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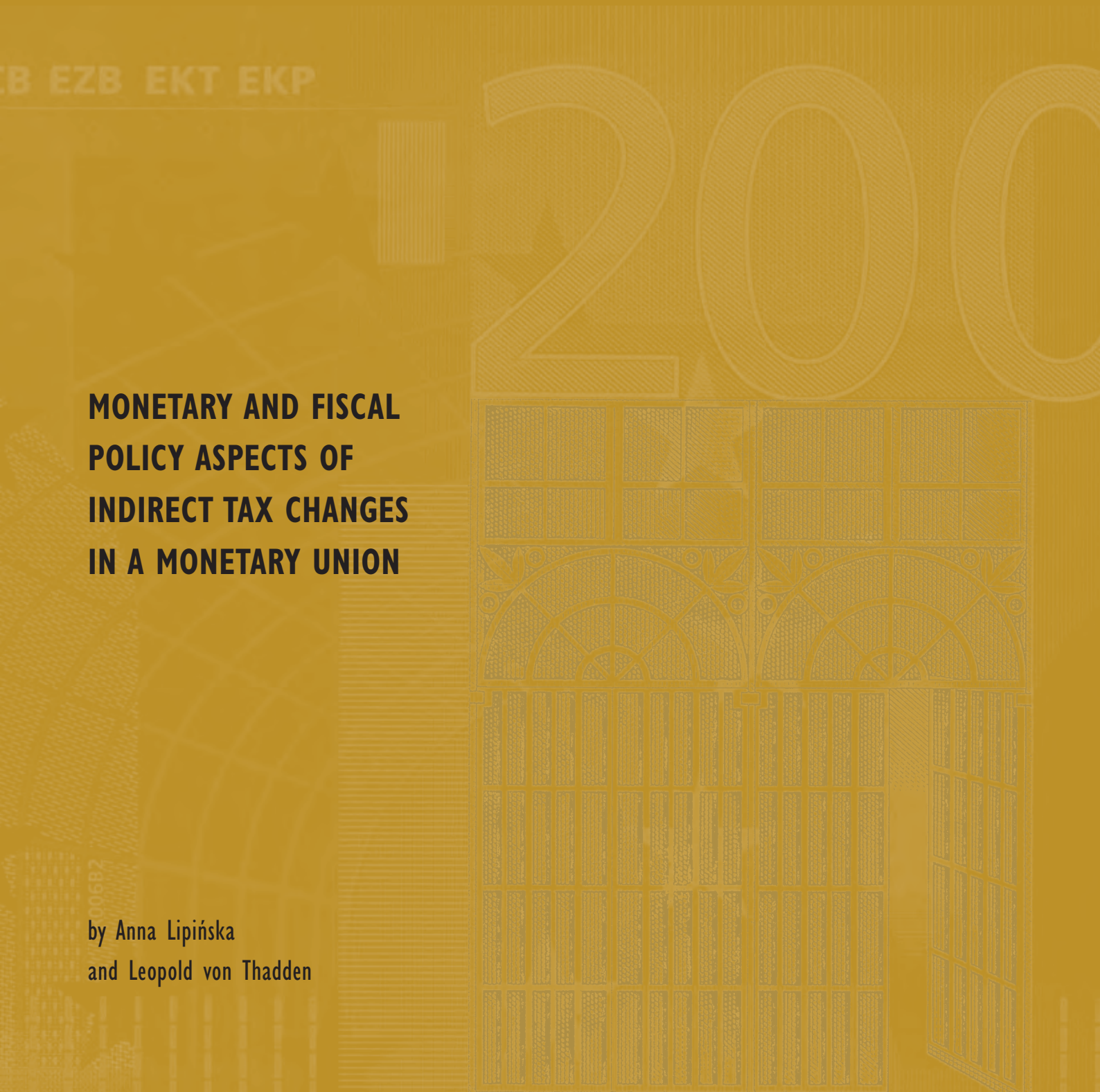

MONETARY AND FISCAL POLICY ASPECTS OF INDIRECT TAX CHANGES IN A MONETARY UNION

by Anna Lipińska
and Leopold von Thadden

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CONTENTS

Abstract

In recent years a number of European countries have shifted their tax structure more strongly towards indirect taxes, motivated, inter alia, by the intention to foster competitiveness. Against this background, this paper develops a tractable two-country model of a monetary union, characterised by national fiscal and supranational monetary policy, with price-setting firms and endogenously determined terms of trade. The paper discusses a number of monetary and fiscal policy questions which emerge if one of the countries shifts its tax structure more strongly towards indirect taxes. Qualitatively, it is shown that the long-run effects of such a unilateral policy shift on output and consumption within and between the two countries depend sensitively on whether indirect tax revenues are used to lower direct taxes or to finance additional government expenditures. Moreover, short-run dynamics are shown to depend significantly on the speed at which fiscal adjustments take place, on the choice of the inflation index stabilised by the central bank, and on whether the tax shift is anticipated or not. Quantitatively, the calibrated model version indicates that only if the additional indirect tax revenues are used to finance a cut in direct taxes there is some, though limited scope for non-negligible spillovers between countries.

Keywords: Fiscal regimes, Monetary policy, Currency union

JEL Classification: E61, E63, F42.

Non-technical summary

It is well-known that the structures of taxation differ significantly between European countries. One important source of cross-country differences is the role of indirect taxes. In the year 2006, the share of indirect taxes in total taxation (including social security contributions) stood for the European Union as a whole at 34.9%. Yet, the dispersion of this share across countries was substantial, ranging from about 50% in Bulgaria and Cyprus to about 30% in Belgium, Germany, and the Czech Republic. At the same time, notwithstanding this variation across countries, the share for the EU as a whole has risen over time and was in 2006 by 1.2pp higher than in 1995. Overall, indirect taxes have become the main source of tax revenues in the EU (amounting in 2006 to 13.9% of GDP), followed by direct taxes (13.5% of GDP) and social security contributions (12.5% of GDP). These developments reflect that in recent years a number of countries have decided to give indirect taxes (relative to taxes on labour), at least at the margin, a more prominent role in their tax systems. Moreover, there is an ongoing debate whether employment and output prospects of European countries can be systematically improved via reforms that involve a more broad-based shift of the tax structure from direct taxes and social security contributions towards indirect taxes.

What can be expected from reform proposals which advocate a shift of tax systems towards indirect taxes? This paper starts out from the idea that, when addressing this inherently complex question, it is helpful to distinguish from a general equilibrium perspective between open and closed economy aspects. We focus on the first type of aspects. In particular, this paper is inspired by the observation that one argument that is typically used in this context refers to the desirability to improve the competitiveness of economies. This particular argument relies largely on the idea that in an open economy context there seems to be scope for balanced-budget tax reforms which shift the tax incidence towards 'immobile' consumers and at the same time, through lower direct taxes, make tradeable production more competitive. This reasoning (which is commonly labeled as the 'fiscal devaluation hypothesis'), however, is controversial. In particular, competitive equilibrium analysis of a small price-taking economy suggests that an across-the-board increase in consumption taxes (which do not discriminate between domestic and imported consumption goods and are rebated on exports), accompanied by a balanced-budget cut in labour taxes, may well be neutral with respect to trade, as summarised by Feldstein and Krugman (1990). In other words, the fiscal devaluation hypothesis may have no bite unless the terms of trade themselves react to changes in the tax structure.

Motivated by these broad observations, this paper addresses the fiscal devaluation hypothesis in a two-country model of a monetary union with endogenously derived terms of trade. The model, which is similar to Benigno (2004), Duarte and Wolman (2008), and Ferrero (2009), is kept deliberately small in order to allow for a transparent discussion of a broad range of monetary and fiscal policy aspects which emerge if one member country of a monetary union unilaterally shifts its tax structure from direct towards indirect taxes. Focusing on both long-run and short-run effects, we link the fiscal devaluation channel to a number of features like the size and the degree of openness of the two countries, the speed at which the increase in indirect taxes leads to a compensating decline in direct taxes, the choice of the inflation index stabilized by monetary policy, and the role of anticipation effects of

pre-announced fiscal reforms. Our main finding is that qualitatively all these features matter for the strength of the fiscal devaluation channel and the exact shape of dynamic adjustment patterns. Quantitatively, however, our conclusion is rather unambiguous. The calibrated model indicates that there is at best limited scope for non-negligible spillovers between countries under any specification we investigate. Moreover, we show in a separate exercise that the fiscal devaluation channel disappears if the additional indirect tax revenues are used to increase government expenditures rather than to lower direct taxes.

Key features of the model are as follows. To allow for non-trivial price-setting decisions of firms, production in both countries is characterised by Dixit-Stiglitz-type monopolistic competition. Monetary policy has a meaningful stabilisation role because of nominal price rigidities, in line with New Keynesian reasoning (see Calvo (1983), Clarida et al. (1999), and Woodford (2003)). Moreover, monetary policy is supranational and follows a Taylor-type feedback rule, targeting union-wide variables. By contrast, fiscal policy is country-specific, and government expenditures and interest payments on outstanding government debt can be financed through a linear (and non-discriminating) consumption tax or a linear tax on labour income (with labour being the only factor of production). Fiscal policymakers follow feedback rules which anchor the economies at country-specific target levels of government debt, similar to Leeper (1991), Schmitt-Grohé and Uribe (2007) and Leith and von Thadden (2008). Each country is specialised in the production of a composite tradeable good which is consumed in both countries. Firms set identical producer prices in both countries and the terms of trade (i.e. the producer price ratio between the two composite tradeable goods) depend in general equilibrium, inter alia, on the structure of taxes and government expenditures in the two countries. The two countries may be of different relative size, measured in terms of the share of goods produced in a country, holding constant the total number of goods produced in the monetary union. Finally, we assume complete asset markets between the two countries such that net foreign asset movements play no role.

1 Introduction

It is well-known that the structures of taxation differ significantly between European countries. One important source of cross-country differences is the role of indirect taxes. In the year 2006, the share of indirect taxes in total taxation (including social security contributions) stood for the European Union as a whole at 34.9%. Yet, the dispersion of this share across countries was substantial, ranging from about 50% in Bulgaria and Cyprus to about 30% in Belgium, Germany, and the Czech Republic. At the same time, notwithstanding this variation across countries, the share for the EU as a whole has risen over time and was in 2006 by 1.2pp higher than in 1995. Overall, indirect taxes have become the main source of tax revenues in the EU (amounting in 2006 to 13.9% of GDP), followed by direct taxes (13.5% of GDP) and social security contributions (12.5% of GDP).[1] These developments reflect that in recent years a number of countries have decided to give indirect taxes (relative to taxes on labour), at least at the margin, a more prominent role in their tax systems. Moreover, there is an ongoing debate whether employment and output prospects of European countries can be systematically improved via reforms that involve a more broad-based shift of the tax structure from direct taxes and social security contributions towards indirect taxes.[2]

What can be expected from reform proposals which advocate a shift of tax systems towards indirect taxes? This paper starts out from the idea that, when addressing this inherently complex question, it is helpful to distinguish from a general equilibrium perspective between open and closed economy aspects. We focus on the first type of aspects.[3] In particular, this paper is inspired by the observation that one argument that is typically used in this context refers to the desirability to improve the competitiveness of economies. This particular argument relies largely on the idea that in an open economy context there seems to be scope for balanced-budget tax reforms which shift the tax incidence towards 'immobile' consumers and at the same time, through lower direct taxes, make tradeable production more competitive. This reasoning (which is commonly labeled as the 'fiscal devaluation hypothesis'), however, is controversial. In particular, competitive equilibrium analysis of a small price-taking economy suggests that an across-the-board increase in consumption taxes (which do not discriminate between domestic and imported consumption goods and are rebated on exports), accompanied by a balanced-budget cut in labour taxes, may well be neutral with respect to trade, as summarised by Feldstein and Krugman (1990). In other words, the fiscal devaluation hypothesis may have no bite unless the terms of trade themselves react to changes in the tax structure.[4]

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[1] For a detailed description of European taxation structures from a cross-country perspective, see, in particular, European Commission (2008). The reported numbers (which are taken from this study) do not yet include the effects of the substantial increase in German VAT by 3pp in 2007 which was partly offset by reduced contributions to the unemployment insurance scheme.

[2] For a broad discussion of recent policy initiatives and proposals that advocate a shift of tax systems towards indirect taxes, both at the European level and within individual member countries, see European Commission (2006, 2008).

[3] We touch on the second type of aspects in Section 4 which discusses a closed economy version of our set-up as a limiting case. Yet, as argued in this section, our model is too stylised to address closed-economy aspects in much detail.

[4] Within the European context, the fiscal devaluation hypothesis may have particular appeal for countries belonging to the euro area which share an irrevocably fixed nominal exchange rate, a feature which makes it elusive to affect the competitiveness of economies through nominal exchange rate adjustments.

taxes, the choice of the inflation index stabilized by monetary policy, and the role of anticipation effects of pre-announced fiscal reforms. Our main finding is that qualitatively all these features matter for the strength of the fiscal devaluation channel and the exact shape of dynamic adjustment patterns. Quantitatively, however, our conclusion is rather unambiguous. The calibrated model indicates that there is at best limited scope for non-negligible spillovers between countries under any specification we investigate. Moreover, we show in a separate exercise that the fiscal devaluation channel disappears if the additional indirect tax revenues are used to increase government expenditures rather than to lower direct taxes.

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Within this broad set-up, we assume first that the 'home' country changes its long-run fiscal priorities and decides once and for all, at unchanged government expenditures, to permanently increase its consumption tax. In line with the fiscal devaluation hypothesis, the additional consumption tax revenues are used to reduce the labour tax such that the home country's long-run level of real government debt stays unchanged, consistent with the target level. The 'foreign' country does not have actively any intention to change its taxes and government spending levels, but, to keep its own level of real debt on target, it reacts passively by adjusting its labour tax. In sum, the consumption tax changes only in the home country, while labour taxes adjust endogenously in both countries.

To summarise the results of this experiment, it is convenient to distinguish between long-run effects (pertaining to steady-state comparisons) and short-run effects (pertaining to the transitional dynamics between steady states). The tax shift leads to a long-run increase in the terms of trade (indicating the improved competitiveness of the home economy), ensuring that home output rises, while foreign output declines. Moreover, reflecting changes in consumer prices (which include consumption taxes) as well as the role of complete asset markets, home consumption decreases, while foreign consumption increases.[5]

As a general feature, within our model the strength of the terms of trade channel on home variables decreases in the relative size of the home country. In other words, as the home country becomes small, this strengthens the effects of the fiscal devaluation channel on home consumption and output levels, indicating that under Dixit-Stiglitz monopolistic competition the price setting power of a country does not vanish as a country becomes small. Quantitatively, for our symmetric benchmark calibration of two equally sized countries exhibiting some home bias (such that home (foreign) produced goods make up 75% of home (foreign) consumed goods) long-run spillovers between countries are limited, but not

[5] For a thorough analysis of patterns in which, because of the terms of trade channel, output effects between countries are of the beggar-thy-neighbour type, while consumption effects are beggar-thyself, see Corsetti and Pesenti (2001).

entirely negligible, i.e. a permanent increase in the home consumption tax by 1pp decreases foreign output in the long-run by 0.11%, while home output rises by 0.15 %. From a short-run perspective, all effects (within and between countries) are shown to depend on a number of additional channels which we discuss in isolated experiments. Specifically, depending on whether i) the compensating decline in the labour tax allows for a permanently balanced budget or temporary budget imbalances, ii) the central bank's objective is specified in terms of pre-tax or after-tax consumer price inflation, and iii) the tax shift is anticipated by the private sector or not, short-run dynamics exhibit significant differences. For the particular combination of permanently balanced budgets, an inflation objective in terms of pre-tax consumer prices and a non-anticipated tax shift our analysis reveals that the central bank may not face any aggregate (pre-tax) inflationary pressure (because of offsetting deflationary and inflationary impact effects in the home and foreign country, respectively) such that union-wide monetary policy remains neutral with respect to the fiscal reform in the home country. However, departures from these particular assumptions lead to less symmetric constellations in which the feedback of union-wide monetary policy matters for the pattern of short-run dynamics in both countries.

We then compare these results with a second, separate tax change scenario in which the home country permanently increases its consumption tax to finance additional government expenditures at unchanged direct taxes. Ceteris paribus, in this second scenario the consumption tax changes only in the home country, while government expenditures adjust in both countries such that the long-run levels of government debt remain unchanged at constant labour tax rates. As we discuss in detail in Section 6, this scenario no longer supports the fiscal devaluation channel and leads to distinctly different long-run effects and transitional dynamics.[6] In short, this scenario serves the purpose to illustrate that it is impossible to assess the effects of an increase in the consumption tax in isolation, i.e. without a comprehensive description of the fiscal environment in which the tax change takes place.

It is worth stressing that our analysis is exclusively concerned with positive implications of fiscal reforms undertaken in the home country. Hence, we do not address strategic aspects of optimal monetary and fiscal policies in monetary unions, as explored, for example, by Lombardo and Sutherland (2004), Beetsma and Jensen (2005), Ferrero (2009), and Gali and Monacelli (2008). In particular, the beggar-thy-neighbour-type output effects of the fiscal devaluation hypothesis would be counteracted in (cooperative or non-cooperative) optimal policy settings in which both countries are allowed to choose optimal actions. In line with our positive approach, Roeger and in't Veld (2006) and European Commission (2008), using a richer model structure, assess quantitatively the effects of unilateral tax shifts towards indirect taxation within EMU. The order of magnitude of long-run output effects is similar to our benchmark findings. Yet, as discussed in more detail in Section 4 (together with further contributions from the literature), the role of the terms of trade is less important and, differently from the focus of our paper, these studies do not address in analytical detail the open-economy dimension of unilateral tax shifts. More closely related to our monetary union set-up, Duarte and Wolman (2008) explore the ability of national fiscal policies to reduce inflation differentials with respect to union-wide average inflation. However, the paper focuses on the design of systematic fiscal stabilisation rules in a business cycle context (and not on the effects of lasting changes in tax structures which are the focus of our paper).[7] Coenen et al. (2008) use a large scale two-country model to investigate systematic effects of tax reforms for the euro area as a whole, focusing on tax-related labour market distortions

[6] The very different dynamics of the two experiments have counterparts in the closed-economy literature on balanced-budget rules. Schmitt-Grohé and Uribe (1997), Guo and Harrison (2004), and Giannitsarou (2007) show that stability and determinacy requirements differ significantly, depending on whether budget balance is achieved by labour or consumption taxes or by government spending adjustments.

[7] Canzoneri et al. (2005) develop a monetary union model which allows for countries of different size and asymmetric fiscal positions, in line with stylised features of euro area countries. The paper argues that fiscal shocks, compared with other shocks, are relatively unimportant for the explanation of inflation differentials in the euro area. Differently from our paper, however, the paper does not investigate systematic effects of country-specific changes in fiscal policy.

in the euro area relative to the US economy. However, the focus is on international spillovers, while, by construction, there is no scope for spillovers between euro area countries.
The paper is structured as follows. Section 2 summarises the model. Section 3 presents the benchmark calibration. Sections 4 and 5 discuss long-run and short-run effects, respectively, of a tax shift in the home country, in line with the fiscal devaluation hypothesis. Section 6 discusses the second experiment of a consumption tax financed increase in home government expenditures. Section 7 concludes. Technical material as well as various impulse response figures are displayed in the Appendix.

2 The model

We consider a small-scale model of a monetary union which consists of two countries, similar to Benigno (2004), Duarte and Wolman (2008), and Ferrero (2009). For convenience we label these two countries as 'home' and 'foreign'. Fiscal policy is country-specific. By contrast, monetary policy is supranational and the common central bank targets union-wide variables. The two economies are structurally identical, but we allow for differences in size. The description of the model economy, unless explicitly needed, is kept short since most of the assumed New Keynesian open economy features are standard (see, in particular, Obstfeld and Rogoff, 1996). We treat in the following the home country as the representative one to avoid duplication of notation whenever possible.

2.1 Consumers

The monetary union consists of a measure one of consumers of which $[0, n)$ belong to the home country and $[n, 1]$ to the foreign country. Each of the two countries produces a composite tradeable good. The two composite goods consist of differentiated home tradeable goods, indexed on the interval $[0, n)$, and foreign tradeable goods, indexed on the interval $[n, 1]$, respectively. Hence, the parameter n measures the size of the home country both in terms of population size and in terms of the share of produced goods. Home and foreign consumers are infinitely lived. In each country, consumers demand a mix of home and foreign produced tradeable goods which enter an aggregate consumption index as described below. Let C_t and L_t denote private consumption and the labour supply of the representative home consumer in period t. As of period $t = 0$, this consumer maximises the following utility function:[8]

$$\max E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[U\left(C_t\right) - V\left(L_t\right) \right] \right\}, \tag{1}$$

where E_0 denotes the expectation conditional on the information set at date $t = 0$, β is the intertemporal discount factor (with $0 < \beta < 1$) and U and V denote the flow utilities from consumption and labour, assumed to be additively separable. The home consumption index C_t, made up of home tradeable goods ($C_{H,t}$) and foreign tradeable goods ($C_{F,t}$), is given by

$$C_t = \left[\nu^{\frac{1}{\phi}} C_{H,t}^{\frac{\phi-1}{\phi}} + (1-\nu)^{\frac{1}{\phi}} C_{F,t}^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}},$$

where $\phi > 0$ denotes the elasticity of substitution between home and foreign goods and ν represents the share of home goods in the basket of home consumers if the prices of $C_{H,t}$ and $C_{F,t}$ are equal.

[8] In order to have a well defined maximisation problem we assume that U is twice continously differentiable, increasing and concave in C_t, while V is twice continously differentiable, increasing and convex in L_t. For the specific functional forms, see Section 2.6.

Moreover, let $\nu = 1-(1-n)\lambda$, where $\lambda \in (0,1]$ denotes the degree of openness of the home country. Similarly we write the consumption bundle of the representative foreign consumer as

$$C_t^* = \left[\nu^{*\frac{1}{\phi^*}} C_{H^*,t}^{\frac{\phi^*-1}{\phi^*}} + (1-\nu^*)^{\frac{1}{\phi^*}} C_{F^*,t}^{\frac{\phi^*-1}{\phi^*}} \right]^{\frac{\phi^*}{\phi^*-1}},$$

where $\nu^* = n\lambda^*$ relates to the share of home goods in the basket of foreign consumers and $\lambda^* \in (0,1]$ denotes the degree of openness of the foreign economy. In the benchmark calibration reported below we allow for home bias, i.e. home consumers demand relatively more home goods than foreign consumers and vice versa, implying $\nu > \nu^*$. The variables C_j and C_{j^*} (where $j = H, H^*$ and $j^* = F, F^*$) are composite goods which bundle together the underlying individual tradeable goods according to

$$C_{j,t} = \left[\left(\frac{1}{n}\right)^{\frac{1}{\sigma}} \int_0^n c_{j,t}(h)^{\frac{\sigma-1}{\sigma}} dh \right]^{\frac{\sigma}{\sigma-1}}, \; C_{j^*,t} = \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\sigma^*}} \int_n^1 c_{j^*,t}(f)^{\frac{\sigma^*-1}{\sigma^*}} df \right]^{\frac{\sigma^*}{\sigma^*-1}},$$

where $\sigma > 1$, $\sigma^* > 1$ denote the constant elasticities of substitution between the components in each country. Consistent with these aggregators, the consumption-based price indices in the two countries are given by

$$P_t = \left[\nu P_{H,t}^{1-\phi} + (1-\nu) P_{F,t}^{1-\phi} \right]^{\frac{1}{1-\phi}} \tag{2}$$

$$P_t^* = \left[\nu^* P_{H^*,t}^{1-\phi^*} + (1-\nu^*) P_{F^*,t}^{1-\phi^*} \right]^{\frac{1}{1-\phi^*}}, \tag{3}$$

$$P_{j,t} = \left[\left(\frac{1}{n}\right) \int_0^n p_{j,t}(h)^{1-\sigma} dh \right]^{\frac{1}{1-\sigma}}, \; P_{j^*,t} = \left[\left(\frac{1}{1-n}\right) \int_n^1 p_{j^*,t}(f)^{1-\sigma^*} df \right]^{\frac{1}{1-\sigma^*}}.$$

Firms are assumed to charge identical producer prices in the two countries ($p_{H,t}(h) = p_{H^*,t}(h) \equiv p_t(h)$ and $p_{F,t}(f) = p_{F^*,t}(f) \equiv p_t(f)$), i.e. the law of one price holds at the producer price level such that $P_{H,t} = P_{H^*,t}$ and $P_{F,t} = P_{F^*,t}$. Let the real exchange rate be defined as $RS_t = \frac{P_t^*}{P_t}$. Then, in the presence of home bias, purchasing power parity does not hold ($P_t \neq P_t^*$) and the real exchange rate may fluctuate over time. Moreover, we define the terms of trade as $T_t = \frac{P_{F,t}}{P_{H,t}}$.

In line with Duarte and Wolman (2008), we assume that consumers have access to a complete set of state-contingent claims traded between home and foreign consumers (in equilibrium restricted to be in zero net supply), ensuring thereby that net foreign asset movements play no role in the transmission of shocks.[9] Consumers also hold riskless nominal government bonds. Moreover, consumers own the firms of their own country. In sum, the representative consumer of the home country faces in period t the budget constraint

$$\left(1+\tau_t^C\right) P_t C_t + E_t\{Q_{t,t+1} D_{t+1}\} + B_{H,t} \leq D_t + \left(1-\tau_t^L\right) W_{H,t} L_t + \frac{\int_0^n \Pi_t(h) dh}{n} + R_{t-1} B_{H,t-1}, \tag{4}$$

where $W_{H,t}$, τ_t^L, and τ_t^C denote the nominal wage, the labour tax rate and the consumption tax rate, respectively. $\Pi_t(h)$ represents the nominal profit of home firm h, while $B_{H,t-1}$ denotes one–period

[9] For details on this and discussions of differences between complete and incomplete market structures, see, for example, Chari, Kehoe, and McGrattan (2002) and Ghironi (2006).

home government bonds (purchased in period $t-1$ and redeemed in period t), measured in per-capita terms. Moreover, $R_{t-1} = 1 + i_{t-1}$ denotes the nominal interest factor paid on these bonds in period t, respectively.[10] Finally, D_t represents the consumer's nominal state-contingent payoffs in period t (on a portfolio chosen in period $t-1$), while $Q_{t,t+1}$ denotes the stochastic discount factor for one-period ahead nominal payoffs which is relevant for the home consumer in choosing his portfolio in period t. A similar budget constraint applies for consumers in the foreign country. In both countries consumers face no-Ponzi restrictions. For simplicity, we assume that both economies operate at the cashless limit. The nominal interest rate is defined as the price of the portfolio which delivers one unit of currency in each contingency that can occur next period

$$\frac{1}{1+i_t} = E_t\{Q_{t,t+1}\}$$

In sum, the optimisation problem of the home consumer amounts to choose paths of private consumption (C_t), labour supply (L_t), state contingent claims (D_{t+1}) and government bonds ($B_{H,t}$) in order to maximise (1) subject to the budget constraint (4), $\forall t \geqslant 0$.
The solution to this problem is characterised by a number of well-known first-order conditions, describing optimal consumer behaviour. Intertemporal optimality of portfolio decisions leads to the following Euler equations for home and foreign consumers:

$$U_C(C_t) = \beta E_t \left\{ U_C(C_{t+1}) Q_{t,t+1}^{-1} \frac{1+\tau_t^C}{1+\tau_{t+1}^C} \frac{P_t}{P_{t+1}} \right\} \tag{5}$$

$$U_C(C_t^*) = \beta E_t \left\{ U_C(C_{t+1}^*) Q_{t,t+1}^{-1} \frac{1+\tau_t^{C*}}{1+\tau_{t+1}^{C*}} \frac{P_t^*}{P_{t+1}^*} \right\} \tag{6}$$

The assumption of complete asset markets in this setting ensures that the marginal rates of substitution in consumption are equalised between countries in all states and at all times in nominal terms (after tax) such that the following condition holds

$$\frac{U_C(C_{t+1}^*)}{U_C(C_t^*)} \frac{P_{t+1}}{P_t} \frac{1+\tau_{t+1}^C}{1+\tau_t^C} = \frac{U_C(C_{t+1})}{U_C(C_t)} \frac{P_{t+1}^*}{P_t^*} \frac{1+\tau_{t+1}^{C*}}{1+\tau_t^{C*}}.$$

After choosing appropriately the distribution of initial wealth, one obtains

$$\frac{U_C(C_t)}{U_C(C_t^*)} = \upsilon \frac{P_t}{P_t^*} \frac{1+\tau_t^C}{1+\tau_t^{C*}}, \tag{7}$$

where the parameter $\upsilon > 0$ depends on the initial wealth distribution, measured in terms of after-tax consumer prices. This relationship implies that in all states and at all times there is a strong correlation between home and foreign private consumption. In particular, in the absence of home bias and assuming identical consumption tax rates, per capita consumption levels will be equalised in both countries. The optimal labour supply satisfies the static first-order condition,

$$\frac{V_L(L_t)}{U_C(C_t)} = \frac{1-\tau_t^L}{1+\tau_t^C} \frac{W_{H,t}}{P_t} \tag{8}$$

where $(1-\tau_t^L)/(1+\tau_t^C)$ captures the relevant tax wedge for the labour-consumption trade-off. Finally, let $G_{H,t}$ and $G_{F,t}$ denote the (per capita) levels of composite government expenditures in the two

[10] One could assume, more generally, that home consumers can also hold riskless foreign government bonds $B_{F,t-1}$ (paying the same nominal equilibrium interest factor R_{t-1}), and vice versa, as considered by Duarte and Wolman (2008). Given the supply of government bonds introduced below, this would affect none of our results.

countries. As concerns the composition of these goods in terms of individual components, we assume perfect home bias for government expenditures. Combined with optimal consumer behaviour, this implies that the demand for generic home and foreign tradeable goods can be written as

$$y_t(h) = \left[\frac{p_t(h)}{P_{H,t}}\right]^{-\sigma} \left\{ \left[\frac{P_{H,t}}{P_t}\right]^{-\phi} \nu C_t + G_{H,t} + \left(\frac{P_{H,t}}{P_t^*}\right)^{-\phi^*} \frac{\nu^*(1-n)}{n} C_t^* \right\} = \left[\frac{p_t(h)}{P_{H,t}}\right]^{-\sigma} Y_{H,t}. \quad (9)$$

$$y_t(f) = \left[\frac{p_t(f)}{P_{F,t}}\right]^{-\sigma^*} \left\{ \left[\frac{P_{F,t}}{P_t}\right]^{-\phi} \frac{(1-\nu)n}{1-n} C_t + \left[\frac{P_{F,t}}{P_t^*}\right]^{-\phi^*} (1-\nu^*) C_t^* + G_{F,t} \right\} = \left[\frac{p_t(f)}{P_{F,t}}\right]^{-\sigma^*} Y_{F,t} \quad (10)$$

where $Y_{H,t}$ and $Y_{F,t}$ denote per capita levels of composite home and foreign output, respectively.

2.2 Firms

Output markets are subject to monopolistic competition, while labour markets (with labour being the only production input) are perfectively competitive within each of the two countries. Labour is immobile between the two countries. Consider the home country. Let $A_{H,t}$ denote the home level of labour productivity (assumed, for simplicity, to be identical across home sectors). Output of the representative home firm h is produced according to the linear production function

$$y_t(h) = A_{H,t} L_t(h) \quad (11)$$

where $L_t(h)$ denotes the labour input used by firm h. Notice that competitive equilibria (as further discussed below) satisfy $L_t = \left(\frac{1}{n}\right) \int_0^n L_t(h)\, dh$, since both workers and firms are of measure n. Nominal wages are taken as given by the representative firm such that nominal marginal costs are identical for all home firms, i.e.

$$MC_{H,t} = \frac{W_{H,t}}{A_{H,t}}.$$

The price-setting of firms is in line with Calvo (1983). Each period a fraction $(1-\alpha)$ of firms has the chance to reset prices in an optimal manner, implying that $P_{H,t}$ follows the law of motion

$$P_{H,t}^{1-\sigma} = \alpha (P_{H,t-1})^{1-\sigma} + (1-\alpha)(\widetilde{p}_t(h))^{1-\sigma},$$

where $\widetilde{p}_t(h)$ denotes the optimal price chosen by home firms in period t which have the chance to adjust prices. The optimal price $\widetilde{p}_t(h)$ solves $\forall t \geqslant 0$ the maximisation problem

$$\max_{p_t(h)} E_t \sum_{s=0}^{\infty} (\alpha)^s Q_{t,t+s} \left[p_t(h) - MC_{H,t+s}\right] y_{t:t+s}(h)$$

$$\text{subject to} \quad y_{t:t+s}(h) = \left(\frac{p_t(h)}{P_{H,t+s}}\right)^{-\sigma} Y_{H,t+s},$$

where $y_{t:t+s}(h)$ denotes the demand for good h at time $(t+s)$, conditional on keeping the price $p_t(h)$ for s periods fixed at the level chosen at time t. The solution of the maximisation problem is characterised by the first-order condition

$$\frac{\widetilde{p}_t(h)}{P_{H,t}} = \frac{\sigma}{\sigma-1} \frac{E_t \sum_{s=0}^{\infty} (\alpha\beta)^s U_C(C_{t+s}) MC^r_{H,t+s} \frac{P_{H,t+s}}{P_{t+s}(1+\tau^C_{t+s})} Y_{H,t+s} \left(\frac{P_{H,t+s}}{P_{H,t}}\right)^{\sigma}}{E_t \sum_{s=0}^{\infty} (\alpha\beta)^s U_C(C_{t+s}) \frac{P_{H,t+s}}{P_{t+s}(1+\tau^C_{t+s})} Y_{H,t+s} \left(\frac{P_{H,t+s}}{P_{H,t}}\right)^{\sigma-1}},$$

where

$$MC^r_{H,t} = MC_{H,t}/P_{H,t}$$

represents real marginal costs in period t, expressed in terms of home producer prices, and where (5) has been used to substitute out for the $Q_{t,t+s}-$terms. Notice that under flexible price setting the optimal price in the representative home sector is set according to the well-known static mark-up equation

$$\frac{\widetilde{p}^{Flex}_t(h)}{P_{H,t}} = \frac{\sigma}{\sigma-1} MC^r_{H,t}. \tag{12}$$

Analogous expressions can be derived for the foreign country.

2.3 Fiscal policies

The fiscal authority in the home country issues one-period nominal debt ($B_{H,t}$) and taxes home labour income at rate τ^L_t and home private consumption expenditures at rate τ^C_t, respectively. Revenues are spent on home government expenditures $G_{H,t}$ (exhibiting perfect home bias) and interest payments on outstanding debt, issued in the previous period.[11] Hence, the home country's flow government budget constraint in nominal terms (and on a per capita basis) is given by

$$B_{H,t} = R_{t-1}B_{H,t-1} - s_{H,t},$$

with the nominal primary surplus ($s_{H,t}$) being defined as

$$s_{H,t} = \tau^L_t W_{H,t} L_t + \tau^C_t P_t C_t - P_{H,t} G_{H,t}.$$

To rewrite these two equations in real terms let $R^r_{H,t-1} = R_{t-1}P_{t-1}/P_t$ denote the real interest factor and use $B^r_{H,t} = B_{H,t}/P_t$, $s^r_{H,t} = s_{H,t}/P_t$ and $w_{H,t} = W_{H,t}/P_t$, leading to

$$\begin{aligned} B^r_{H,t} &= R^r_{H,t-1}B^r_{H,t-1} - s^r_{H,t} \\ s^r_{H,t} &= \tau^L_t w_{H,t} L_t + \tau^C_t C_t - \frac{P_{H,t}}{P_t} G_{H,t}, \end{aligned}$$

with analogous equations holding for the foreign country. Notice that the primary surplus depends on three separate fiscal instruments ($\tau^L_t, \tau^C_t, G_{H,t}$), allowing, in principle, for a large range of fiscal scenarios to be studied.

2.3.1 Benchmark specification of fiscal policy

We use this broad set-up to explore the effects of permanent and unilateral changes in the home consumption tax on home and foreign variables in a number of distinct general equilibrium scenarios. Our benchmark scenario exhibits two particular assumptions, in line with the fiscal devaluation hypothesis. First, in response to the change in the home consumption tax by $\Delta\tau^C$ both fiscal authorities keep their budgets permanently balanced in real terms, ensuring that the real debt levels in both countries remain constant in all periods, i.e. $B^r_{H,t} = B^r_H$ and $B^r_{F,t} = B^r_F$ for all t. For given target levels of real debt this implies that real primary surpluses are given by

$$s^{r,\,BB}_{H,t} = (R^r_{H,t-1} - 1)B^r_H \quad \text{and} \quad s^{r,\,BB}_{F,t} = (R^r_{F,t-1} - 1)B^r_F. \tag{13}$$

[11] For simplicity, it is assumed that government expenditures do not enter the preferences of households. Yet, none of our results would change if government expenditures entered preferences in an additively separable manner.

Second, our benchmark assumes that budget balance is achieved by adjustments in labour taxes. In other words, in response to the permanent change in τ^C by $\Delta\tau^C$, we treat τ_t^L and τ_t^{L*} as the residual instruments which ensure that (13) is satisfied, taking as given G_H and G_F (which are held constant at their steady-state values). These two assumptions imply for τ_t^L and τ_t^{L*} the following law of motions

$$\tau_t^{L_{BB}} = \frac{(R_{H,t-1}^r - 1)B_H^r - (\tau^C + \Delta\tau^C)C_t + \frac{P_{H,t}}{P_t}G_H}{w_{H,t}L_t} \text{ and } \tau_t^{L*_{BB}} = \frac{(R_{F,t-1}^r - 1)B_F^r - \tau^{C*}C_t^* + \frac{P_{F,t}}{P_t^*}G_F}{w_{F,t}L_t^*} \tag{14}$$

Both benchmark assumptions will be relaxed subsequently below. In Section 5.2, when discussing short-run features of the fiscal devaluation hypothesis, we relax the balanced-budget requirement and allow for temporary imbalances in real government debt (maintaining, however, that labour taxes are the instruments to ultimately stabilise the economies at unchanged long-run debt levels). In Section 6 we consider a separate tax change scenario which satisfies the balanced-budget requirement, assuming, however, that government expenditures are the residual instruments (at constant labour taxes).

2.4 Monetary policy

Because of nominal price stickiness, there is a stabilisation role for monetary policy. The central bank runs a common monetary policy for the two countries, responding only to aggregate union-wide variables. To this end, the central bank follows a New Keynesian interest rate feedback rule

$$1 + \widetilde{i}_t = \left(\frac{Y_{U,t}}{Y_{U,t}^n}\right)^{\mu_{y_u}} \left(\frac{\pi_{U,t}}{\pi_U}\right)^{\mu_{\pi_u}} (1+i), \tag{15}$$

where i denotes the steady-state nominal interest rate, while μ_{y_u} and μ_{π_u} denote the feedback coefficients associated with the union-wide output gap (with $Y_{U,t}$ and $Y_{U,t}^n$ denoting the current union-wide output level and the natural union-wide output level under flexible prices, respectively) and pre-tax union-wide consumer price inflation ($\pi_{U,t}$) in deviation from the target rate π_U, normalised to $\pi_U = 1$. Moreover, to allow for interest rate smoothing we assume

$$(1 + i_t) = (1 + \widetilde{i}_t)^{1-\kappa}(1 + i_{t-1})^{\kappa},$$

where $\kappa \in (0, 1)$ captures the degree of interest rate smoothing. Union-wide real output $Y_{U,t}$ is obtained from the corresponding values of union-wide nominal output

$$nP_{H,t}Y_{H,t} + (1-n)P_{F,t}Y_{F,t} = P_{U,t}Y_{U,t},,$$

and the deflator $P_{U,t}$ corresponds to the pre-tax union-wide consumer price level (i.e. net of consumption taxes), $P_{U,t} = s_C P_t + (1 - s_C)P_t^*$, where $s_C = \frac{nPC}{nPC+(1-n)P^*C^*}$ denotes the steady-state share of the home country in union-wide nominal consumption. Because of $\pi_{U,t} = P_{U,t}/P_{U,t-1}$ the central bank's inflation objective in our benchmark specification is based on the index $P_{U,t}$ which measures pre-tax consumer prices. However, this assumption is not without alternatives, as further discussed below in subsection 5.3.

2.5 Price levels and real wages: some definitions

2.5.1 Price level definitions

This subsection summarises compactly the different price level definitions (and short-cuts) which will be used in the remainder of this paper:

(i) $P_{H,t}$: producer price level of the (composite) home produced good, for short: *home producer price level.*
(ii) P_t : consumer price level prevailing in the home country net of the home consumption tax, for short: *pre-tax home consumer price level.*
(iii) $P_{U,t}$: union-wide consumer price level net of consumption taxes, for short: *pre-tax union-wide consumer price level*, with $P_{U,t} = s_C P_t + (1 - s_C)P_t^*$, $s_C = \frac{nPC}{nPC+(1-n)P^*C^*}$ and the corresponding inflation measure $\pi_{U,t} = P_{U,t}/P_{U,t-1}$.
(iv) $(1 + \tau_t^C)P_t$: consumer price level prevailing in the home country including home consumption taxes, for short: *after-tax home consumer price level.*
(v) $P_{U,t}^{\tau^C}$: union-wide consumer price level including consumption taxes of both countries, for short: *after-tax union-wide consumer price level,* with $P_{U,t}^{\tau^C} = s_C^{\tau^C}(1 + \tau_t^C)P_t + (1 - s_C^{\tau^C})(1 + \tau_t^{C*})P_t^*$, $s_C^{\tau^C} = \frac{n(1+\tau^C)PC}{n(1+\tau^C)PC+(1-n)(1+\tau^{C*})P^*C^*}$ and the corresponding inflation measure $\pi_{U,t}^{\tau^C} = P_{U,t}^{\tau^C}/P_{U,t-1}^{\tau^C}$.

2.5.2 Real wage definitions

As indicated by the notation introduced above, we consider symmetric equilibria across households and firms. To characterise such equilibria in a compact manner, it is convenient to introduce

$$w_{H,t}^p = \frac{W_{H,t}}{P_{H,t}} \quad \text{and} \quad w_{H,t}^c = \frac{1 - \tau_t^L}{1 + \tau_t^C}\frac{W_{H,t}}{P_t},$$

where $w_{H,t}^p$ and $w_{H,t}^c$ denote the real producer and real consumer wage in the home country, respectively. Since the producer real wage is deflated by $P_{H,t}$ it is directly linked to real marginal costs, i.e.

$$MC_{H,t}^r = \frac{w_{H,t}^p}{A_{H,t}},$$

implying that $w_{H,t}^p$, $w_{H,t}^c$, and $MC_{H,t}^r$ are related to each other according to

$$w_{H,t}^c = \frac{1 - \tau_t^L}{1 + \tau_t^C}\frac{P_t^H}{P_t}w_{H,t}^p = \frac{1 - \tau_t^L}{1 + \tau_t^C}\frac{P_t^H}{P_t}A_{H,t}MC_{H,t}^r. \tag{16}$$

2.6 General equilibrium

In general equilibrium, the decisions of households and firms need to be individually optimal and consistent with each other at the aggregate level, taking as given the behaviour of monetary and fiscal policymakers and the evolution of exogenous shock processes. In principle, the model could be used to analyse the effects of a broad range of shocks. However, we focus exclusively on the fiscal experiments mentioned above, i.e. we abstract from productivity shocks (and assume, for simplicity, $A_{H,t} = A_{F,t} = 1, \forall t \geqslant 0$) and refrain from the specification of any other shock processes.
Our analysis of competitive equilibria proceeds in two steps. First, for a given vector of constant policy variables, we solve for the unique symmetric steady-state equilibrium, as discussed in the next subsection. Second, starting out from this initial steady state, we consider a permanent change in τ^C by $\Delta\tau^C$ and discuss in separate sections long- and short-run responses of the model economy to this change. The long-run analysis compares the new and the initial steady state from a comparative statics perspective, while the short-run analysis addresses properties of the transitory dynamics, using a log-linearised version of the model (which is summarised in the Appendix).

2.6.1 Steady states

Let variables without time index denote steady-state values. For simple tractability, we consider from now onwards the specific functional forms $U(C) = \frac{1}{1-\rho}C^{1-\rho}$ and $V(L) = \frac{1}{1+\eta}L^{1+\eta}$, with $\rho > 0$ and $\eta > 0$ denoting the inverse of the intertemporal elasticity of substitution in consumption and of the Frisch elasticity of labour supply, respectively. Notice that (12) implies $MC_H^r = \frac{\sigma-1}{\sigma}$. Moreover, (5) and (6) imply $Q_{t,t+1} = Q^*_{t,t+1} = \beta$, with $\beta = 1/(1+i) = 1/(1+r)$ because of $\pi_U = 1$. By symmetry, $\frac{p(h)}{P_H} = \frac{p(f)}{P_F} = 1$. Finally, we define $\frac{P^H}{P} \equiv p_H$ and $\frac{P^F}{P^*} \equiv p_F$.
Then, using (11) and (16), the steady-state counterparts of (2), (3), (7), (8), (9) and (10) for *both* countries can be compactly summarised as the following system of nine equations in the nine unknowns Y_H, Y_F, C, C^*, p_H, p_F, τ^L, τ^{L*}, RS, taking as given constant values of the fiscal variables B_H^r, B_F^r, τ^C, τ^{C*}, G_H, G_F:

$$Y_H = p_H^{-\phi}\nu C + G_H + p_H^{-\phi^*} RS^{\phi^*} \frac{\nu^*(1-n)}{n} C^* \tag{17}$$

$$Y_F = (p_F RS)^{-\phi} \frac{(1-\nu)n}{1-n} C + G_F + (p_F)^{-\phi^*}(1-\nu^*)C^* \tag{18}$$

$$(Y_H)^{\eta} = C^{-\rho} \frac{1-\tau^L}{1+\tau^C} \frac{\sigma-1}{\sigma} p_H \tag{19}$$

$$(Y_F)^{\eta^*} = (C^*)^{-\rho^*} \frac{1-\tau^{L*}}{1+\tau^{C*}} \frac{\sigma^*-1}{\sigma^*} p_F \tag{20}$$

$$\frac{C^{-\rho}}{(C^*)^{-\rho^*}} = \upsilon RS^{-1} \frac{1+\tau^C}{1+\tau^{C*}} \tag{21}$$

$$1 = \nu p_H^{1-\phi} + (1-\nu)(p_F RS)^{1-\phi} \tag{22}$$

$$1 = \nu^*(p_H RS^{-1})^{1-\phi^*} + (1-\nu^*)p_F^{1-\phi^*} \tag{23}$$

$$B_H^r = \frac{\beta}{1-\beta} s_H^r = \frac{\beta}{1-\beta}\left[\tau^L \frac{\sigma-1}{\sigma} p_H Y_H + \tau^C C - p_H G_H\right] \tag{24}$$

$$B_F^r = \frac{\beta}{1-\beta} s_F^r = \frac{\beta}{1-\beta}\left[\tau^{L*} \frac{\sigma^*-1}{\sigma^*} p_F Y_F + \tau^{C*} C^* - p_F G_F\right] \tag{25}$$

Below we solve numerically a calibrated version of this system for the nine unknowns, and, using these numbers, it is straightforward to back out the steady-state values of the remaining endogenous variables. In particular, the steady-state terms of trade can be calculated from $T = RSp_F/p_H$.

3 Calibration of the benchmark monetary union with countries of equal size and symmetric home bias

This section summarises our benchmark calibration which considers a monetary union in which the two countries are assumed to have equal size ($n = 0.5$) and a symmetric home bias because of $\lambda = 0.5$. We calibrate the model using aggregate euro area data, with a quarterly frequency. Both countries are characterised by identical structural parameters (as summarised in Table 1), which are chosen in line with related literature. The intertemporal elasticity of substitution is set to 0.5 (i.e. $\rho = 2$), as in Stockman and Tesar (1995). The labour supply elasticity is chosen to be 0.4 (i.e. $\eta = 2.5$), striking a balance between micro data evidence and macro aspects, in line with the DSGE literature concerned with the euro area (e.g. Smets and Wouters (2003), Altissimo et al. (2005), Coenen et al. (2008), Christiano et al. (2008)). The discount factor equals $\beta = 0.99$, implying an annual interest rate of around four percent. As in Rotemberg and Woodford (1997) and Altissimo et al.

(2005), the elasticity of substitution between differentiated goods within countries is assumed to be $\sigma = 7.88$, consistent with a steady-state markup of 15%. The elasticity of substitution between home and foreign goods is set as $\phi = 1.5$ (as in Altissimo et al. (2005) and Chari et al. (2002)). Since this intratemporal elasticity of substitution is higher than the intertemporal elasticity of substitution (i.e. $\phi > \frac{1}{\rho}$), home and foreign goods are substitutes in the preferences of agents. Like Duarte and Wolman (2008), the degree of openness in both countries equals $\lambda = 0.5$, implying an import share of 25% in the consumption basket. The Calvo parameter, which fixes the share of firms that cannot change prices every quarter, is assumed to be $\alpha = 0.85$, implying that the average duration between price adjustments is 11 months. This value is somewhat higher than the estimated values found in micro studies for euro area countries, but in line with the values chosen by Smets and Wouters (2003) and Coenen et al. (2008).

Table 1: Structural parameters

Size of the (home) country	n	0.5
Inverse of the intertemporal elasticity of substitution	ρ	2
Inverse of the labour supply elasticity	η	2.5
Discount factor	β	0.99
Elasticity of substitution between goods within countries	σ	7.88
Elasticity of substitution between home and foreign goods	ϕ	1.5
Degree of openness	λ	0.5
Degree of nominal price stickiness	α	0.85

Table 2 summarises the fiscal policy values which were used to calibrate the initial steady state, assumed to be identical for both countries. The consumption and labour tax rates as well as the debt-output ratio have been set at values which are roughly in line with average euro area data (see Table A.1. in the Appendix) and consistent with related literature. Notice that the assumed value of the debt-output ratio corresponds to a value of 66% in annualised terms, while the government expenditure share is residually determined by the steady-state government budget constraint.[12]

Table 2: Fiscal characteristics of the initial steady state

Consumption tax rate	$\tau^C = \tau^{C*}$	0.15
Labour tax rate	$\tau^L = \tau^{L*}$	0.30
Share of government expenditures in output	$d_{GH} = \frac{G_H}{Y_H} = d_{GF} = \frac{G_F}{Y_F}$	0.33
Debt-output ratio	$b_H = \frac{B_H}{P_H Y_H} = b_F = \frac{B_F}{P_F Y_F}$	2.64

Table 3 summarises the parameter values used for the monetary policy rule. Following the DSGE literature concerned with the euro area, the rule is characterised by a large smoothing parameter, i.e. the coefficient on the lagged interest rate is set equal to $\kappa = 0.95$. Moreover, the benchmark response coefficient to inflation is set equal to $\mu_{\pi_u} = 2$, while we assume that monetary policy does not respond

[12] A more detailed matching of all aspects of fiscal data would require a richer specification of government activities which is beyond the scope of this paper. In particular, our model does not allow for public transfers and investment, implying that the residually determined share of government expenditures is too high compared with the data. Moreover, the labour tax rate is too low if one looks at the combined numbers for labour taxes and social contribution rates (as reported, for example, in Coenen et al (2008). For numerical choices similar to ours in small scale DSGE models, see Ferrero (2007) and Canzoneri et al (2005).

to output fluctuations ($\mu_{y_u} = 0$).[13] Notice that the benchmark balanced-budget rule (14) does not require any additional fiscal parameter.

Table 3: Parameters of monetary policy rule

Response parameter of monetary policy to union output gap	μ_{y_u}	0
Response parameter of monetary policy to union inflation	μ_{π_u}	2
Smoothing parameter	κ	0.95

4 Long-run effects of a permanent shift in the tax structure of the home country from direct towards indirect taxes

This section focuses on long-run effects of a permanent shift in the tax structure of a union member country, abstracting from the transitory dynamics induced by the short-run monetary and fiscal feedbacks. Specifically, to address the fiscal devaluation hypothesis, it is assumed that the home country permanently increases its consumption tax by 1 pp from 15% to 16% (i.e. $\Delta\tau^C = 0.01$) and uses the additional revenues to finance a permanent cut in the labour tax rate such that the home country's long-run level of real government debt stays unchanged, holding constant government expenditures. The foreign country does not have actively any intention to change its tax structure, but, to keep its own level of real debt on target, it reacts passively by adjusting its labour tax rate at unchanged government expenditures. In sum, the consumption tax changes only in the home country, while labour taxes adjust endogenously in both countries, in line with (14).

Table 4 summarises the long-run effects for key real variables of the two countries. The table covers the benchmark 'monetary union with countries of equal size and symmetric home bias' (as summarised in Section 3), but also a number of alternative monetary unions specifications. These specifications differ from the benchmark, ceteris paribus, in terms of i) the size of the two countries (captured by n) and ii) the strength of the home bias (captured by λ), while otherwise the calibration is identical to Section 3. To allow for variation along these two dimensions facilitates the identification of the core general equilibrium channels which are of relevance for the benchmark monetary union.

All these specifications have in common that the driving force behind the shift in the tax structure of the home country from direct towards indirect taxes is the following clear-cut difference between the two considered tax instruments: The home consumption tax affects the entire consumption of the home country, irrespective of whether the consumption goods have been produced at home or in the foreign country. By contrast, the home labour tax affects the entire production of the home country, irrespective of whether the produced output is sold at home or in the foreign country. Hence, the change in the tax structure of the home country from direct to indirect taxes tends to favour home production relative to home consumption. Since the terms of trade are endogenously determined, this feature has significant implications for the two countries in our model. However, to establish a clear reference point, we discuss first the degenerate case of a monetary union which consists only of the home economy, i.e. by considering $n \to 1$ our discussion starts out from a closed economy scenario.

4.1 Closed economy

For the special case of a closed economy (column 1 in Table 4), the two taxes have very similar steady-state effects under the particular assumptions of our set-up, in which labour is the only input for production and all tax schedules are linear. This finding can be readily reconciled with well-

[13] For a discussion of this assumption, see Secton 5.1.

known channels as summarised, for example, in Layard et al. (1996), Bovenberg (2006), and European Commission (2008). Specifically, in order for a revenue-neutral shift from labour taxes to indirect taxes to be able to increase output and employment it is crucial that this shift reduces the effective tax burden on labour. Given our simplifying assumption of linear tax schedules, this in turn requires that the share of non-labour income (related, in particular, to non-indexed unemployment benefits and pensions as well as capital income) is sufficiently large.[14] However, under our modelling assumptions (which abstract from unemployment, life-cycle behaviour and capital accumulation) the only alternatives to labour income are pure profit income and interest income on predetermined bond holdings, and both of these items are quantitatively small. Because of these features, there is, by construction, little scope for significant real effects of the considered change in the tax structure. Under our calibration, a permanent increase of the consumption tax by 1 pp from 15% to 16% leads to a decline in the labour tax by 0.76 pp from 30% to 29.24%. The implied increase in output (which is proportional to employment) and consumption by 0.05% and 0.04%, respectively, is very small, indicating that under our modelling assumptions in the special scenario of a closed economy the consumption tax is only marginally less distortionary in the initial steady state than the labour tax.

Table 4 : Long-run effects of a permanent shift in the home tax structure, percentage changes

	Closed economy	Monetary union			
					benchmark
Home bias	–	no home bias ($\lambda = 1$)			home bias ($\lambda = 0.5$)
Country size	$n = 1$	$n = 0.75$	$n = 0.5$	$n = 0.1$	$n = 0.5$
Change in τ^C in pp	1	1	1	1	1
Change in τ^L in pp	−0.76	−0.75	−0.73	−0.71	−0.74
Change in τ^{C*} in pp	–	–	–	–	–
Change in τ^{L*} in pp	–	−0.05	−0.03	−0.01	−0.02
Terms of trade	–	0.21	0.21	0.21	0.38
Real exchange rate	–	0	0	0	0.19
Home consumption	0.04	−0.07	−0.19	−0.38	−0.14
Home output	0.05	0.12	0.18	0.29	0.15
Home consumer real wage	0.21	0.13	0.06	−0.06	0.08
Foreign consumption	–	0.36	0.25	0.06	0.20
Foreign output	–	−0.20	−0.13	−0.03	−0.11
Foreign consumer real wage	–	0.21	0.13	0.02	0.11
Change in b_H in pp	−0.13	−0.16	−0.2	−0.26	−0.15
Change in b_F in pp	–	0.12	0.08	0.02	0.03

4.2 Monetary union with countries of equal size (no home bias)

In a monetary union of two equally sized countries with no home bias (column 3 in Table 4), the shift in the tax structure of the home country towards indirect taxation has more significant effects on real

[14] In this spirit, benefits from redirecting the tax structure towards consumption taxes are substantially larger in full-fledged dynamic settings with capital accumulation. In such environments, consumption taxes act implicitly as efficient taxes on the inelastically supplied, predetermined capital stock, as discussed and quantitatively explored in Atkinson and Stiglitz (1972), Cooley and Hansen (1992), Mendoza and Tesar (1998), and Coleman (2001).

variables, affecting both countries. In particular, this shift ensures that domestic producers benefit from a cost advantage relative to their foreign competitors, leading to a long-run increase in the terms of trade. This change in the terms of trade is responsible for two spillover effects which are absent in the closed economy scenario. First, reflecting the relative improvement in the competitiveness of home production, home output increases, while foreign output decreases. Since the law of one price holds consumers in both countries support this reallocation of production by switching their relative consumption structure towards home goods. Second, the terms of trade channel hurts home consumers. While home consumers bear the burden of the higher consumption tax, they do not fully reap the benefits of the compensating tax measure, i.e. they 'share' with foreign consumers the benefits of a reduced tax burden of home production, as can be inferred from the following steady-state relationship

$$w_H^c = \frac{1-\tau^L}{1+\tau^C} p_H w_H^p = \frac{1-\tau^L}{1+\tau^C} \left[\nu + (1-\nu)T^{1-\phi}\right]^{\frac{1}{\phi-1}} \frac{\sigma-1}{\sigma} = Y_H^{\eta} C^{\rho}.$$

Compared with the closed economy, for any given change in τ^L and τ^C and any given increase in home output, the new real consumer wage will be smaller in the open economy because of the terms of trade increase, implying, ceteris paribus, a decline in home consumption. Moreover, this mechanism ensures, when combined with the complete asset market condition (7), that foreign consumption increases.
In sum, the terms of trade channel drives a certain wedge between consumption and production in the two countries. In absolute terms, the effects are small, but not entirely negligible, as evidenced by the terms of trade increase by 0.21%. This terms of trade effect (which is at the heart of the fiscal devaluation hypothesis) ensures that home output increases by 0.18% (which is about four times the effect of the closed economy), while home consumption decreases by 0.19% (i.e. the terms of trade effect dominates the consumption increase reported for the closed economy). Moreover, with foreign output decreasing by 0.13% and foreign consumption increasing by 0.25%, the terms of trade channel generates limited, but non-negligible spillovers.
To conclude this subsection it is worth stressing that, since the terms of trade are endogenous, one may argue that it can be a bit misleading if we talk in the following repeatedly about 'terms of trade effects'. Evidently, the strength of these effects depends on all structural features of the model economy (like the pricing strategies of firms, labour market assumptions etc.), and the effects are particularly strong under the assumption of complete asset markets. Yet, lacking a better alternative, we refer to these effects as a short-cut that captures all model-specific open-economy aspects which make the analysis different from a closed economy model.[15]

4.3 Monetary unions with countries of different size (no home bias)

The results established so far can be generalised if one looks at monetary unions consisting of countries of different size (and no home bias). To this end, columns 2 and 4 in Table 4 report also results for a 'large' home country ($n = 0.75$) and a 'small' home country ($n = 0.1$). Notice that the long-run change in the terms of trade is independent of the size of the two countries. Moreover, it is straightforward to verify that all the other long-run effects discussed so far are a monotonic function of the size of the two countries. Hence, the reasoning given so far can be extended to two more general and symmetric conclusions. As concerns the home country, the magnitude of the terms of trade related effects on production, consumption and the real consumer wage decreases in the size of the home country, i.e. the leverage of a change in the home tax structure on home variables is largest in the case of a small home country. In other words, this finding indicates that under Dixit-Stiglitz-type monopolistic competition the price setting power of a country does not vanish as the country becomes

[15] For a model-based discussion of how the terms of trade channel depends on various structural features in open economy models, see Lipinska et al (2009).

small, differing thereby from the textbook case of a small open economy, as discussed in Feldstein and Krugman (1990). Similarly, as concerns the foreign country, the magnitude of the terms of trade related effects on production, consumption and the real consumer wage decreases in the size of the foreign country, i.e. the leverage of a change in the home tax structure on foreign variables is largest in the case of a small foreign country.

These numerical findings reflect a robust pattern of our model economy. To substantiate this claim, it is instructive to analyse key equations which come from a first-order approximation of the equilibrium conditions of the model. As derived in the Appendix, one can show that changes in the terms of trade do not *directly* depend on changes in consumption taxes. Instead, they are entirely driven by changes in labour tax rates:[16]

$$\widehat{T}_t = \frac{1}{1+\eta\phi\,(d_C+d_{C^*})}(w^{L^*}\widehat{\tau}_t^{L*} - w^L\widehat{\tau}_t^L). \tag{26}$$

Because of the assumption of constant productivity levels, the home real producer wage stays constant in the long run. By contrast, the home real consumer wage varies, depending on the changes in the two tax rates as well as in the terms of trade

$$\begin{aligned}\widehat{\omega}_{H,t}^p &= 0\\ \widehat{\omega}_{H,t}^c &= -(1-n)\widehat{T}_t - w^C\widehat{\tau}_t^C - w^L\widehat{\tau}_t^L\end{aligned}$$

While the change in the tax structure has a priori an ambiguous effect on the home real consumer wage, Table 4 shows that for the special case of a closed economy the net effect is positive. As one moves from this limiting scenario to 'proper' monetary unions, the terms of trade effect becomes increasingly important for the home real consumer wage, and home consumers are most strongly hurt in the case of a small home economy (i.e. n being small). Extending this reasoning, the long-run effects for home consumption and output can also be decomposed into changes in the two tax rates and the terms of trade, i.e.

$$\widehat{C}_t = -(1-n)\frac{1+\eta\phi(d_C+d_{C^*})}{\eta(d_C+d_{C^*})+\rho}\widehat{T}_t - \frac{1+\frac{\eta}{\rho}d_{C^*}}{\eta(d_C+d_{C^*})+\rho}w^C\widehat{\tau}_t^C - \frac{1}{\eta(d_C+d_{C^*})+\rho}w^L\widehat{\tau}_t^L \tag{27}$$

$$\begin{aligned}\widehat{Y}_{H,t} &= (1-n)\,(\rho\phi-1)\,\frac{\phi(d_C+d_{C^*})}{\eta\phi(d_C+d_{C^*})+\rho\phi}\widehat{T}_t \\ &\quad -\frac{d_C}{\eta(d_C+d_{C^*})+\rho}w^C\widehat{\tau}_t^C - \frac{d_C+d_{C^*}}{\eta(d_C+d_{C^*})+\rho}w^L\widehat{\tau}_t^L.\end{aligned} \tag{28}$$

Equations (27) and (28) reveal that the terms of trade effects on $\widehat{C}_t$ and $\widehat{Y}_{H,t}$ are largest in the case of a small home economy. Moreover, the partial effects of $\widehat{T}$, $\widehat{\tau}_t^C$, and $\widehat{\tau}_t^L$ on home consumption have the same sign structure as established for the home real consumer wage. By contrast, the effect of $\widehat{T}$ on home output is of opposite sign (i.e. positive) whenever $\rho\phi > 1$, in line with our calibration. Hence, home output increases in the terms of trade if home and foreign goods are substitutes in the preferences of agents, as discussed in Corsetti and Pesenti (2001) and Tille (2001).[17]

[16] The following equations use $w^C = \frac{\tau^C}{1+\tau^C}$, $w^L = \frac{\tau^L}{1-\tau^L}$, $w^{C^*} = \frac{\tau^{C^*}}{1+\tau^{C^*}}$, $w^{L^*} = \frac{\tau^{L^*}}{1-\tau^{L^*}}$, $d_C = \frac{nC}{Y_H}$, $d_{C^*} = \frac{(1-n)C^*}{Y_F}$.

[17] Evidently, $\widehat{C}_t$ and $\widehat{Y}_{H,t}$ can be entirely expressed as a function of tax-related terms if one uses (26) in (27) and (28), as shown in the Appendix. However, to understand the special role played by the terms of trade, (27) and (28) offer more intuitive representations. Moreover, corresponding patterns can be established for the long-run effects on foreign variables. In particular, the foreign real consumer wage can be decomposed as follows

$$\widehat{\omega}_{F,t}^c = n\widehat{T}_t - w^{C^*}\widehat{\tau}_t^{C^*} - w^{L^*}\widehat{\tau}_t^{L^*},$$

implying that the terms-of-trade effect on the foreign real consumer wage is of opposite sign (i.e. positive), and it can be shown that the terms-of-trade effects on foreign consumption and foreign output are also of opposite sign.

4.4 Benchmark monetary union with countries of equal size and symmetric home bias

Building on these insights it is straightforward to see how the results change if one considers a monetary union with countries of equal size and symmetric home bias in consumption patterns, in line with the calibration in Section 3. As one can infer from the last column in Table 4, the assumption of home bias implies that the real exchange rate is no longer constant over time. Compared with column 3, this feature dampens the long-run effects on home consumption and home output as well as the spillover effects on foreign consumption and foreign output. In other words, the assumption of home bias ensures that both economies are less exposed to the terms of trade related effects of the considered change in the tax structure of the home economy. Quantitatively, however, this dampening effect is negligible, i.e. the increase in home output (by 0.15%) and foreign consumption (by 0.20%) as well as the decrease in home consumption (by 0.14%) and foreign output (by 0.11%) are only marginally smaller than in the absence of home bias.

It is worth stressing that for all scenarios discussed in Table 4 the balanced-budget closure implies that the debt-output-ratios (b_H and b_F) change in steady-state comparison (because of the changes in the output levels). However, quantitatively the effects on the debt-output-ratios are very small. Corresponding to this feature, we confirmed that all *long-run* patterns in Table 4 do not change if the balanced-budget assumption is dropped and it is instead assumed that the labour tax rates are changed such that the debt-output ratios in in the two countries remain at their initial levels. For the *short-run* dynamics, however, the details of the fiscal closure do matter, as we show below.

To conclude this section, we point out that the order of magnitude of the effects summarised in Table 4, when appropriately normalised for the size of the tax changes, is similar to quantitative findings for tax reforms established in related papers. Yet, our particular focus on the terms of trade channel within a monetary union in which all available taxes are assumed to be distortionary makes some of the results somewhat special. Most closely related to this paper, Roeger and in't Veld (2006) and European Commission (2008, p. 199 ff.), when quantifying the effects of unilateral tax shifts towards indirect taxation within EMU, obtain similar output effects for the home country. Yet, in these studies, because of strong redistribution effects within countries and complementarities between employment and capital formation, domestic demand effects are more pronounced than in our analysis.[18] Moreover, asset markets between countries are incomplete. These features ensure that the terms of trade channel is of little importance, implying that there are virtually no long-run spillovers between countries.[19] Similarly, the reported long-run effects hardly depend on the relative size of the countries. As concerns genuine open economy contributions, Mendoza and Tesar (1998), consider a revenue-neutral replacement of US income taxes by consumption taxes in a framework which abstracts from terms of trade effects. Instead, the output and consumption effects (which are larger than in the also reported closed economy experiment) are attributed to smoothing and redistribution effects via world capital markets. Coenen et al. (2008) use a large scale two-country model to investigate systematic effects of tax reforms for the euro area as a whole, focusing on labour market distortions in the euro area relative to the US. The paper considers a revenue-neutral change of consumption taxes which is financed via compensating variations of lump-sum taxes. The latter feature leads to terms of trade reactions which are different from our paper and, similar to Mendoza and Tesar (1998), output and consumption move in the same direction. While the paper establishes non-negligible international

[18] In particular, the tax reform shifts the tax burden from liquidity-constrained consumers with a high propensity to consume towards unconstrained consumers (with unrestricted access to capital markets and, hence, to all non-labour related income), triggering thereby significant demand effects in the home country.

[19] Consistent with these findings, we checked that in our model, under the extreme assumption of financial autarky, the terms of trade channel loses significance and the effects become similar to the closed economy case.

spillovers, there is, by construction, no scope for spillovers between euro area countries.[20]

5 Short-run effects of a permanent shift in the tax structure of the home country from direct towards indirect taxes

Reflecting the assumption of nominal rigidities, the model implies that monetary policy is non-neutral in the short run. Importantly, since monetary policy reacts to union-wide developments there is scope for short-run interactions between the two countries which go beyond the long-run spillovers identified in the previous Section. Moreover, short-run dynamics depend on the fiscal feedback structure. To characterise core features of the short-run dynamics in a tractable manner, this Section proceeds as follows. Section 5.1 summarises the short-run dynamics of the benchmark specification introduced above. We report then, as a robustness exercise, how these dynamics change under three distinct and isolated experiments, each relaxing a different characteristic feature of the benchmark. Section 5.2 considers an alternative fiscal feedback rule which relaxes the balanced-budget requirement and allows instead for a different speed at which the compensating decline in direct taxes takes place. Section 5.3 considers short-run dynamics which result from the use of a different target index of monetary policy, holding the other features of the Taylor rule constant. In particular, Section 5.3 discusses how the benchmark results of Section 5.1 change if monetary policy targets after-tax rather than pre-tax union-wide consumer price inflation. Finally, Section 5.4 discusses how the benchmark results of Section 5.1 change if the change in the tax structure is no longer modelled as a genuine surprise, but rather as a policy which is announced ahead and therefore anticipated by the private sector.

5.1 Benchmark monetary union with countries of equal size and symmetric home bias

This subsection complements Subsection 4.4 and summarises main characteristics of the transitional dynamics triggered by the unilateral shift in the tax structure of the home economy. In particular, notwithstanding the above identified long-run changes in consumption and output both within and between countries, these adjustments leave pre-tax union-wide CPI inflation dynamics unaffected. This implies that the home country can implement its reform of the tax structure without triggering a reaction of the common monetary policy. As to be inferred from Figure 1 (bold lines), the logic underlying this result can be summarised as follows.[21] Consider first the variables of the home country. Because of nominal price stickiness, the terms of trade increase relatively slowly over time before reaching the new long-run level after about 20 quarters. Corresponding to this slow change in the terms of trade, on impact home output increases less than in the long run. Notice that home output is proportional to labour, implying that under the balanced-budget requirement the labour tax is bound to decline slowly over time, i.e. on impact τ_t^L declines by less than in the long run. This in turn implies that consumers, while facing immediately the once and for all increase in the consumption tax, benefit from the compensating reduction of the labour tax only with a certain delay. Consistent with this pattern, home consumption, home consumer real wages and home producer real wages all decline on impact by more than in the long run. With the dynamics of home producer prices being

[20] See, in particular, Table 2 on p. 237 in Mendoza and Tesar (1998) and Column 1, Table 2 on p. 45 in Coenen et al (2008), requiring scaling factors of around 40 and 10, respectively, to obtain dimensions for output and consumption effects comparable with the numbers reported in our Table 4. Notice, however, that the very different scale of the considered tax changes in both papers makes comparisons questionable which do not allow explicitly for non-linearities.

[21] The impule responses in Figure 1 are based on a first-order approximation of the economy developed in Section 2. The approximate long-run levels in Figure 1 are virtually identical to the exact values reported in column 5 in Table 1, i.e. the approximation error is negligible.

driven by the New-Keynesian Phillips curve

$$\widehat{\pi}_{H,t} = k_H \widehat{MC}^r_{H,t} + \beta E_t \widehat{\pi}_{H,t+1} \quad \text{with:} \quad \widehat{MC}^r_{H,t} = \widehat{w}^p_{H,t},$$

this implies that the change in the tax structure exerts on impact a deflationary effect on home producer prices. This deflationary effect is very small, i.e. $\widehat{\pi}_{H,t}$ drops on impact by about 5 basis points. Irrespective of its small size, this effect is inconsequential for pre-tax union-wide inflation dynamics since it is offset by an equally sized inflationary effect on foreign producer prices. This latter effect reflects that short-run dynamics in the foreign country are the mirror image of developments in the home country. In particular, the slow change in the terms of trade implies that foreign output is on impact higher than in the long run. Similarly, foreign consumption is also on impact higher than in the long run, in line with the complete asset market condition which establishes a crucial link between the consumption levels of the two countries. In sum, these features generate inflationary dynamics of foreign producer prices which offset the deflationary dynamics of home producer prices. To see this point in greater clarity, notice that pre-tax union-wide CPI inflation dynamics are approximately given by

$$\widehat{\pi}_{U,t} = s_C \widehat{\pi}_t + (1 - s_C)\widehat{\pi}^*_t,$$

with the country-specific elements being given by

$$\begin{aligned} \widehat{\pi}_t &= \nu \widehat{\pi}_{H,t} + (1-\nu)\widehat{\pi}_{F,t} \\ \widehat{\pi}^*_t &= \nu^* \widehat{\pi}_{H,t} + (1-\nu^*)\widehat{\pi}_{F,t}. \end{aligned}$$

Our benchmark calibration of $n = \lambda = 0.5$ implies $\nu = 0.75$ and $\nu^* = 0.25$, while $s_C = 0.5$. Hence, $\widehat{\pi}_{U,t} = 0.5\widehat{\pi}_{H,t} + 0.5\widehat{\pi}_{F,t}$, implying that deflationary and inflationary producer price effects of equal size in the two countries exactly offset each other in terms of pre-tax union-wide CPI inflation.
Because of this symmetric feature the nominal interest rate remains unchanged during the transition period. In other words, the union-wide monetary policy remains entirely 'neutral' with respect to the unilateral change in the tax structure of the home country. Notice, however, that after-tax union-wide CPI inflation does reflect the increase in consumption taxes of the home country. With the tax change being modelled as a genuine surprise, with producer prices being largely predetermined, and with monetary policy being unresponsive, the pass-through into after-tax consumer prices is on impact virtually complete, i.e. after-tax union-wide CPI inflation increases on impact by close to 50 basis points, in line with the weight of 50% in $\widehat{\pi}^U_t$ carried by the home country.[22]
To conclude this subsection two points are worth emphasising. First, the offsetting effects of pre-tax national inflation developments on union wide inflation also hold for monetary unions composed of countries of different size: If the home country (where the consumption tax increase takes place) is, for example, the smaller one of the two countries, the impact on home inflation will be relatively stronger, while the impact on inflation of the foreign (and larger) country will be weaker. As a result of these counteracting effects, pre-tax union-wide inflation will not change. However if the countries differ with respect to their openness this reasoning needs to modified. For example, if the home country is characterised by a stronger home bias the deflationary effect in the home economy will outweigh the inflationary effect in the foreign economy. Consequently, pre-tax union wide inflation will decrease. Second, for the benchmark monetary union the union-wide output gap (i.e. the difference between union-wide output levels under sticky and flexible prices) is zero. Because of this feature, the assumption of $\mu_{y_u} = 0$ in (15) is inconsequential, provided the countries satisfy the symmetric features of the benchmark specification.

[22] This reasoning would require modifications if the assumption of Calvo-style price-setting would be replaced by state-dependent pricing, as discussed, for example, in Dotsey et al (1999).

5.2 Different fiscal adjustment speeds

This subsection analyses the impact of a once and for all, permanent increase in the home consumption tax if the associated adjustments of labour taxes have a sluggish character, i.e. we drop the assumption of balanced budgets during the transitional dynamics. To this end, we replace (14) against the broad fiscal feedback rule studied by Mitchell et al. (2000) and Duarte and Wolman (2008), implying that labour taxes adjust according to

$$\begin{aligned} \tau_t^L &= \tau_{t-1}^L + \alpha_{b,\tau}(b_{H,t} - b_H) + \alpha_{\Delta b,\tau}(b_{H,t} - b_{H,t-1}) \\ \tau_t^{L*} &= \tau_{t-1}^{L*} + \alpha_{b,\tau}^*(b_{F,t} - b_F) + \alpha_{\Delta b,\tau}^*(b_{F,t} - b_{F,t-1}), \end{aligned}$$

where $b_{H,t} = B_{H,t}/P_{H,t}Y_{H,t}$ and $b_{F,t} = B_{F,t}/P_{F,t}Y_{F,t}$ denote the debt-output ratios of the two countries (with target values b_H and b_F taken from Table 2). In line with the numerical specification of Duarte and Wolman (2008), we calibrate the fiscal feedback coefficients as follows:[23]

Table 5: Parameters of alternative fiscal policy rule

Response to debt-output ratio	$\alpha_{b,\tau} = \alpha_{b,\tau}^*$	0.04/16
Smoothing parameter	$\alpha_{\Delta b,\tau} = \alpha_{\Delta b,\tau}^*$	0.3/4

Figure 1 (dashed lines) shows the impulse responses from this alternative fiscal closure. The sluggish response of home and foreign labour taxes changes qualitatively the nature of the transitory dynamics in both countries, compared with the in Section 5.1 discussed balanced-budget rule (bold lines). Since labour taxes barely change on impact, the increase in the home consumption tax acts like a cost-push shock in the first quarters. In particular, the home real consumer wage declines more strongly, leading on impact to a stronger decline in home consumption. At the same time, the home real producer wage now increases on impact. In other words, the transitory burden of the delayed response of the compensating decline in the labour tax is shared by consumers and producers. Similar to a cost-push shock, the increase in the home real producer wage ensures that home output now declines on impact and, at the same time, we now observe a (small) increase in home producer inflation. Moreover, with the balanced-budget assumption being dropped, home real debt decreases and stays for many quarters at below steady-state levels. As concerns the foreign economy, foreign consumption increases by less as a result of the complete asset market condition. Since labour taxes stay initially virtually unchanged, there is no change in the competitiveness between both countries, implying that the terms of trade do not move on impact. This triggers a slightly stronger increase both in foreign producer real wages and in foreign producer inflation.

In sum, with labour taxes responding only slowly over time to the permanent increase in the home consumption tax, this now creates inflationary pressures in both countries. As a result, pre-tax union wide inflation increases, implying that monetary policy responds by increasing the nominal interest rate. In other words, the delayed response of the compensating fiscal measure in the home country not only causes transitory fiscal imbalances, but it also leads to union-wide inflation effects, prompting a reaction of monetary policy which was absent under the balanced-budget scenario.

[23] This calibration in Table 5 converts the annual values reported by Mitchell et al. (2000) into quarterly frequencies. Alternatively, we also considered a fiscal feedback rule of the type $sr_{H,t} = \phi_d^m sr_{H,t-1} + \phi_b^m b_{H,t-1}$, where $sr_{H,t}$ and $b_{H,t}$ denote, respectively, the primary surplus-output ratio and the debt-output ratio in the home country. In line with the (cyclically adjusted) average estimation results for OECD countries reported in Gali and Perotti (2003, Table 2, p. 549), we let $\phi_d^m = 0.45$ and $\phi_b^m = 0.06$. Under this calibration, the specification generates impulse responses which are similar (although not entirely identical) to our balanced- budget scenario. Hence, we do not report them independently.

5.3 Different targets of monetary policy

This subsection shifts focus and switches to a genuine aspect of monetary policy which affects the short-run dynamics. Specifically, we illustrate that the short-run response of key endogenous variables like consumption, output and inflation depends sensitively on whether the monetary policy reaction specifies the consumer price inflation objective net of indirect taxes or not.[24] To this end, Figure 2 compares the findings from the benchmark specification, as discussed in Section 5.1, with an alternative specification (dashed lines) in which, everything else being equal, the after-tax union-wide CPI inflation rate $\pi_{U,t}^{\tau^C}$ replaces $\pi_{U,t}$ in the monetary feedback rule (15). This change in the target variable has a number of interesting implications. First, the alternative specification shows that, in principle, the degree and the timing of the pass-through of the tax increase into consumer prices depends on the index which underlies the inflation objective. By this we mean that, if monetary policy reacts to $\pi_{U,t}^{\tau^C}$, both the pre-tax and the after-tax inflation rates will be lower during the transition than in the benchmark specification.[25] Quantitatively, however, with the tax change being modelled as a genuine surprise and with producer prices being largely predetermined, this relative decline in both inflation measures is insignificant. Second, the change in τ^C pushes after-tax union wide inflation above the target level of inflation and the interest rate reaction of monetary policy introduces for the transitional dynamics a certain stabilisation trade-off, i.e. consumption and output, both in the home and the foreign country, are uniformly lower than in the benchmark specification. Specifically, with monetary policy being no longer neutral with respect to the tax change in the home country, this finding implies that indirect negative spillovers for the foreign country emerge which are triggered by the reaction of monetary policy to union-wide variables. Moreover, under the two assumptions of i) the tax change being modelled as a genuine surprise and ii) producer prices being largely predetermined, Figure 2 indicates that gains in terms of lower inflation are rather costly in terms of output and consumption sacrifices during the transitional dynamics. However, it should be emphasised that the model does not capture a number of other margins which would influence the assessment of this trade-off from a comprehensive welfare perspective. In particular, during the entire transitional dynamics the assumption of rational expectations firmly anchors inflation expectations and constrains wage settlements in a stabilising manner. Hence, within our analysis there is no scope for so–called 'second-round' effects of inflation which typically concern central banks.

5.4 Anticipated versus unanticipated policy changes

Another key feature which shapes the short-run dynamics relates to the fact that fiscal policy changes of the discussed type are typically not genuine surprises to the private sector when they become implemented. To ignore implementation lags associated with fiscal policymaking in rational expectation models has quantitatively important implications, as shown by Yang (2005) and Leeper at al. (2008). To confirm the importance of this aspect in our context, this subsection compares the benchmark results (of an unanticipated change in the tax structure) with an alternative scenario in which the change in the tax structure is credibly announced and correctly anticipated four quarters ahead. The ex ante announcement of the policy change affects the transitory dynamics in a sizable manner, as depicted in Figure 3 (dashed lines). Three features are worth pointing out. First and most importantly, home

[24] For detailed references and a recent summary discussion of aspects related to the appropriate inflation indices stabilised by central banks, see, for example, Camba-Mendez (2003). Notice that in the particular context of our tax experiments one may find it more suggestive to think of pre-tax inflation as 'core inflation', while after-tax inflation has some correspondence to 'headline' inflation.

[25] Recall from above that this difference does not affect the long-run incidence of the fiscal experiment. This feature can also be seen in Figure 2 in which eventually the impulse responses of all variables converge against the same levels under the two specifications.

consumption increases immediately (i.e. at the time of the announcement of the future policy change) in anticipation of higher consumption taxes in the future. This upward jump in home consumption is sizable (i.e. about 0.2 percent of the steady-state value) and exerts on impact a significant demand stimulus which pulls up both home output and home producer prices. However, reflecting the presence of intertemporal substitution effects these movements are reversed in the future, i.e. once the tax change has been implemented home consumption, home output and home producer price inflation are all lower than in the benchmark scenario. Second, the initial demand stimulus in the home country spills over into the foreign country, leading on impact, relative to the benchmark scenario, to an increase in foreign output and foreign producer price inflation, while foreign consumption, because of the complete asset market condition, on impact increases by less. Third, the inflationary stimulus in the two countries implies that on impact pre-tax union-wide CPI inflation also rises. This feature has the interesting implication that nominal interest rates increase on impact. In other words, due to the anticipation effects of private consumers, monetary policy reacts even before the announced fiscal change has been implemented.

6 Using indirect taxes to fund government expenditures in the home country: an alternative fiscal scenario

This section argues that the results of Sections 4 and 5 change substantially if one considers an alternative motivation of the unilateral consumption tax increase in the home country which differs from the fiscal devaluation hypothesis. In other words, it is shown that it is impossible to assess the effects of an increase in the consumption tax in isolation, i.e. without a comprehensive description of the entire fiscal environment in which the tax change takes place. To demonstrate this, we investigate a second tax change experiment in which the home country permanently increases its consumption tax by 1 pp from 15% to 16% to finance additional government expenditures, at unchanged levels of labour taxes and long-run debt. The foreign country does not have actively any intention to change its taxes and government spending levels, but, to keep its own level of real debt on target, it reacts passively by adjusting its government expenditures. In sum, everything else being equal, in this second experiment the consumption tax changes only in the home country, while government expenditures adjust in both countries such that the long-run levels of government debt remain unchanged at constant labour tax rates. Hence, maintaining all the other features of the benchmark specification, we replace (14) against

$$G^{BB}_{H,t} = \frac{\tau^{L} w_{H,t} Y_{H,t} + (\tau^{C} + \Delta\tau^{C}) C_t - (R^{r}_{H,t-1} - 1) B^{r}_{H}}{\frac{P_{H,t}}{P_t}}$$

$$G^{BB}_{F,t} = \frac{\tau^{L*} w_{F,t} Y_{F,t} + \tau^{C*} C^{*}_t - (R^{r}_{F,t-1} - 1) B^{r}_{F}}{\frac{P_{F,t}}{P^{*}_t}}$$

6.1 Long-run effects

Table 6 summarises the long-run effects of this alternative experiment which we discuss directly in comparison with Table 4. The following differences are worth mentioning. First, for the closed economy, the consumption tax financed increase of government expenditures, while leading to a slightly stronger increase in home output, generates a substantial decrease in home consumption. This pattern reflects crowding out effects, i.e. to make room for the additional home government expenditures home private consumption declines.[26] Second, as concerns comparisons between various monetary unions

[26] The strongly negative effect of government expenditures on private consumption is well-known for this type of model. In order to moderate or even to overturn it, one needs to restrict the (intertemporal) substitution in private

(which differ in terms of the size of the two countries) and the closed economy, it is remarkable that the effect on home output remains virtually unchanged, reflecting the assumption of home bias in government expenditures.

Table 6: Long-run effects of a permanent increase in τ^C to fund gov't spending, percentage changes

	Closed economy	Monetary union			
					benchmark
Home bias	–	no home bias ($\lambda = 1$)			home bias ($\lambda = 0.5$)
Country size	$n = 1$	$n = 0.75$	$n = 0.5$	$n = 0.1$	$n = 0.5$
Change in τ^C in pp	1	1	1	1	1
Change in G_H/Y_H in pp	0.58	0.58	0.57	0.57	0.58
Change in τ^{C*} in pp	–	–	–	–	–
Change in G_F^*/Y_F^* in pp	–	0.01	0.00	0.00	0.00
Terms of trade	–	−0.45	−0.45	−0.45	−0.40
Real exchange rate	–	0	0	0	−0.20
Home consumption	−0.66	−0.61	−0.55	−0.45	−0.61
Home output	0.19	0.19	0.19	0.18	0.17
Home consumer real wage	−0.87	−0.75	−0.64	−0.47	−0.77
Foreign consumption	–	−0.19	−0.12	−0.03	−0.07
Foreign output	–	0.01	0.01	0.00	0.02
Foreign consumer real wage	–	−0.36	−0.24	−0.06	−0.11
Change in b_H in pp		−0.80	−1.09	−1.55	−0.73
Change in b_F in pp	–	0.87	0.58	0.12	0.22

Third, the latter feature also ensures that there are no spillovers on foreign output, implying that the open economy aspects are very different from the fiscal devaluation scenario discussed above. Instead, the tax financed increase in government expenditures acts like a demand stimulus in the home country, implying that P_H rises relative to P_F, i.e. the terms of trade $T = P_F/P_H$ decline. Similar to our discussion of equation (26) in Section 4.3 and as shown in the Appendix, changes in the terms of trade do not directly depend on changes in consumption taxes. Instead, they are, again, driven by the changes in the fiscal instruments which are used to ensure budget balance, namely the level of government expenditures:

$$\widehat{T}_t = \frac{\eta d_G}{1 + \eta\phi(d_C + d_{C^*})}(\widehat{G}_{F,t} - \widehat{G}_{H,t}) \tag{29}$$

Yet, since the compensating variations in $\widehat{G}_{H,t}$ and $\widehat{G}_{F,t}$ are of opposite sign (compared with $\widehat{\tau}_t^L$ and $\widehat{\tau}_t^{L*}$), the terms of trade move in opposite direction, i.e. they decline. This decline of the terms of trade moderates the crowding out of home consumption, i.e. it ensures that home consumption falls by less than in the closed economy case. By contrast, it hurts foreign consumers such that foreign consumption declines. Fourth, the magnitude of the terms of trade related effects on consumption is, again, a monotonic function of the relative size of the two economies. Specifically, the outcomes for the home country differ most strongly from the closed economy scenario if the home country is

consumption, as addressed in the literature which allows for non-Ricardian consumers (in particular, see Gali et al. (2007)). For monetary union models with this feature, see Canzoneri et al. (2005) and Coenen et al. (2007).

small. Similarly, the effects on foreign consumption are strongest if the foreign country is small. Fifth, as concerns monetary unions with a positive home bias in consumption, the adjustment of the real exchange rate reduces the exposure of consumers to the terms of trade channel. Hence, in the presence of home bias, home consumption, ceteris paribus, decreases by more and foreign consumption by less, as to be inferred from comparing the third and the fifth column in Table 6.
In sum, these effects differ substantially from the fiscal devaluation scenario discussed in Section 4. Most importantly, there are no longer spillover effects on foreign output. Moreover, the terms of trade move into the opposite direction, implying that foreign consumption is negatively affected. Yet, the magnitude of this negative spillover on consumption is small, reflecting that the fiscal experiment in the home country leaves little scope for interactions between the two countries in the first place.

6.2 Short-run effects

The above summarised long-run effects are associated with a distinct pattern of short-run dynamics. As shown in Figure 4 (dashed lines) these short-run dynamics are qualitatively different from the benchmark economy (characterised by labour tax adjustments), as discussed in Section 5.1 (bold lines). These differences can be most easily inferred from the different behaviour of the terms of trade, which decline slowly over time to the lower long-run value. To absorb the demand stimulus in the home economy, triggered by the increase in home government expenditures, home output overshoots during the first quarters. This overshooting of home output is accompanied by an increase in home real producer wages and home producer inflation. In the foreign economy, these impact effects are of opposite sign, i.e. foreign output undershoots, leading to a decline in foreign real producer wages and foreign producer inflation. Hence, compared with the benchmark specification discussed in Section 5.1., the (pre-tax) inflationary and deflationary effects in the two countries are strictly of opposite sign. Interestingly, these country-specific inflation developments offset each other at the aggregate level such that monetary policy - like in the benchmark specification - does not react. In other words, the implications for the aggregate picture of inflation are identical, despite the fact that the country-specific inflation developments are of opposite nature.

7 Conclusion

This paper considers a two-country model of a monetary union to discuss monetary and fiscal interactions between member countries of a monetary union in response to a unilateral fiscal reform in one of the countries. The paper addresses a number of questions which emerge if one of the countries directs its tax structure more strongly towards indirect taxes. In particular, we distinguish between two different fiscal scenarios in which the additional indirect tax revenues of the reform country are either used to finance a cut in labour taxes (in line with the fiscal devaluation hypothesis), or, alternatively, to fund additional government spending. Our analysis reveals that for these two scenarios the terms of trade move in opposite directions, implying that the long-run effects on output and consumption within and between the countries are qualitatively different. Moreover, from a short-run perspective, all these effects are shown to depend on a number of additional channels which we discuss in isolated experiments. Specifically, depending on whether i) the fiscal reform allows for temporary budget imbalances or not, ii) the central bank's objective is specified in terms of pre-tax or after-tax consumer prices, and iii) the policy change is anticipated by the private sector or not, short-run dynamics exhibit significant differences. Quantitatively, the calibrated model version indicates that only if the additional indirect tax revenues are used to finance a cut in direct taxes there is some, though limited, scope for non-negligible spillovers between countries.

To obtain clear analytical findings associated with the terms of trade channel, the paper makes a number of simplifying assumptions. In particular, redistribution effects within countries are negligible, and government expenditures play no interesting role. Similarly, the model counterfactually imposes linear tax schedules for direct and indirect taxes. Moreover, it would be of interest to compare the results of this paper with an alternative set-up which allows for incomplete asset markets between countries. Extensions of the model in these directions are left fur future work. Finally, the analysis takes a strictly positive perspective to discuss implications of unilateral fiscal reforms. Not least because of the beggar-thy-neighbour nature of output effects associated with such reforms, it seems worthwhile to re-investigate the issue at hand in future work in an optimal policy framework which allows for strategic behaviour of policymakers in both countries.

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8 Appendix

8.1 Calibration

Table A.1 Characteristics of euro area countries

	Consumption tax rate	Labour tax rate	Debt to GDP ratio
Euro Area	19.46	39.17	69.06
Austria	21.53	40.58	64.82
Belgium	21.64	43.5	106.45
Finland	28.25	43.49	45.53
France	21.03	41.82	60.65
Germany	18.46	40.09	62.07
Greece	18.21	37.96	105.52
Ireland	25.74	27.48	41.66
Italy	17.29	43.24	110.16
Luxembourg	22.76	29.23	6.77
Netherlands	24.08	31.94	57.15
Portugal	19.66	28.08	57.53
Spain	15.66	28.89	54.7

Note: All the data are taken from Eurostat (source folders: Economy and Finance, Annual Government Finance Statistics). Data on consumption and labour tax rates are implicit tax rates by economic function. The values shown are averages (in %) over the period 1996 - 2006.

8.2 Log-linearization around the steady state

This Appendix summarises the log-linearisation of the model around the steady state summarised in Section 2.6, for both the flexible price economy and the sticky price economy. Let key steady-state ratios be defined as follows:

$$\begin{aligned} d_{GH} &= \frac{G_H}{Y_H}, \quad d_{GF} = \frac{G_F}{Y_F} \\ d_{CH} &= \nu \frac{C}{Y_H}, \quad d_{C^*H} = \nu^* \frac{1-n}{n} \frac{C^*}{Y_H} \\ d_{CF} &= (1-\nu) \frac{n}{1-n} \frac{C}{Y_F}, \quad d_{C^*F} = (1-\nu^*) \frac{C^*}{Y_F} \end{aligned}$$

$$\begin{aligned} w^C &= \frac{\tau^C}{1+\tau^C}, w^L = \frac{\tau^L}{1-\tau^L} \\ w^{C^*} &= \frac{\tau^{C^*}}{1+\tau^{C^*}}, w^{L^*} = \frac{\tau^{L^*}}{1-\tau^{L^*}} \end{aligned}$$

8.2.1 The flexible price economy

Real consumer wage:

$$\begin{aligned} \widehat{\omega}^c_{H,t} &= \widehat{p}_{H,t} - w^C \widehat{\tau}^C_t - w^L \widehat{\tau}^L_t \\ \widehat{\omega}^c_{F,t} &= \widehat{p}_{F,t} - w^{C*} \widehat{\tau}^{C*}_t - w^{L*} \widehat{\tau}^{L*}_t, \end{aligned}$$

with:

$$\widehat{p}_{H,t} = -(1-\nu)\widehat{T}_t \quad \text{and} \quad \widehat{p}_{F,t} = \nu^* \widehat{T}_t.$$

Labour supply:

$$\begin{aligned} \widehat{\omega}^c_{H,t} &= \eta \widehat{Y}_{H,t} + \rho \widehat{C}_t \\ \widehat{\omega}^c_{F,t} &= \eta \widehat{Y}_{F,t} + \rho \widehat{C}^*_t \end{aligned}$$

Market clearing:

$$\begin{aligned} \widehat{Y}_{H,t} &= d_{CH}(\widehat{C}_t + \phi(1-\nu)\widehat{T}_t) + d_{C^*H}(\widehat{C}^*_t + \phi(1-\nu^*)\widehat{T}_t) + d_{GH}\widehat{G}_{H,t} \\ \widehat{Y}_{F,t} &= d_{CF}(\widehat{C}_t - \phi\nu\widehat{T}_t) + d_{C^*F}(\widehat{C}^*_t - \phi\nu^*\widehat{T}_t) + d_{GF}\widehat{G}_{F,t} \end{aligned}$$

Complete asset markets:

$$\widehat{C}^*_t = \widehat{C}_t - \frac{1}{\rho}\widehat{RS}_t + \frac{1}{\rho}\left(w^C \widehat{\tau}^C_t - w^{C*}\widehat{\tau}^{C*}_t\right)$$

Euler conditions:

$$\begin{aligned} \widehat{R}^r_{H,t} + w^C\left(\widehat{\tau}^C_t - \widehat{\tau}^C_{t+1}\right) &= \rho(E_t\widehat{C}_{t+1} - \widehat{C}_t) \\ \widehat{R}^r_{F,t} + w^{C*}\left(\widehat{\tau}^{C*}_t - \widehat{\tau}^{C*}_{t+1}\right) &= \rho(E_t\widehat{C}^*_{t+1} - \widehat{C}^*_t), \end{aligned}$$

with:

$$\widehat{R}^r_{H,t} = \widehat{R}_t - \widehat{\pi}_{t+1} \quad \text{and} \quad \widehat{R}^r_{F,t} = \widehat{R}_t - \widehat{\pi}^*_{t+1}$$

Relationship between real exchange rate and terms of trade:

$$\widehat{RS}_t = (\nu - \nu^*)\,\widehat{T}_t$$

Fiscal policy (flow budget constraint):

$$\begin{aligned} \widehat{B}^r_{H,t} &= \frac{1}{\beta}\left(\widehat{B}^r_{H,t-1} + \widehat{R}^r_{H,t-1}\right) \\ &\quad -\frac{s^r_H}{B^r_H}\left(\frac{\tau^L p_H Y_H(\sigma-1)}{\sigma s^r_H}(\widehat{\tau}^L_t + \widehat{\omega}^p_{H,t} + \widehat{p}_{H,t} + \widehat{Y}_{H,t}) + \frac{\tau^C C}{s^r_H}(\widehat{\tau}^C_t + \widehat{C}_t) - \frac{p_H G_H}{s^r_H}(\widehat{p}_{H,t} + \widehat{G}_{H,t})\right) \end{aligned}$$

$$\begin{aligned} \widehat{B}^r_{F,t} &= \frac{1}{\beta}\left(\widehat{B}^r_{F,t-1} + \widehat{R}^r_{F,t-1}\right) \\ &\quad -\frac{s^r_F}{B^r_F}\left(\frac{\tau^{L*} p_F Y_F(\sigma-1)}{\sigma s^r_F}(\widehat{\tau}^{L*}_t + \widehat{\omega}^p_{F,t} + \widehat{p}_{F,t} + \widehat{Y}_{F,t}) + \frac{\tau^{C*} C^*}{s^r_F}(\widehat{\tau}^{C*}_t + \widehat{C}^*_t) - \frac{p_F G_F}{s^r_F}(\widehat{p}_{F,t} + \widehat{G}_{F,t})\right) \end{aligned}$$

Balanced-budget rule (benchmark: $\widehat{G}_{H,t} = \widehat{G}_{F,t} = 0$, second experiment in Section 6: $\widehat{\tau}^L_t = \widehat{\tau}^{L*}_t = 0$)

$$\begin{aligned} &\frac{1}{\beta}\left(\widehat{B}^r_{H,t-1} + \widehat{R}^r_{H,t-1}\right) \\ = &\frac{s^r_H}{B^r_H}\left(\frac{\tau^L p_H Y_H(\sigma-1)}{\sigma s^r_H}(\widehat{\tau}^L_t + \widehat{\omega}^p_{H,t} + \widehat{p}_{H,t} + \widehat{Y}_{H,t}) + \frac{\tau^C C}{s^r_H}(\widehat{\tau}^C_t + \widehat{C}_t) - \frac{p_H G_H}{s^r_H}(\widehat{p}_{H,t} + \widehat{G}_{H,t})\right) \end{aligned}$$

$$\begin{aligned} &\frac{1}{\beta}\left(\widehat{B}^r_{F,t-1} + \widehat{R}^r_{F,t-1}\right) \\ = &\frac{s^r_F}{B^r_F}\left(\frac{\tau^{L*} p_F Y_F(\sigma-1)}{\sigma s^r_F}(\widehat{\tau}^{L*}_t + \widehat{\omega}^p_{F,t} + \widehat{p}_{F,t} + \widehat{Y}_{F,t}) + \frac{\tau^{C*} C^*}{s^r_F}(\widehat{\tau}^{C*}_t + \widehat{C}^*_t) - \frac{p_F G_F}{s^r_F}(\widehat{p}_{F,t} + \widehat{G}_{F,t})\right) \end{aligned}$$

Benchmark with different fiscal adjustment speed (Section 5.2):

$$\begin{aligned}\widehat{\tau}_t^L &= \alpha'_{b,\tau}\widehat{b}_{H,t} + \alpha'_{\Delta b,\tau}(\widehat{b}_{H,t} - \widehat{b}_{H,t-1}) \\ \widehat{\tau}_t^{L*} &= \alpha'^*_{b,\tau}\widehat{b}_{F,t} + \alpha'^*_{\Delta b,\tau}(\widehat{b}_{F,t} - \widehat{b}_{F,t-1})\end{aligned}$$

where $\widehat{b}_{H,t} = \widehat{B}^r_{H,t} - \widehat{p}_{H,t} - \widehat{Y}_{H,t}$, $\widehat{b}_{F,t} = \widehat{B}^r_{F,t} - \widehat{Y}_{F,t} - \widehat{p}_{F,t}$ and $\alpha'_{b,\tau} = \alpha_{b,\tau}\frac{b_H}{\tau^L}$, $\alpha'_{\Delta b,\tau} = \alpha_{\Delta b,\tau}\frac{b_H}{\tau^L}, \alpha'^*_{b,\tau} = \alpha^*_{b,\tau}\frac{b_F}{\tau^{L*}}$, $\alpha'^*_{\Delta b,\tau} = \alpha^*_{\Delta b,\tau}\frac{b_F}{\tau^{L*}}$

8.2.2 The sticky price economy

The equations for the labour supply, market clearing, complete asset markets, the Euler conditions, the relationship between the real exchange rate and the terms of trade, and the fiscal policy specifications are identical with the flexible price economy. In addition, we use:
New Keynesian Phillips-curve:

$$\begin{aligned}\widehat{\pi}_{H,t} &= k_H(\widehat{\omega}^c_{H,t} + w^C\widehat{\tau}^C_t + w^L\widehat{\tau}^L_t + (1-\nu)\widehat{T}_t) + \beta E_t\widehat{\pi}_{H,t+1} \\ \widehat{\pi}_{F,t} &= k_F(\widehat{\omega}^c_{F,t} + w^{C*}\widehat{\tau}^{C*}_t + w^{L*}\widehat{\tau}^{L*}_t - \nu^*\widehat{T}_t) + \beta E_t\widehat{\pi}_{F,t+1}\end{aligned}$$

Monetary policy rule:

$$\widehat{R}_t = \mu_{y_u}(1-\kappa)\widehat{Y}^U_{t-1} + \mu_{\pi_u}(1-\kappa)\widehat{\pi}^U_{t-1} + \kappa\widehat{R}_{t-1}$$

$$\widehat{\pi}^U_t = s_C\widehat{\pi}_t + (1-s_C)\widehat{\pi}^*_t$$

$$\widehat{Y}^U_t = ((1-s_C)\nu^* - s_Y + s_C\nu)\,\widehat{T}_t + s_Y\widehat{Y}_{H,t} + (1-s_Y)\,\widehat{Y}_{F,t}$$

where $s_Y = \frac{nP_HY_H}{P_UY_U}$.
After-tax union-wide CPI inflation rate (used in Section 5.3):

$$\widehat{\pi}^{\tau^C}_{U,t} = s^{\tau^C}_C(1+\tau^C)\pi_t + (1-s^{\tau^C}_C)(1+\tau^{C*})\widehat{\pi}^*_t + s^{\tau^C}_C(1+\tau^C)w_C\left(\widehat{\tau}^C_t - \widehat{\tau}^C_{t-1}\right) + (1-s^{\tau^C}_C)(1+\tau^{C*})w^*_C\left(\widehat{\tau}^{C*}_t - \widehat{\tau}^{C*}_{t-1}\right)$$

Relationships between inflation rates and terms of trade:

$$\begin{aligned}\widehat{\pi}_t &= \nu\widehat{\pi}_{H,t} + (1-\nu)\widehat{\pi}_{F,t} \\ \widehat{\pi}^*_t &= \nu^*\widehat{\pi}_{H,t} + (1-\nu^*)\widehat{\pi}_{F,t} \\ \widehat{T}_t &= \widehat{\pi}_{F,t} - \widehat{\pi}_{H,t} + \widehat{T}_{t-1}\end{aligned}$$

8.2.3 Equations used in Section 4

To derive equation (26), let $\widehat{\tau}^{C*}_t = 0$, $\widehat{G}_{H,t} = \widehat{G}_{F,t} = 0$. Moreover, assuming there exists no home bias ($\lambda = \lambda^* = 1$), this implies $\nu = \nu^* = n$ and $\widehat{RS}_t = 0$. Combining the equations for real consumer wages, labour supplies and complete asset markets yields

$$\begin{aligned}\widehat{Y}_{H,t} &= \frac{1}{\eta}\left[-(1-n)\widehat{T}_t - w^C\widehat{\tau}^C_t - w^L\widehat{\tau}^L_t - \rho\widehat{C}_t\right] \\ \widehat{Y}_{F,t} &= \frac{1}{\eta}\left[n\widehat{T}_t - w^{L*}\widehat{\tau}^{L*}_t - \rho\widehat{C}_t - w^C\widehat{\tau}^C_t\right]\end{aligned}$$

Combining the equations for market clearing and complete asset markets yields

$$\begin{aligned}\widehat{Y}_{H,t} &= d_{CH}(\widehat{C_t} + \phi(1-n)\widehat{T}_t) + d_{C^*H}\left(\widehat{C}_t + \frac{1}{\rho}w^C\widehat{\tau}^C_t + \phi(1-n)\widehat{T}_t\right) \\ \widehat{Y}_{F,t} &= d_{CF}(\widehat{C_t} - \phi n\widehat{T}_t) + d_{C^*F}\left(\widehat{C}_t + \frac{1}{\rho}w^C\widehat{\tau}^C_t - \phi n\widehat{T}_t\right)\end{aligned}$$

Since the two economies are assumed to be structurally identical and calibrated at the same initial fiscal positions, output levels per capita must also be identical, implying $d_{CH} = d_{CF} \equiv d_C$ and $d_{C^*H} = d_{C^*F} \equiv d_{C^*}$.Then, by combining the two pairs of equations and substituting out for i) $\widehat{Y}_{H,t}$ and $\widehat{Y}_{F,t}$ and ii) $\widehat{C}_t$ one can solve for $\widehat{T}_t$, leading to

$$\widehat{T}_t = \frac{1}{1+\eta\phi\left(d_C+d_{C^*}\right)}\left(w^{L*}\widehat{\tau}_t^{L*} - w^{L}\widehat{\tau}_t^{L}\right)$$

which is equation (26) in the main text. Using this expression in the above derived expressions for $\widehat{C_t}$ and $\widehat{Y}_{H,t}$, one readily verifies

$$\widehat{C_t} = -\frac{1+d_{C^*}\frac{\eta}{\rho}}{\eta\left(d_C+d_{C^*}\right)+\rho}w^{C}\widehat{\tau}_t^{C} - n\frac{1}{\eta\left(d_C+d_{C^*}\right)+\rho}w^{L}\widehat{\tau}_t^{L} - (1-n)\frac{1}{\eta\left(d_C+d_{C^*}\right)+\rho}w^{L*}\widehat{\tau}_t^{L*}$$

$$\widehat{Y}_{H,t} = \frac{1}{\eta}\left[-\frac{\eta d_C}{\eta\left(d_C+d_{C^*}\right)+\rho}w^{C}\widehat{\tau}_t^{C} + \left[n\theta - \frac{\eta\phi\left(d_C+d_{C^*}\right)}{1+\eta\phi\left(d_C+d_{C^*}\right)}\right]w^{L}\widehat{\tau}_t^{L} + (1-n)\theta w^{L*}\widehat{\tau}_t^{L*}\right]$$

with

$$\theta = \frac{1}{1+\frac{\eta}{\rho}\left(d_C+d_{C^*}\right)} - \frac{1}{1+\eta\phi\left(d_C+d_{C^*}\right)}$$

and $\theta > 0$ if $\phi\rho > 1$. Moreover, one can also verify that the equations (27) and (28), in which $\widehat{T}_t$ has not yet been substituted out, are equivalent to these expressions for $\widehat{C_t}$ and $\widehat{Y}_{H,t}$.

8.2.4 Equations used in Section 6

To derive equation (29), let $\widehat{\tau}_t^{C*} = 0$, $\widehat{\tau}_t^{L} = \widehat{\tau}_t^{L*} = 0$. Assuming there exists no home bias, i.e. $\nu = \nu^* = n$ and $\widehat{RS}_t = 0$. Combining the equations for real consumer wages, labour supplies and complete asset markets yields

$$\begin{aligned}
\widehat{Y}_{H,t} &= \frac{1}{\eta}\left[-(1-n)\widehat{T}_t - w^{C}\widehat{\tau}_t^{C} - \rho\widehat{C}_t\right] \\
\widehat{Y}_{F,t} &= \frac{1}{\eta}\left[n\widehat{T}_t - \rho\widehat{C}_t - w^{C}\widehat{\tau}_t^{C}\right]
\end{aligned}$$

Combining the equations for market clearing and complete asset markets yields

$$\begin{aligned}
\widehat{Y}_{H,t} &= d_{CH}(\widehat{C_t} + \phi(1-n)\widehat{T}_t) + d_{C^*H}\left(\widehat{C}_t + \frac{1}{\rho}w^{C}\widehat{\tau}_t^{C} + \phi(1-n)\widehat{T}_t\right) + d_{GH}\widehat{G}_{H,t} \\
\widehat{Y}_{F,t} &= d_{CF}(\widehat{C_t} - \phi n\widehat{T}_t) + d_{C^*F}\left(\widehat{C}_t + \frac{1}{\rho}w^{C}\widehat{\tau}_t^{C} - \phi n\widehat{T}_t\right) + d_{GF}\widehat{G}_{F,t}
\end{aligned}$$

Invoke $d_{CH} = d_{CF} \equiv d_C$ and $d_{C^*H} = d_{C^*F} \equiv d_{C^*}$ and let $d_{GH} = d_{GF} = d_G$. Then, by combining the two pairs of equations and substituting out for i) $\widehat{Y}_{H,t}$ and $\widehat{Y}_{F,t}$ and ii) $\widehat{C}_t$ one can solve for $\widehat{T}_t$, leading to (29), i.e.

$$\widehat{T}_t = \frac{\eta d_G}{1+\eta\phi(d_C+d_{C^*})}\left(\widehat{G}_{F,t} - \widehat{G}_{H,t}\right)$$

8.3 Short run analysis

Figure 1: Impulse responses to an increase in the home consumption tax rate by 1pp: comparison of different fiscal adjustment speeds

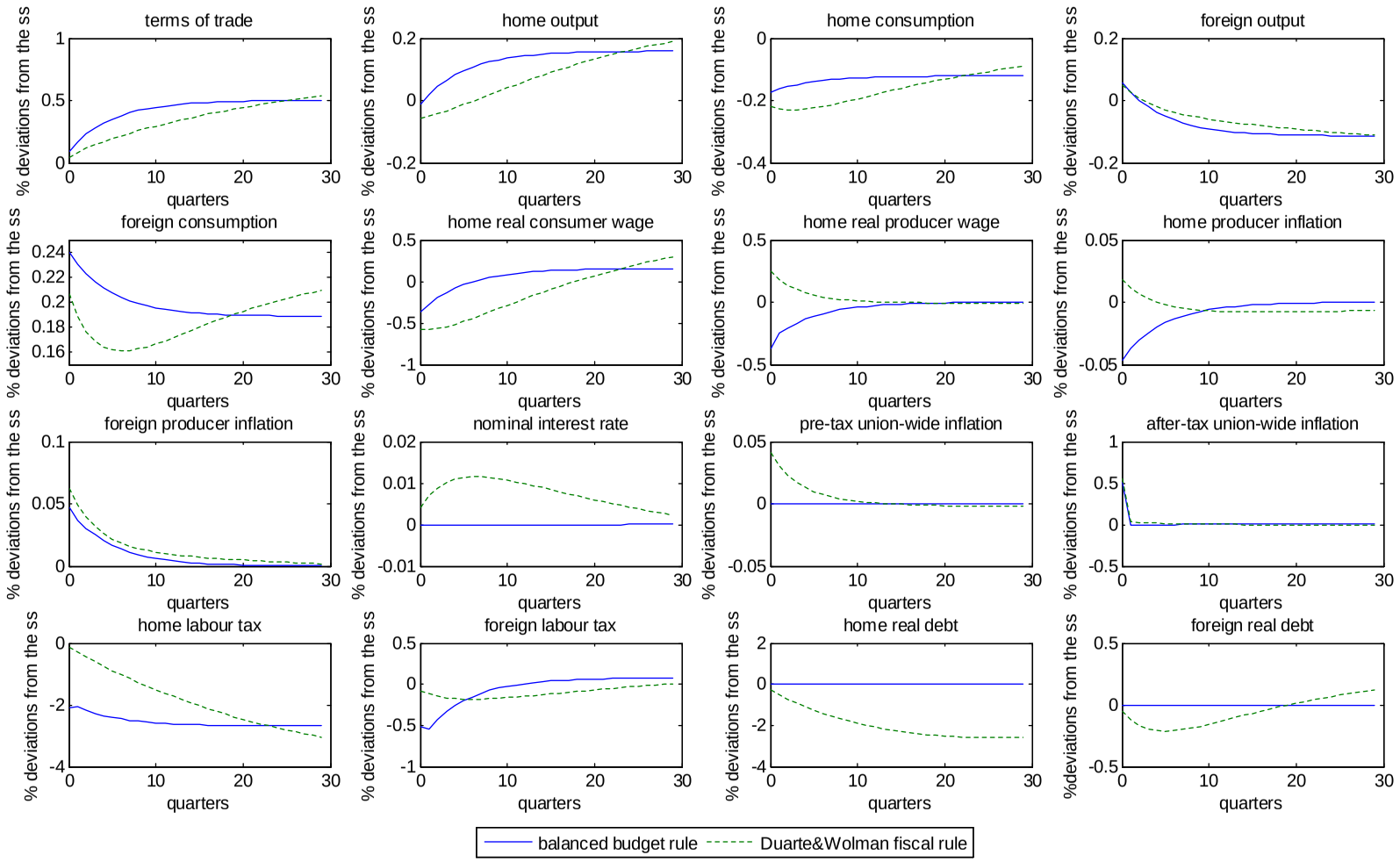


Figure 2: Impulse responses to an increase in the home consumption tax rate by 1pp: comparison of different targets of monetary policy

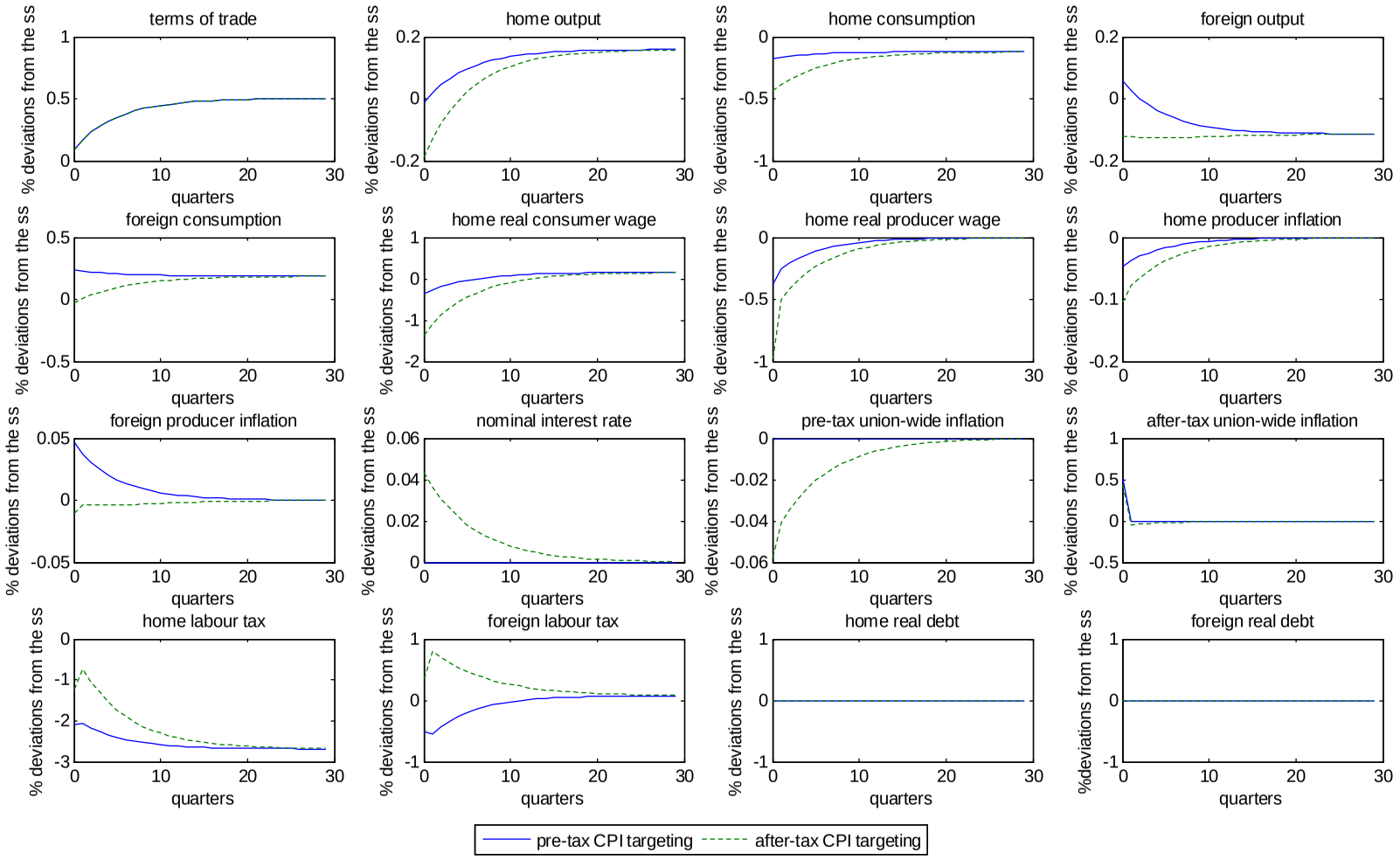


Figure 3: Impulse responses to an increase in the home consumption tax rate by 1pp: unanticipated versus anticipated fiscal policy change

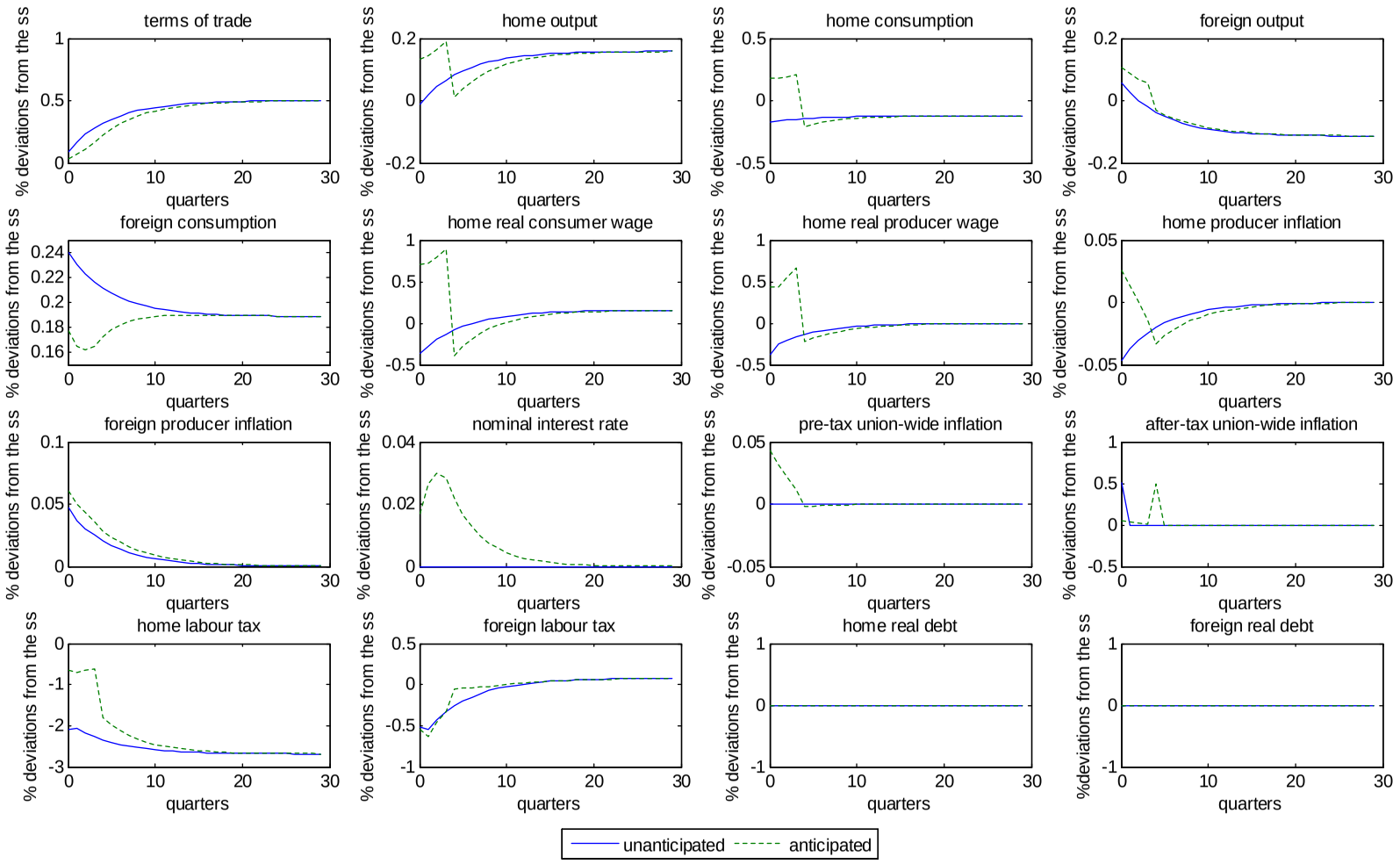
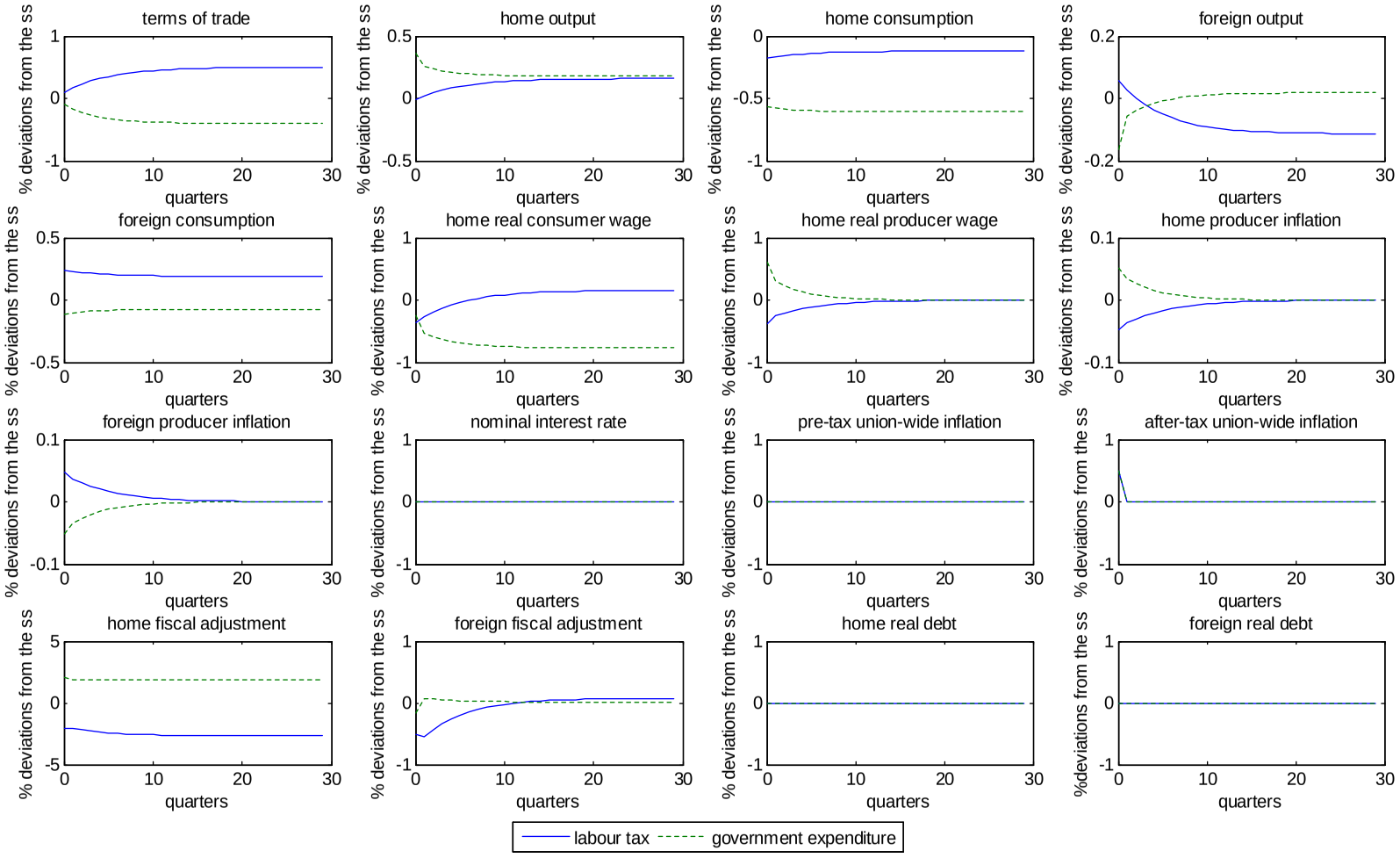


Figure 4: Impulse responses to an increase in the home consumption tax rate by 1pp: comparison of different instruments of the fiscal adjustment



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