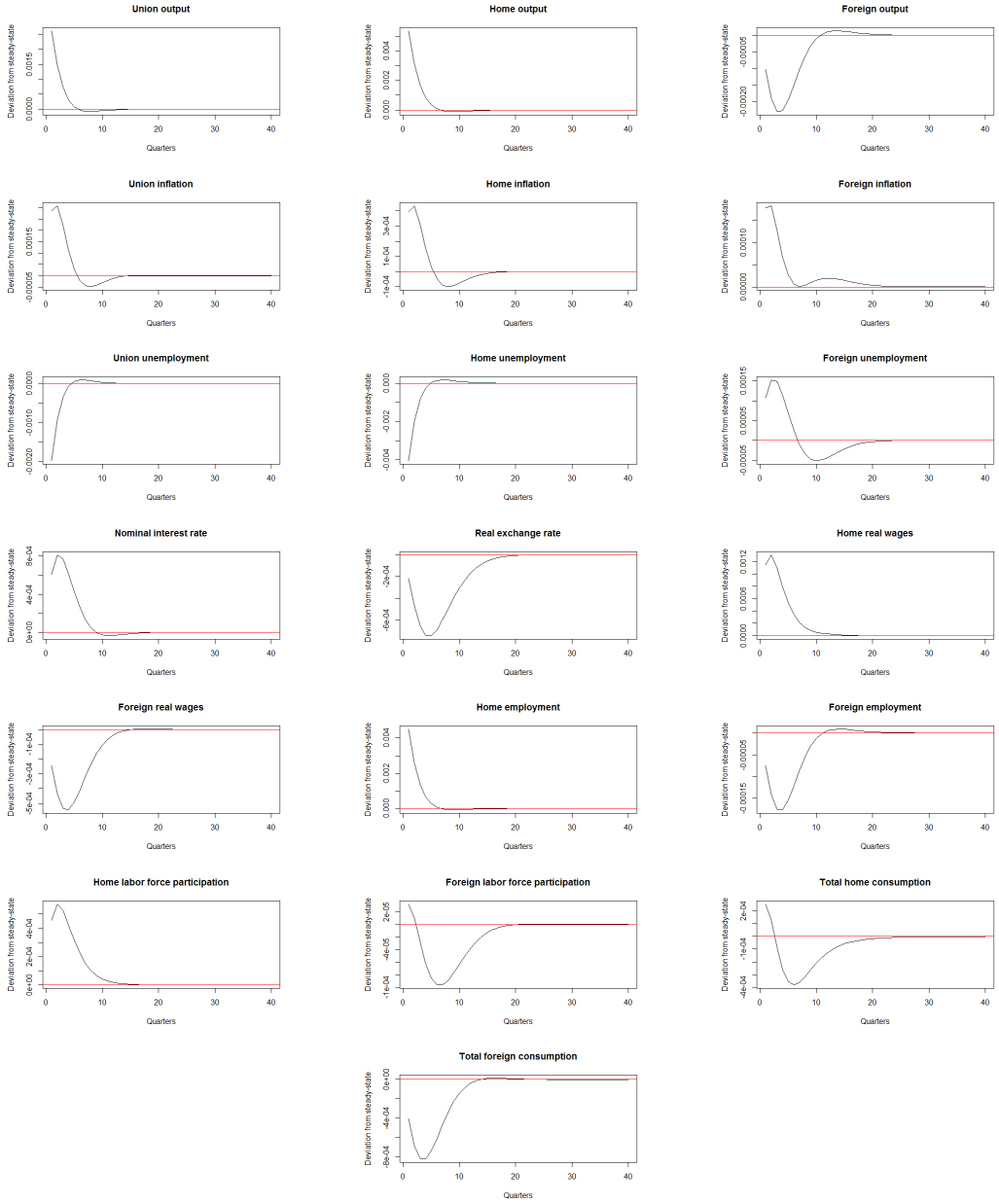


Figure 2: Increase in domestic public transfers

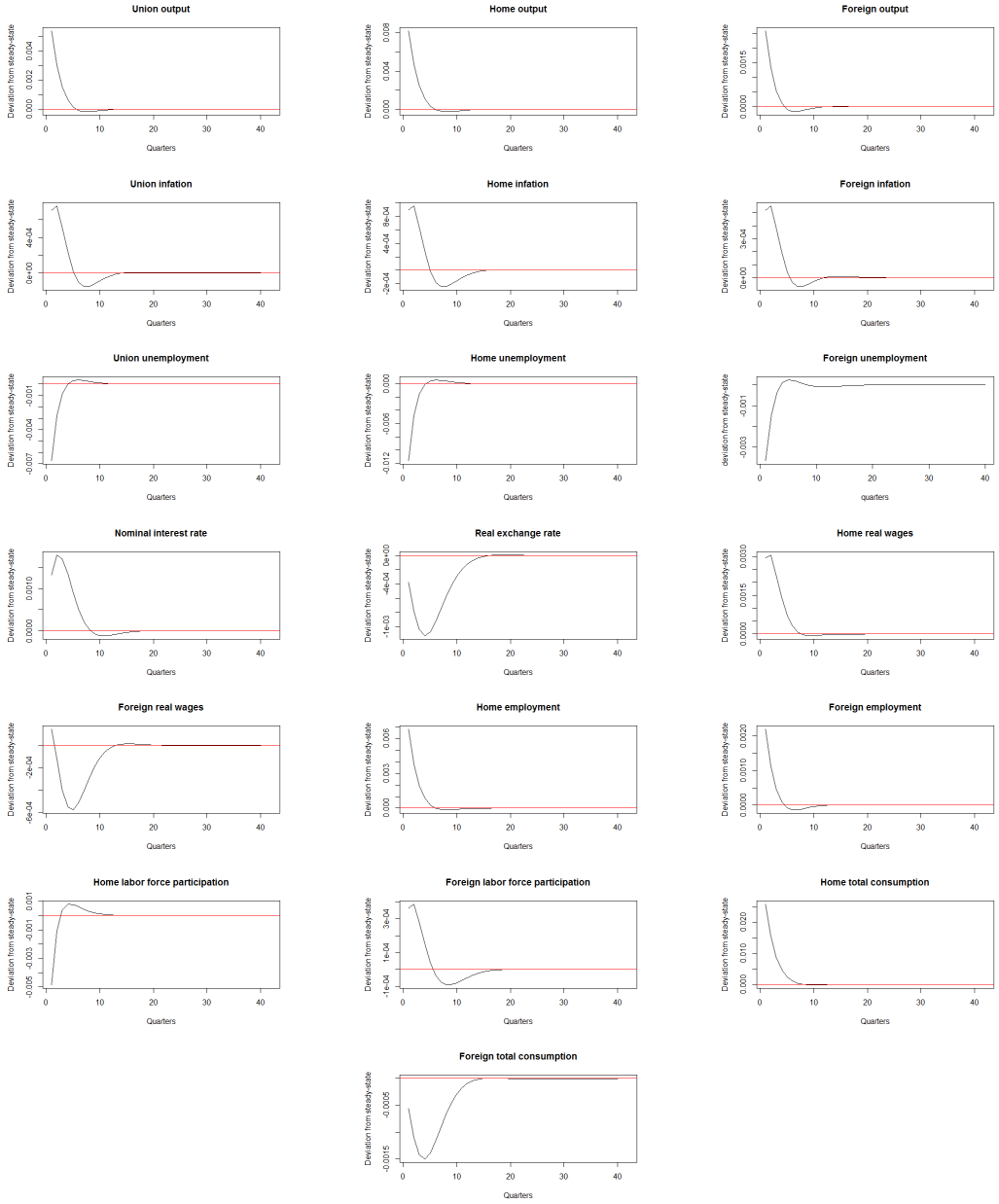


Figure 3: Increase in domestic public investment

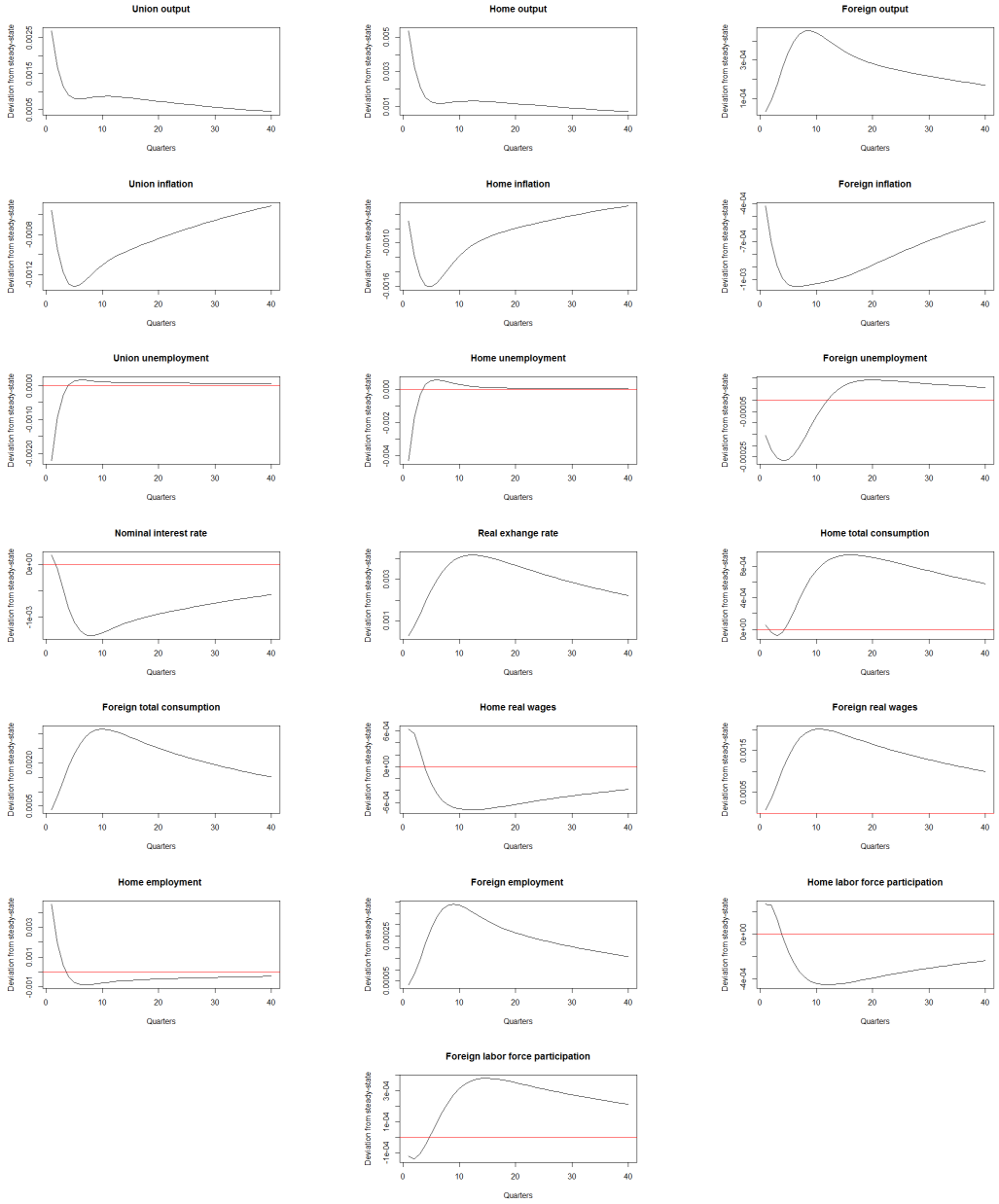


Figure 4: Decrease in domestic VAT

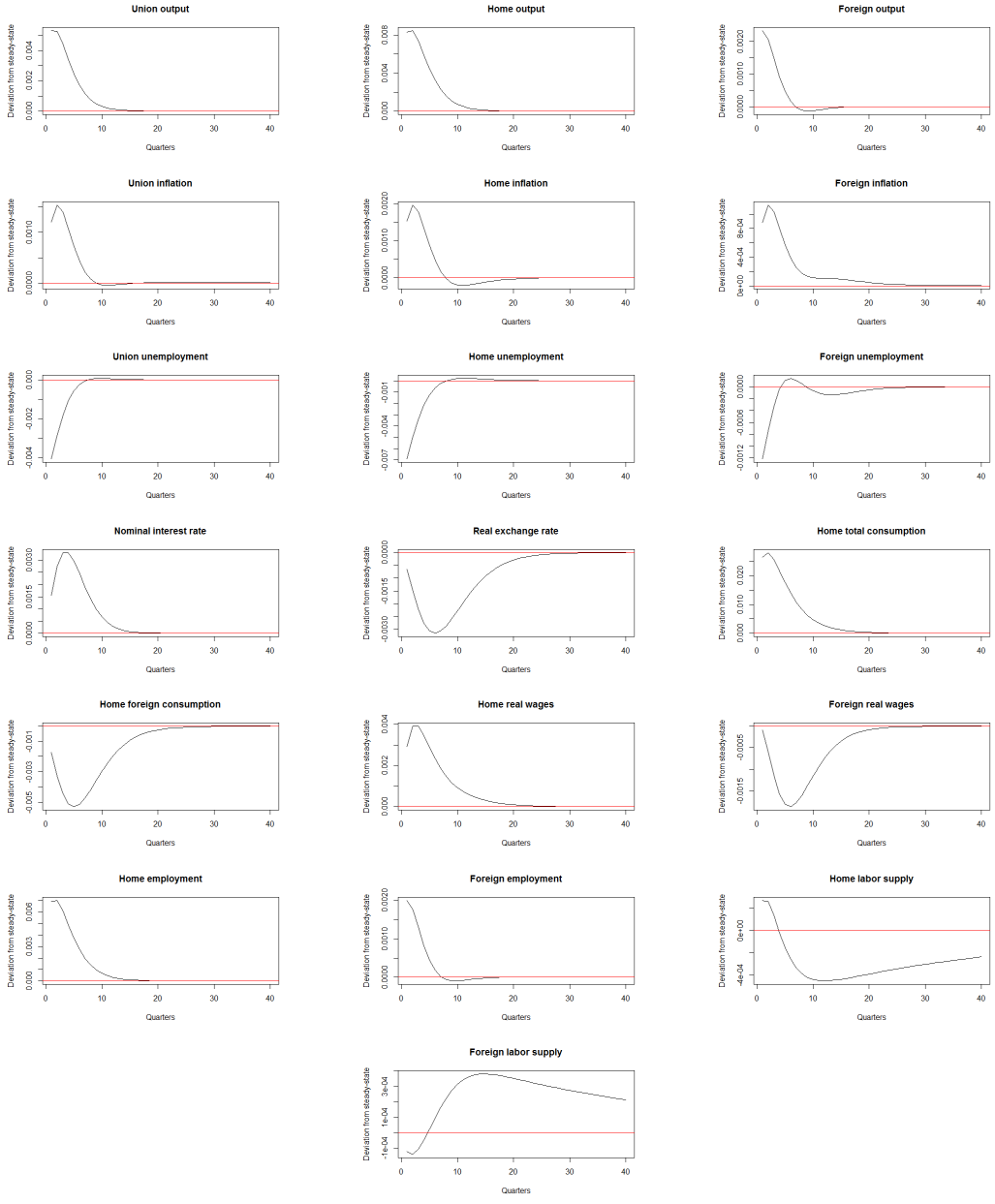


Figure 5: Decrease in domestic social protection tax

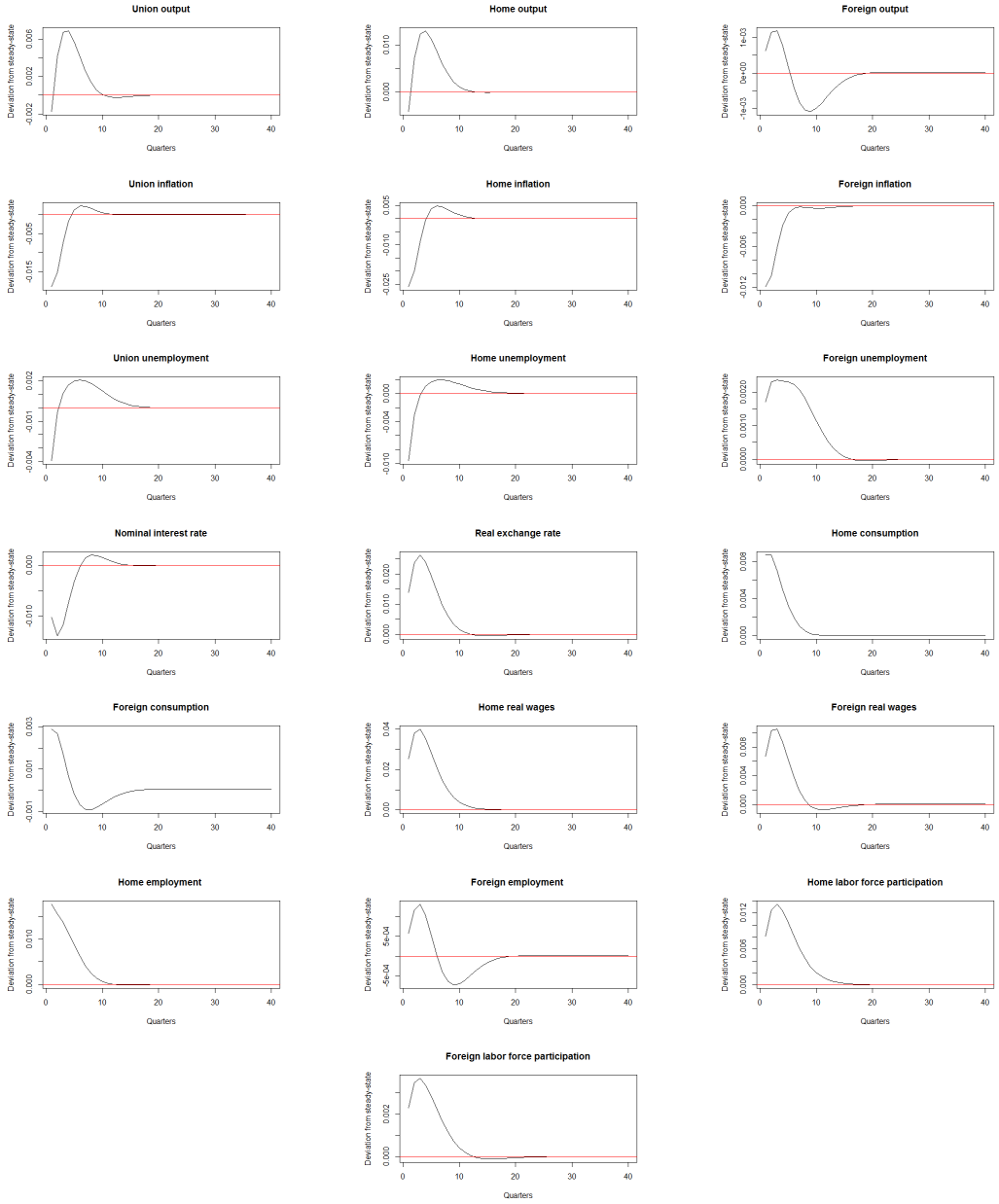
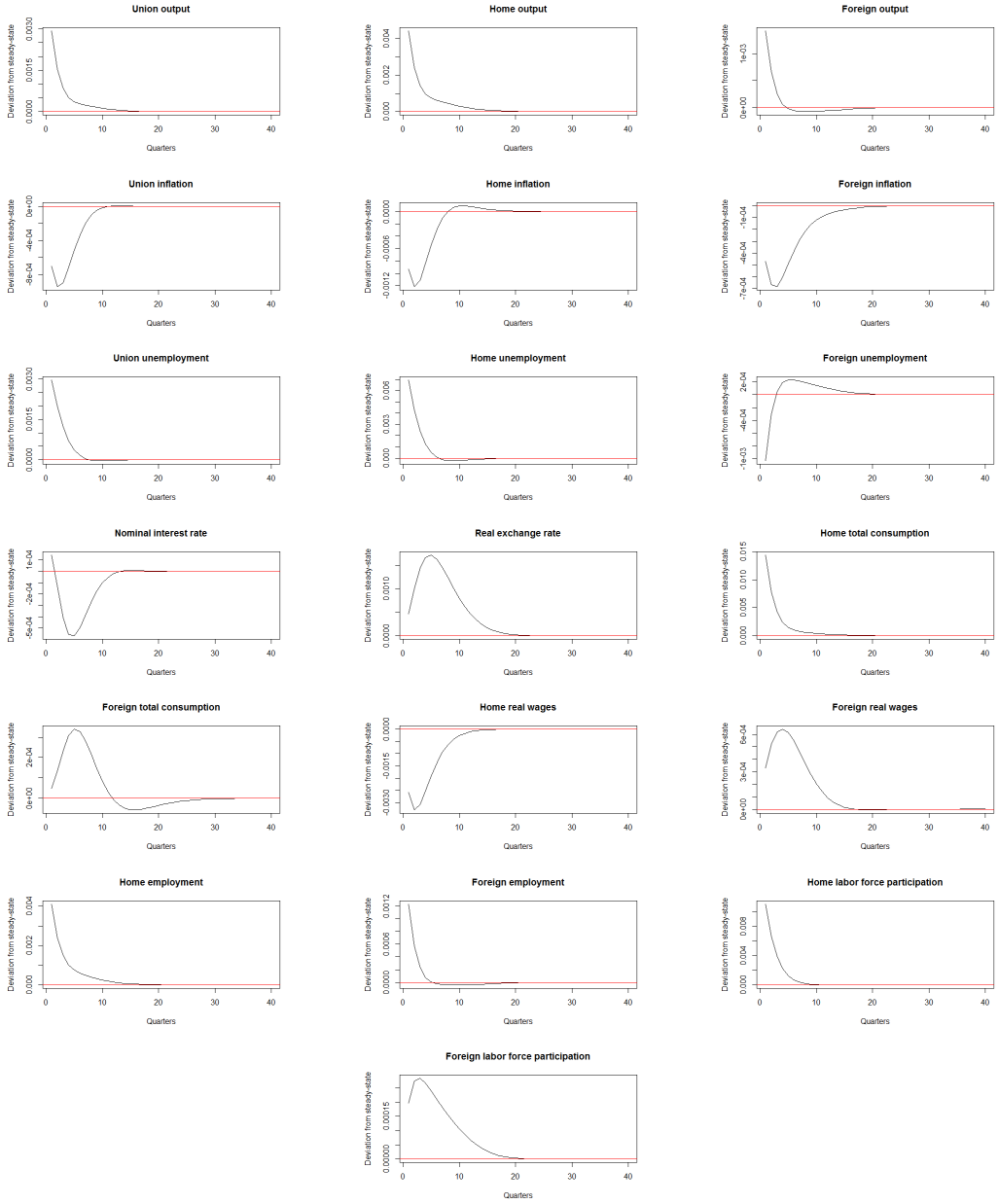


Figure 6: Decrease in domestic labor income tax



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