On the (In)effectiveness of Fiscal Devaluations in a Monetary Union*

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Abstract

This paper explores the fiscal devaluation hypothesis in a model of a monetary union characterised by national fiscal policies and supranational monetary policy. We show that a unilateral tax shift in one of the countries, which replaces direct by indirect taxes, produces small but non-negligible long-run effects on output and consumption within and between the two countries only when international financial markets are perfectly integrated. In contrast to the existing literature, we find that short-run effects are not always amplified by nominal wage rigidities. We document also how short-run effects of the tax shift depend on the choice of the inflation index stabilized by the central bank and on whether the tax shift is anticipated.

Keywords: Fiscal regimes, Monetary policy, Currency union

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1 Introduction

It is well-known that the structures of taxation differ significantly between European countries. One interesting source of cross-country differences is the importance of indirect taxes in the tax systems of specific countries. The share of indirect taxes in total taxation (including social security contributions) stands for the European Union as a whole at about 35%. Yet, the dispersion of this share across countries is substantial, ranging from more than 50% in Bulgaria to about 30% in Belgium, Germany, and Finland.[1] Differences in taxation structures are of particular relevance for countries belonging to the euro area which share an irrevocably fixed nominal exchange rate, a feature which makes it impossible to affect the competitiveness of economies through nominal exchange rate adjustments. Similarly, internal reversals of competitiveness losses through adjustments in domestic prices and wages seem in many cases elusive. These features have triggered a debate whether those euro area countries that need to improve their competitiveness may be able to mimic the effects of the devaluation of the exchange rate through an appropriate use of fiscal instruments, in particular, by rebalancing the tax structure away from direct (production-based) taxes towards indirect (consumption-based) taxes.[2]
This argument (which is commonly labelled as the 'fiscal devaluation hypothesis') 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 (or social security contributions), make tradeable production more competitive. Motivated by this observation, our paper explores quantitatively the relevance of the fiscal devaluation hypothesis in a two-country model of a monetary union with endogenously derived terms of trade.
Our main finding is that the long-run effects of such a tax shift on output and consumption within and between the two countries depend significantly on the degree of financial integration between the two countries. Moreover, short-run dynamics are shown to depend on the choice of the inflation index stabilised by the central bank, on whether the tax shift is anticipated or not, and on the degree of nominal wage stickiness. Quantitatively, the calibrated model version indicates that only in the case

[1] The numbers refer to the year 2010. Notwithstanding the variation across countries, indirect taxes have become the main source of tax revenues in the EU as a whole (amounting in 2010 to 13.2% of GDP), followed by social security contributions (12.7%) and direct taxes (12.6%). For further details, see European Commission (2012).

[2] Since 2010 about half of the Member States have increased (standard and reduced) VAT rates, including all those countries that are under macroeconomic adjustment programs with IMF involvement, as summarised in European Commission (2012). Broader approaches of some countries to give indirect taxes (relative to taxes on labour), at least at the margin, a more prominent role predate the crisis. A prominent example is the substantial increase in German VAT by 3pp in 2007 which was partly offset by reduced contributions to the unemployment insurance scheme. Tax shifts of this type have also been undertaken by Denmark and Hungary, while France has recently embarked on a similar agenda under the label of a 'social VAT'. For comprehensive discussions of policy initiatives advocating a shift of tax systems towards indirect taxes see European Commission (2006) and European Commission (2008). For a recent appraisal of the fiscal devaluation strategy in the context of euro area crisis management, see EEAG (2013).

of complete financial integration there is scope for small but non-negligible long-run spillovers between countries. Under incomplete financial integration spillovers are negligible such that the quantitative effects of the tax shift are similar to the closed economy version of our model (which we characterise as a limiting case of our general set-up).[3]

Our model of a monetary union is in line with the New Keynesian tradition (see Woodford (2003)) and similar to Benigno (2004), Duarte and Wolman (2008), and Ferrero (2009). We deliberately keep the model 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. 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).[4] Each country is specialised in the production of a composite tradeable good which is consumed in both countries. Firms are Dixit-Stiglitz monopolistic competitors and set identical prices in both countries. Finally, the monetary union can be characterised by three distinct degrees of financial integration. In particular, we assume that households in each country have access to state-contingent riskless bonds (*complete markets*) or have access to non state-contingent bonds (*incomplete markets*) or have no access at all to international bonds (*financial autarky*).

Within this broad set-up, we assume 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.[5] 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.

As already stressed, our analysis suggests, in general, that the (in-)effectiveness of the fiscal devaluation hypothesis depends significantly on the degree of financial integration between the two countries. From

[3]While our focus is on open economy aspects, the closed economy version of our model offers a natural benchmark for the quantitative assessment of the fiscal devaluation hypothesis. As argued in detail below, under our modeling assumptions the quantitative effects of the tax shift in the closed economy version turn out to be unimportant.

[4]Fiscal policymakers follow feedback rules which anchor the economies at country-specific target levels of government debt, similar to Leeper (1991), Schmitt-Grohe and Uribe (2007) and Leith and von Thadden (2008).

[5]This assumption is important to bear in mind, since it makes clear that our findings do not address a scenario in which an increase in consumption taxes is motivated by short-term fiscal consolidation needs.

a more detailed perspective, four findings are worth summarising. First, long-run outcomes depend strongly on the degree of financial integration, since the wealth effects associated with the shift in the tax structure tend to be very different, depending on whether financial markets are complete or not. Under complete markets the increase in home output is sizable. The risk sharing which characterises complete markets leads to a decline in home consumption, while foreign consumption increases, and welfare effects are not negligible. Under incomplete markets, in the absence of risk sharing, consumption patterns are markedly different: home consumption increases mildly, in line with the significantly dampened increase in home output, while foreign consumption and output are virtually unaffected. Moreover, welfare effects are negligible. Second, our analysis indicates that the strength of the terms of trade channel on home variables decreases in the relative size of the home country.[6] Third, from a short-run perspective, all effects (within and between countries) are shown to depend on whether i) the central bank's objective is specified in terms of pre-tax or after-tax consumer price inflation, ii) the tax shift is anticipated by the private sector or not, and iii) the degree of nominal wage stickiness.[7] Fourth, relative to a world with flexible nominal wages, the short-run effects of sticky nominal wages depend crucially on the degree of financial integration. In particular, we establish the novel finding that sticky wages amplify the effects of the tax shift in the short run only when the degree of financial integration is not perfect.

The remainder of our paper is structured as follows. Section 2 summarises how our main findings can be linked to related literature. Section 3 summarises the model. Section 4 presents the benchmark calibration. Sections 5 and 6 discuss long-run and short-run effects, respectively, of a tax shift in the home country. Section 7 concludes. Technical material as well as various impulse response figures are displayed in the Appendix.

2 Related Literature

Our analysis is related to a recent paper by Farhi et al. (2012). This paper derives exact equivalence results under which fiscal devaluations (at an unchanged nominal exchange rate) replicate allocations that result from a nominal devaluation of the exchange rate. Farhi et al. (2012) consider four distinct

[6] 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.

[7] For a detailed discussion of aspects related to the appropriate inflation indices stabilised by central banks, see, for example, Camba-Mendez (2003). In the particular context of our tax shift experiment one may find it suggestive to think of pre-tax inflation as 'core inflation', while after-tax inflation corresponds to 'headline' inflation.

fiscal instruments (i.e. value added, payroll, consumption, and income taxes) and show that particular combinations of these instruments can mimic the effects of a nominal exchange rate devaluation under various assumptions about the microeconomic environment (e.g. nominal rigidities, anticipation effects, degree of asset market incompleteness). In particular, under incomplete asset markets the effects of an unexpected nominal devaluation can be fully replicated with only two of these instruments (namely the value-added tax and the payroll tax). By contrast, under complete markets, since changes in taxes affect the risk sharing among countries, equivalence requires that all four instruments are used.[8] These results are consistent with our findings in two ways. First, under incomplete markets the two pairs of value-added vs. payroll taxes (stressed by Farhi et al. (2012)) and consumption vs. income taxes (stressed in our analysis) are very similar, leading to negligible long-run effects (and are thus in line with conventional reasoning concerning the long-run effects of a nominal devaluation).[9] Moreover, in either analysis short-run effects of fiscal devaluations are amplified under sticky wages (relative to a scenario in which only prices are sticky). Second, we find that under complete asset markets long-run effects of the tax shift are not negligible and short-run effects will no longer be amplified by sticky wages. Again, these findings are in line with the analysis of Farhi et al. (2012), in the sense that we are not interested in the derivation of equivalence results between fiscal and nominal devaluations.

In general, the focus of our paper is different from Farhi et al. (2012) as we study under what assumptions, if at all, the fiscal reform undertaken by a member country of a monetary union can lead to quantitatively relevant effects. Given this focus, our paper can be used to see why the long-run effectiveness of the fiscal devaluation channel is subject to a number of specific modeling assumptions. In particular, several authors, including Feldstein and Krugman (1990), Calmfors (1998) and recently de Mooij and Keen (2012), argue 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, tends to have no long-run effects on trade patterns if changes in domestic goods and factor prices undo the effects of the tax changes. Similarly, studies in the spirit of Poterba et al. (1986) stress that short-run effects of a fiscal devaluation that are driven by nominal rigidities will disappear in the long run (i.e. under flexible prices). These results hold for the special case of a small open economy which acts as a price-taker in international output

[8] Farhi et al. (2012) finds that an increase in VAT and a decline in the payroll tax need to be accompanied by a reduction in the consumption tax and an increase in the income tax.

[9] While being negligible, the effects are not entirely identical because of our different fiscal closure in terms of the assumed debt targeting rule.

markets. Our paper, by contrast, explores the quantitative relevance of the fiscal devaluation channel under the assumption that the terms of trade are endogenous (i.e. they react to changes in the tax structure).

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 under imperfect financial integration. The order of magnitude of the long-run output effects is similar to our findings. 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 under alternative asset market assumptions. 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).[10] 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 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.

3 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

[10] Canzoneri et al. (2004) 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.

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.

3.1 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

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

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.[11] 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. Moreover, let $\nu = 1 - (1-n)\lambda$, where $\lambda \in (0, 1]$ denotes the degree of openness of the home country.

[11] In order to have a well defined maximisation problem we assume that U is twice continuously differentiable, increasing and concave in C_t, while V is twice continuously differentiable, increasing and convex in L_t. For the specific functional forms, see Section 3.7.1.

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 $T_t = \frac{P_{F,t}}{P_{H,t}}$.

We assume that the monetary union can be characterised by three distinct degrees of financial integration. In particular, we assume that households in each country have access to state-contingent riskless bonds (*complete markets*) or have access to non state-contingent bonds (*incomplete markets*) or have no access at all to international bonds (*financial autarky*). Apart from that, 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:

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

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 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.[12] $D_{H,t-1}$ represents holdings of nominal one–period international bonds, possibly state-contingent, purchased in period $t-1$ and redeemed in period t with the nominal interest rate factor R_{t-1}. In the case of incomplete markets, we follow Schmitt-Grohe and Uribe (2003) and introduce bond adjustment costs (AC_t) in order to guarantee stationarity of the current account. The adjustment cost is defined by the following expression:

$$AC_t = \frac{\chi}{2}\left(\frac{D_{H,t}}{P_t} - \overline{d}_H\right)^2,$$

where $\overline{d}_H$ is the steady-state holding of the bond by the home consumers. The adjustment cost implies that households in both economies have a strong incentive to return to their initial position and creditors face lower nominal interest rate than debtors. Finally, in the case of financial autarky households do not have access to any international bonds, thus $D_{H,t} = 0\ \forall t$.

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. In sum, the optimisation problem of the home consumer amounts to choose paths of private consumption (C_t), labour supply (L_t), international bonds ($D_{H,t+1}$) 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. The optimal labour supply satisfies the static first-order condition:

$$\frac{V_L(L_t)}{U_C(C_t)} = \frac{1-\tau_t^L}{1+\tau_t^C}\frac{W_{H,t}}{P_t}, \tag{5}$$

[12] 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.

where $(1-\tau_t^L)/(1+\tau_t^C)$ captures the relevant tax wedge for the labour-consumption trade-off. Let $G_{H,t}$ and $G_{F,t}$ denote the (per capita) levels of composite government expenditures in the two countries. As concerns the composition of these goods in terms of individual components, we assume perfect home bias for government expenditures. Combined with the optimal consumption behaviour, this implies that the demand for generic home and foreign tradeable goods can be written as:

$$y_t(h) = \left[\frac{p_t(h)}{P_{H,t}}\right]^{-\sigma} \left\{ \left[\frac{P_{H,t}}{P_t}\right]^{-\phi} \nu C_t + G_{H,t} + \left(\frac{P_{H,t}}{P_t^*}\right)^{-\phi^*} \frac{\nu^*(1-n)}{n} C_t^* \right\} = \left[\frac{p_t(h)}{P_{H,t}}\right]^{-\sigma} Y_{H,t}, \quad (6)$$

$$y_t(f) = \left[\frac{p_t(f)}{P_{F,t}}\right]^{-\sigma^*} \left\{ \left[\frac{P_{F,t}}{P_t}\right]^{-\phi} \frac{(1-\nu)n}{1-n} C_t + \left[\frac{P_{F,t}}{P_t^*}\right]^{-\phi^*} (1-\nu^*) C_t^* + G_{F,t} \right\} = \left[\frac{p_t(f)}{P_{F,t}}\right]^{-\sigma^*} Y_{F,t}, \quad (7)$$

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

3.2 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:

$$y_t(h) = A_{H,t} L_t(h), \quad (8)$$

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:

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

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

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. 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:

$$\frac{\widetilde{p}^{Flex}_t(h)}{P_{H,t}} = \frac{\sigma}{\sigma - 1} MC^r_{H,t}. \tag{9}$$

Analogous expressions can be derived for the foreign country.

3.3 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.[13] Hence, the home country's flow government budget constraint in nominal terms (and on a per capita basis) is given by:

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

[13]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.

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

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

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:

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

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

3.3.1 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 $B^r_{F,t} = B^r_F \ \forall\ t$. For given target levels of real debt this implies that real primary surpluses are given by:

$$s^{r,\,BB}_{H,t} = (R^r_{H,t-1} - 1) B^r_H \quad \text{and} \quad s^{r,\,BB}_{F,t} = (R^r_{F,t-1} - 1) B^r_F. \tag{10}$$

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 (10) 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:

$$\tau_t^{L_{BB}} = \frac{(R^r_{H,t-1} - 1) B^r_H - (\tau^C + \Delta\tau^C) C_t + \frac{P_{H,t}}{P_t} G_H}{w_{H,t} L_t} \text{ and } \tau_t^{L*_{BB}} = \frac{(R^r_{F,t-1} - 1) B^r_F - \tau^{C*} C^*_t + \frac{P_{F,t}}{P^*_t} G_F}{w_{F,t} L^*_t}. \tag{11}$$

3.4 Degree of Financial Integration

As stated above, we allow for three different degrees of financial integration. First, in the case of complete asset markets households in both countries have access to state-contingent bonds. This assumption implies 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 (derived from Euler equations for home and foreign consumers) holds:

$$\frac{U_C(C^*_{t+1})}{U_C(C^*_t)}\frac{P_{t+1}}{P_t}\frac{1+\tau^C_{t+1}}{1+\tau^C_t} = \frac{U_C(C_{t+1})}{U_C(C_t)}\frac{P^*_{t+1}}{P^*_t}\frac{1+\tau^{C*}_{t+1}}{1+\tau^{C*}_t}.$$

After choosing appropriately the distribution of initial wealth, one obtains:

$$\frac{U_C(C_t)}{U_C(C^*_t)} = \upsilon\frac{P_t}{P^*_t}\frac{1+\tau^C_t}{1+\tau^{C*}_t}, \tag{12}$$

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.

Second, in the case of incomplete markets households have access to non state-contingent bonds. This assumption implies that marginal rates of substitution in consumption are equalised between countries only on average. Intertemporal optimality of bond holdings leads to the following Euler equation for home and foreign consumers:

$$E_t\left(\frac{U_C(C_{t+1})P_t(1+\tau^C_t)}{U_C(C_t)P_{t+1}(1+\tau^C_{t+1})}\right)\frac{\beta R_t}{1+\chi(\frac{D_{H,t}}{P_t}-\overline{d}_H)} = 1. \tag{13}$$

Third, in the case of financial autarky households do not have access to any international borrowing. This implies that the value of domestic production has to be equal to the sum of public and private consumption:

$$C_t = p_{H,t}(Y_{H,t} - G_{H,t}). \tag{14}$$

3.5 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:

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

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 $Y^n_{U,t}$ 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), with $P_{U,t} = s_C P_t + (1-s_C)P^*_t$, 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 Section 6.2.

3.6 Some Definitions

3.6.1 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 $\pi_{U,t}^{\tau^C} = P_{U,t}^{\tau^C}/P_{U,t-1}^{\tau^C}$.

3.6.2 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:

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

3.7 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 C).

3.7.1 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 (9) implies $MC_H^r = \frac{\sigma-1}{\sigma}$. Moreover, $\beta = 1/(1+i) = 1/(1+r)$ 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 (8) and (16), the steady-state counterparts of (2), (3), (12) or (14)[14], (5), (6) and (7) 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:

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

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

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

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

$$1 = \nu p_H^{1-\phi} + (1-\nu)(p_F RS)^{1-\phi} \tag{21}$$

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

$$\tag{23}$$

[14] Depending on the degree of financial integration.

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

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

$$\frac{C^{-\rho}}{(C^*)^{-\rho^*}} = \upsilon R S^{-1} \frac{1+\tau^C}{1+\tau^{C*}} or C = p_H(Y_H - G_H) \tag{26}$$

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 $T = RSp_F/p_H$.

4 Calibration

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. (2011), Coenen et al. (2008), Christiano et al. (2005)). 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. (2011), 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. (2011) 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). The portfolio cost adjustment parameter, χ, is set to 0.001 which corresponds

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
Portfolio cost adjustment	χ	0.001

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

to an average annual interest rate premium of 0.405%, in line with Schmitt-Grohe and Uribe (2003). Moreover, we assume that the steady-state value of bond holdings is zero, i.e. $\overline{d}_H = 0$.

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 6 in the Appendix A) 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.[15]

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

[15] 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 (2009) and Canzoneri et al. (2004).

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

to output fluctuations ($\mu_{y_u} = 0$).[16] Notice that the benchmark balanced-budget rule (11) does not require any additional fiscal parameter.

5 Long-run Effects

This section focuses on long-run effects of a permanent shift in the tax structure of a union member country under different degrees of financial integration, 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 (11).

Table 4 summarises the long-run effects for welfare and 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 4), 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 4.

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

[16] For a discussion of this assumption, see Section 6.1.

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.

5.1 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-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.[17] 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 closed economy benefits only slightly from this tax shift, which is reflected in a small welfare gain of 0.01% of the steady state consumption.

5.2 Monetary Union with Countries of Equal Size

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

[17] 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 (2000).

Table 4: Permanent shift in the home tax structure - complete markets, % 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	−0.70	−0.74
Terms of trade	–	0.21	0.21	0.21	0.38
Home consumption	0.05	−0.07	−0.19	−0.38	−0.14
Home output	0.05	0.11	0.18	0.29	0.15
Home consumer real wage	0.22	0.14	0.07	−0.05	0.09
Foreign consumption	–	0.36	0.24	0.05	0.19
Foreign output	–	−0.20	−0.13	−0.03	−0.10
Foreign consumer real wage	–	0.22	0.15	0.03	0.13
Home welfare loss	−0.01	0.16	0.34	0.61	0.27
Foreign welfare loss	–	−0.52	−0.35	−0.07	−0.28

Welfare losses are calculated as percentage changes in the initial steady state consumption to equate the welfare under the tax shift and the welfare in the initial steady state. Welfare is calculated as a present value of the infinite flow of households' utility, in line with equation (1).

on welfare and real variables, affecting both countries.

Importantly, both the sign and the size of spillovers in a monetary union depend on the assumed degree of financial integration. In that respect, our results are in line with Baxter and Crucini (1995), who find that the extent of financial integration is central to the international transmission mechanism of persistent shocks. In particular, the wealth effects associated with the shift in the tax structure tend to be very different, depending on whether financial markets are complete or not.

First, we address the transmission mechanism of the tax shift under complete markets. Under this assumption, both home and foreign consumers own risky claims to home and foreign output. The shift in the tax structure of the home country lowers the tax burden on home production. As a result there is an increase in home production (and, hence, also home labour supply). Because of risk sharing the proceeds of the additional home production are not reserved for home consumers. Foreign consumers, through risk sharing, experience a positive wealth effect, inducing an increase in foreign consumption and a decline in foreign output. By contrast, the home country experiences a negative wealth effect, and the increase in home output is accompanied by a fall in home consumption, leading to a welfare loss of the home country. Moreover, home terms of trade depreciate significantly. This channel supports the reallocation of output from the foreign to the home country.

In sum, risk sharing resulting from perfect financial integration drives a certain wedge between con-

sumption and production in the two countries. In absolute terms, the effects are small, but not negligible, as evidenced by the home welfare loss of 0.34% of the steady state consumption. Accordingly, 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 risk sharing effect dominates the consumption increase reported for the closed economy). Moreover, the risk sharing generates limited, but non-negligible spillovers as foreign welfare increases by 0.35% of the steady state consumption (accompanied by a decline in foreign output by 0.13% and an increase in foreign consumption by 0.25%). Second, we analyse the transmission mechanism under incomplete markets (see Table 5 for comparison with complete markets). In such a situation, home consumers are the sole owners of risky claims to their output. Since the tax shift is assumed to be permanent foreign consumers have no ability to support higher consumption via borrowing.[18] Thus consumption is essentially determined by the output response in either country. Home welfare does not change as the increase in home output due to the tax shift is balanced by an almost equivalent increase in consumption coming from the positive wealth effect. Note that the actual increase in home output is significantly dampened (reflecting that home labour supply is subject to opposite effects from the wealth channel and the significant rise in the home wage rate). These changes in home variables are accompanied by a small terms of trade increase, supporting a small increase in foreign welfare that is accompanied by an increase in foreign consumption and a decrease in foreign output. Quantitatively, however, the effects on foreign variables are very small, implying that under incomplete markets, in the absence of risk sharing, spillovers are negligible. Hence, our model predicts that under incomplete markets the quantitative effects of the permanent tax shift are very similar to the one in the closed economy (compare column 1 in Table 4 and column 2 in Table 5).

5.3 Monetary Unions with Countries of Different Size

The results established so far can be generalised if one looks at monetary unions consisting of countries of different size (and no home bias). It is worth stressing that under incomplete markets the effects of the tax shift are virtually unaffected by the relative size of the home country (see Table 7 in Appendix B). Hence, in this subsection we restrict our attention to the complete markets case.

Columns 2 and 4 in Table 4 report 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

[18] This implies that in the case of permanent shocks reactions under incomplete markets are equivalent to those in financial autarky.

Table 5: Permanent shift in the home tax structure - complete markets vs incomplete markets

	Complete markets	Financial autarky
Change in τ^C in pp	1	1
Change in τ^L in pp	-0.73	-0.76
Terms of trade	0.21	0.04
Home consumption	-0.19	0.03
Home output	0.18	0.05
Home consumer real wage	0.07	0.20
Foreign consumption	0.24	0.01
Foreign output	-0.13	-0.01
Foreign consumer real wage	0.15	0.02
Home welfare loss	0.34	0.01
Foreign welfare loss	-0.35	-0.02

Comparison for the symmetric no home bias case.

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 home welfare and home variables 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. Similarly, as concerns the foreign country, the magnitude of the terms of trade related effects on foreign welfare and other foreign variables 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 Appendix C.3, one can show that in the case of complete markets 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:[19]

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

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

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

two tax rates as well as in the terms of trade:

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

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.:

$$\widehat{C}_t = -(1-n)\frac{1+\eta\phi(d_C+d_{C^*})}{\eta(d_C+d_{C^*})+\rho}\widehat{T}_t - \frac{1+\frac{\eta}{\rho}d_{C^*}}{\eta(d_C+d_{C^*})+\rho}w^{C}\widehat{\tau}^{C}_t - \frac{1}{\eta(d_C+d_{C^*})+\rho}w^{L}\widehat{\tau}^{L}_t \tag{28}$$

$$\begin{aligned}\widehat{Y}_{H,t} = {} & (1-n)\left(\rho\phi-1\right)\frac{\phi(d_C+d_{C^*})}{\eta\phi(d_C+d_{C^*})+\rho\phi}\widehat{T}_t \\ & - \frac{d_C}{\eta(d_C+d_{C^*})+\rho}w^{C}\widehat{\tau}^{C}_t - \frac{d_C+d_{C^*}}{\eta(d_C+d_{C^*})+\rho}w^{L}\widehat{\tau}^{L}_t.\end{aligned} \tag{29}$$

Equations (28) and (29) 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 $\widehat{T}$, $\widehat{\tau}^{C}_t$, and $\widehat{\tau}^{L}_t$ 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).[20] This result is consistent with home welfare declining in the result of the tax shift.

These results heavily depend on the assumption of market completeness. In the case of incomplete

[20]Evidently, $\widehat{C}_t$ and $\widehat{Y}_{H,t}$ can be entirely expressed as a function of tax-related terms if one uses (27) in (28) and (29), as shown in the Appendix C.3. However, to understand the special role played by the terms of trade, (28) and (29) 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:

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

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.

markets one can show that the terms of trade depend not only on labour taxes but also on consumption taxes:

$$\widehat{T}_t = \gamma_{fa}(w^{L^*}\widehat{\tau}_t^{L*} - w^L\widehat{\tau}_t^L - w^C\widehat{\tau}_t^C), \tag{30}$$

where γ_{fa} is defined in the Appendix C.3. As a result, under incomplete markets the implied change in the terms of trade is much smaller than in the case of complete markets. This is in line with the opposite wealth effects under complete and incomplete markets and much smaller welfare losses under incomplete markets. Finally, the effects of the consumption-labour tax shift under incomplete markets are similar to the VAT-payroll tax shift in Farhi et al. (2012) and thus resemble a nominal devaluation.[21]

5.4 Benchmark Monetary Union

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 4. Since under incomplete markets the effects of the tax shift are virtually unaffected by the existence of a home bias of a country (see Table 7 in Appendix B) we summarise only the complete markets case.

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 the home economy as well as the spillover effects on the foreign 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. Similarly, the welfare effects are only marginally different.

6 Short-run Effects

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 Section 5. To characterise core features of the short-run dynamics in a tractable manner, this Section

[21] One can derive for the VAT-payroll tax shift a terms of trade equation similar to equation (30). Notice that the VAT-payroll tax shift does not lead to long-run effects, irrespective of the degree of financial integration. A change in VAT falls on producers and thus does not affect the risk sharing of consumers in the long run.

proceeds as follows. Section 6.1 summarises the short-run dynamics of the benchmark specification introduced above under complete and incomplete markets. We report then, as a robustness exercise, how these dynamics change under three distinct experiments, each relaxing a different characteristic feature of the benchmark. Section 6.2 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 6.2 discusses how the benchmark results of Section 6.1 change if monetary policy targets after-tax (i.e. 'headline') rather than pre-tax (i.e. 'core') union-wide consumer price inflation. Section 6.3 discusses how the benchmark results of Section 6.1 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. Finally, Section 6.4 assumes that nominal wages are no longer flexible but sticky in the short run.

6.1 Benchmark Monetary Union

This subsection complements Subsection 5.4 and summarises main characteristics of the transitional dynamics triggered by the unilateral shift in the tax structure of the home economy. It is worth noting at the outset that, as concerns the different cases of financial integration, the only substantial difference can be seen in the response of home and foreign consumption (see Figures 1- 3), in line with the long-run findings discussed in the previous section. For the other endogenous variables, like output and the terms of trade, the impulse responses are qualitatively of similar shape, notwithstanding their quantitative differences. In all cases, short-run adjustments leave core 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 Figures 1- 3, the logic underlying this result can be summarised as follows.[22] Irrespective of the degree of financial integration, nominal price stickiness ensures that 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 while foreign output is higher in the short run than in the long run. The short-run response of home consumer real wages is smaller than in the long run. This implies that producer real wages (which are equal to the real marginal cost) will decline on impact. With the dynamics of home producer prices being driven by

[22]The impulse responses in Figures 1−3 are based on a first-order approximation of the economy developed in Section 3. The approximate long-run levels in Figures 1-3 are virtually identical to the exact values reported in column 5 in Table 4, i.e. the approximation error is negligible.

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 in the case of complete markets and 1 basis point in the case of incomplete markets. In any case, this deflationary effect is inconsequential for core union-wide inflation dynamics since it is offset by an equally sized inflationary effect on foreign producer prices.[23] This latter effect reflects that short-run dynamics in the foreign country are the mirror image of developments in the home country. 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 core 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:

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

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 core 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 headline 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 headline consumer prices is on impact virtually complete, i.e. headline 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.[24]

[23] Foreign real producer wages increase on impact in line with higher foreign consumer real wages.

[24] This reasoning would require modifications if the assumption of Calvo-style price-setting would be replaced by

Two points are worth emphasising. First, the offsetting effects of core 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, core 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, core 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.

6.2 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. To this end, Figures 4 and 6 compare the findings from the benchmark specification, as discussed in Section 6.1, 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

state-dependent pricing, as discussed, for example, in Dotsey et al. (1999).

[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 Figures 4 and 6 in which eventually the impulse responses of all variables converge against the same levels under the two specifications.

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 4 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.

6.3 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 et 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 Figures 5 and 7 (dashed lines). Three features are worth pointing out. First and most importantly, home 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 for the complete markets case and 0.4 for the incomplete markets case) 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 on impact increases by less (in line with a smaller increase in terms of trade).[26]

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 rate increases 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.

6.4 Sticky Wages

Finally, a crucial factor that should be taken into account in the analysis of the potential effects of the fiscal devaluation hypothesis is the flexibility of the labour market. Several papers, among others Calmfors (1998) and de Mooij and Keen (2012), argue that a shift from direct to indirect taxes can be effective in the short run provided that nominal wages are sticky. According to these papers, if nominal wages are sticky in the short run then a decline in labour taxes will result in smaller labour costs and a reduction in export prices. If nominal wages were flexible, then a decline in labour taxes would be counteracted by an increase in nominal wages. So the tax shift would not be effective. Moreover, this reasoning implies that there are no long-run effects of the tax shift as an adjustment of nominal wages would eliminate any benefits of lower labour taxes. However, this analysis is based on a partial equilibrium analysis of a small open economy which faces exogenously given terms of trade. In order to test the validity of the above reasoning in our model we now assume that nominal wages are sticky à la Calvo (for details, see the specific equations in the Appendix C.4).[27] In our benchmark model with complete markets we obtain, in fact, that the effects of the tax shift are dampened if nominal wages are sticky in the short run. Why is that? Recall that in the short run the home real consumer wage actually declines in the benchmark scenario (see Figure 8). If nominal wages are sticky such decline does not occur, and this feature dampens the increase in home output and in the home terms of trade. As a result, home consumption will decline by less under sticky wages.

The impact of sticky wages is notably different when the degree of financial integration is not perfect. In such a situation home real consumer wages increase in the short run when wages are flexible (see Figure 9). If wages are sticky the rise in home real consumer wages will be smaller, and this feature

[26] In the case of incomplete markets foreign consumption actually decreases on impact due to limited risk sharing.

[27] For simplicity, we assume that in both countries the degree of wage stickiness and of price stickiness are identical to each other.

leads to a stronger depreciation of the terms of trade and thus higher home output and higher home consumption (which is determined by home output). Foreign consumers will also benefit from the fact that wages are sticky as both foreign output and foreign consumption will increase.

In sum, the results presented in this subsection indicate that the impact of nominal sticky wages depends crucially on the degree of financial integration. We find that sticky wages amplify the effects of the tax shift in the short run only when the degree of financial integration is not perfect. This finding extends the existing literature.

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 devaluation reform' in one of the countries. The paper studies conditions under which such a policy, which implies a shift in the tax structure from direct to indirect taxes, is effective both in the short run and long run. We find that the long-run effects depend significantly on the degree of financial integration between the two countries. Short-run effects can be greatly influenced by the conduct of union-wide monetary policy, a possible anticipation of the fiscal reform and, finally, the flexibility of the labour market. Quantitatively, our analysis indicates that, unless there is complete financial integration between member countries, spillovers are negligible such that the quantitative effects of the tax shift are similar to a closed economy.

To obtain clear analytical findings 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. 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.

A Calibration

Table 6: 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.

B Financial autarky - long-run effects

C Log-linearization around the steady state

This Appendix summarises the log-linearisation of the model around the steady state summarised in Section 3 for both the flexible price economy and the sticky price economy. Let key steady-state ratios be defined as follows:

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

Table 7: Permanent shift in the home tax structure - incomplete markets, % 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	−0.76	−0.76	−0.76	−0.76
Terms of trade	–	0.04	0.04	0.04	0.03
Home consumption	0.04	0.04	0.03	0.02	0.04
Home output	0.05	0.05	0.05	0.06	0.05
Home consumer real wage	0.21	0.21	0.20	0.18	0.21
Foreign consumption	–	0.02	0.01	0.00	0.01
Foreign output	–	−0.01	−0.00	−0.00	−0.00
Foreign consumer real wage	–	0.03	0.02	0.00	0.01
Home welfare loss	−0.01	−0.00	0.01	0.02	−0.00
Foreign welfare loss	–	−0.03	−0.02	−0.00	−0.01

Welfare losses are calculated as percentage changes in the initial steady state consumption to equate the welfare under the tax shift and the welfare in the initial steady state. Welfare is calculated as a present value of the infinite flow of households' utility, in line with equation (1).

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

C.1 The flexible price economy

Real consumer wage:

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

with:

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

Labour supply:

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

Market clearing:

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

Euler conditions:

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

with:

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

In case of bond economy:

$$\widehat{R}^r_{H,t} - \chi\widehat{B}^{u,r}_{H,t} + w^C\left(\widehat{\tau}^C_t - \widehat{\tau}^C_{t+1}\right) = \rho(E_t\widehat{C}_{t+1} - \widehat{C}_t)$$
$$\widehat{R}^r_{F,t} - \chi^*\widehat{B}^{u,r}_{F,t} + w^{C*}\left(\widehat{\tau}^{C*}_t - \widehat{\tau}^{C*}_{t+1}\right) = \rho(E_t\widehat{C}^*_{t+1} - \widehat{C}^*_t).$$

Market clearing condition for the international bond:

$$n\widehat{B}^{u,r}_{H,t} + (1-n)\overline{RS}\widehat{B}^{u,r}_{F,t} = 0.$$

Relationship between real exchange rate and terms of trade:

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

Fiscal policy (flow budget constraint):

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

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

Balanced-budget rule ($\widehat{G}_{H,t} = \widehat{G}_{F,t} = 0$)

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

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

Asset markets:

1) Complete markets:

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

2) Financial autarky:

$$\widehat{C}_t = (n-1)\widehat{T}_t + d_{Y_h}\widehat{Y_{Ht}}.$$

3) Bond economy:

$$\widehat{C_t} + \frac{1}{\overline{C}}\widehat{B}^{u,r}_{H,t} - \frac{1}{\beta\overline{C}}\widehat{B}^{u,r}_{H,t-1} = \frac{\overline{p_H}\overline{Y_H}}{\overline{C}}(\widehat{p}_{H,t} + \widehat{Y}_{H,t}) - \frac{\overline{p_H}\overline{G_H}}{\overline{C}}(\widehat{p}_{H,t} + \widehat{G}_{H,t}).$$

C.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:

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

Monetary policy rule:

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

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

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

where $s_Y = \frac{nP_HY_H}{P_UY_U}$.

After-tax union-wide CPI inflation rate (used in Section 6.3):

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

Relationships between inflation rates and terms of trade:

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

C.3 Equations used in Section 5

To derive equation (27), 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

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

Combining the equations for market clearing and complete asset markets yields

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

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

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

which is equation (27) 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 (28) and (29), in which $\widehat{T}_t$ has not yet been substituted out, are equivalent to these expressions for $\widehat{C_t}$ and $\widehat{Y}_{H,t}$.

Similarly, one can derive equivalent equations for the case of financial autarky. In particular, the coefficient γ_{fa} in equation (30) is equal to $\gamma_{fa} = \frac{1}{(\rho\phi-\rho+1)+(\phi-1)\eta d_C+\eta d_{C^*}(\phi+n(1-\phi))}$.

C.4 Sticky wages in Section 6.4

We assume that in the short run nominal wages are sticky à la Calvo in both countries. The degree of wage stickiness is assumed to be the same in both countries. Below we present the derivation of the optimal wage setting and of wage inflation for the home economy. We assume that workers in each country are monopolistic suppliers of their own types of labour. As a result, they have market power and they are able to set their own wage. Demand for a particular worker j can be derived from the minimization problem of firms and is given by:

$$L_t(j) = \left(\frac{w_t(j)}{w_t}\right)^{-\sigma_w} L_t, \tag{31}$$

where σ_w is the elasticity of demand for differentiated labour, w is the economy-wide real wage and L_t is the economy-wide labour. Note that the total labour supply by worker j is given by $L_t(j) = \int_0^n L_{t,j}(i)di$, where $L_{t,j}(i)$ is the amount of labour supplied by worker j to firm i.

We follow Erceg et al. (2000) and assume that in each period only a fraction $(1-\alpha_w)$ of households

can change their wages optimally. We assume that $\alpha_w = \alpha$ (i.e. the degree of wage stickiness is equal to the degree of price stickiness). The problem for a worker j who is able to reset his or her wage is to choose a wage $w(j)$ so as to maximize:

$$\max E_{t_0} \sum_{t=t_0}^{\infty} \beta^t \alpha_w^t (U_{C,t_0+t} w_t(j) - V_{L(j),t_0+t}) L_{t_0+t}(j). \tag{32}$$

The associated aggregate wage index is given by:

$$W_t^{1-\sigma_w} = \alpha_w W_{t-1}^{1-\sigma_w} + (1-\alpha_w)\widetilde{W}_t^{1-\sigma_w}, \tag{33}$$

where $\widetilde{W}$ is the nominal wage that will be set by all workers who are able to reset their wages and W is the economy-wide nominal wage.

In order to derive the wage inflation equation we combine the first-order condition of the above maximization problem and the aggregate wage index and log-linearize them around the steady state. The wage inflation equation is given by:

$$\widehat{\pi}_{w,t} = \frac{(1-\alpha_w)(1-\beta\alpha_w)}{(1+\sigma_w\eta)\alpha_w}(\eta\widehat{Y}_{H,t} + \rho\widehat{C}_t - \widehat{w}^c_{H,t}) + \beta\widehat{\pi}_{w,t+1}. \tag{34}$$

D Short-run analysis

Figure 1: Short-run effects of the tax shift - complete markets

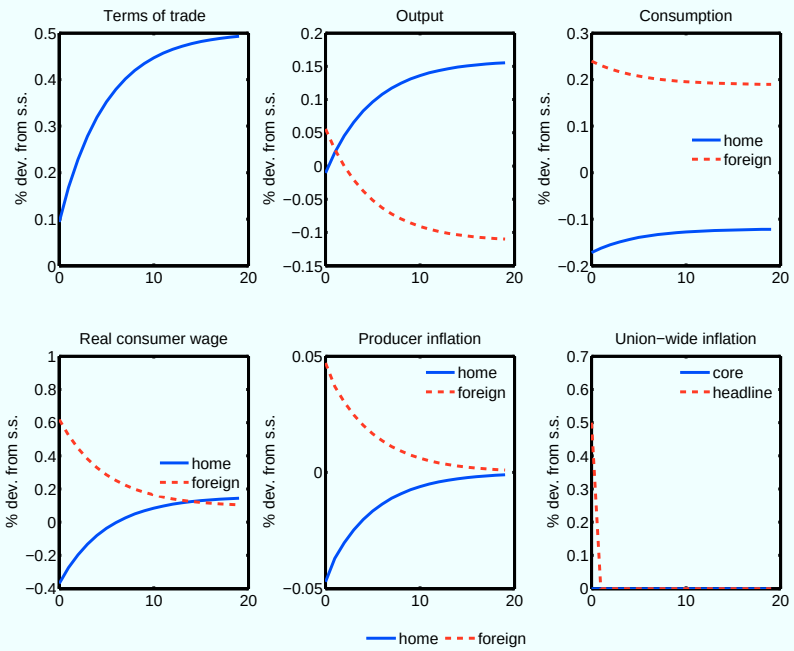


Figure 2: Short-run effects of the tax shift - comparison of different asset markets

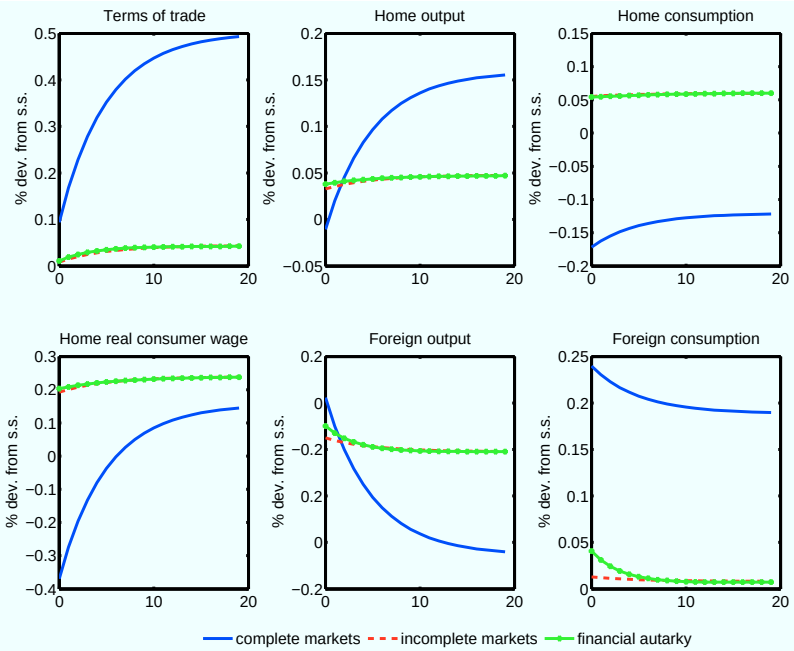


Figure 3: Short-run effects of the tax shift - incomplete markets

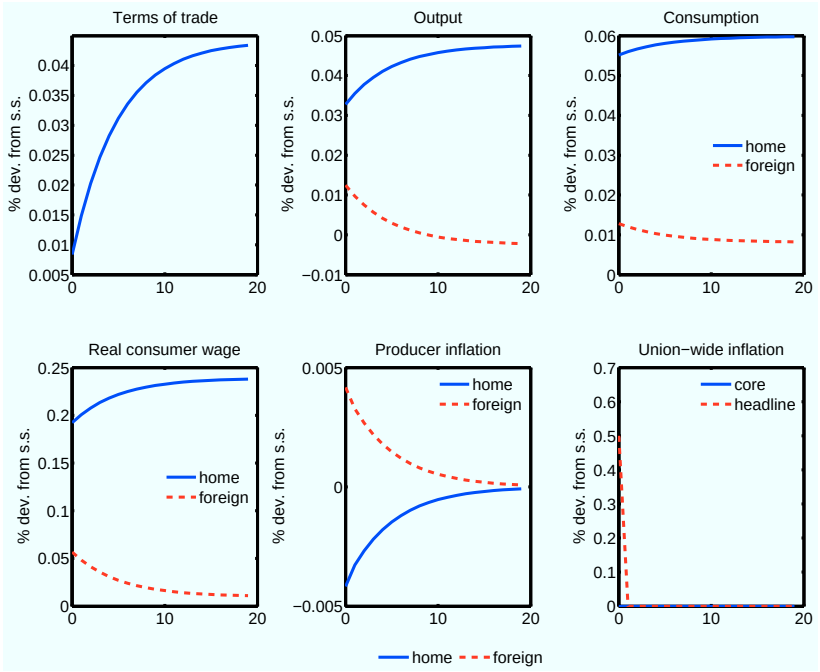


Figure 4: Short-run effects of the tax shift - target of monetary policy (complete markets)

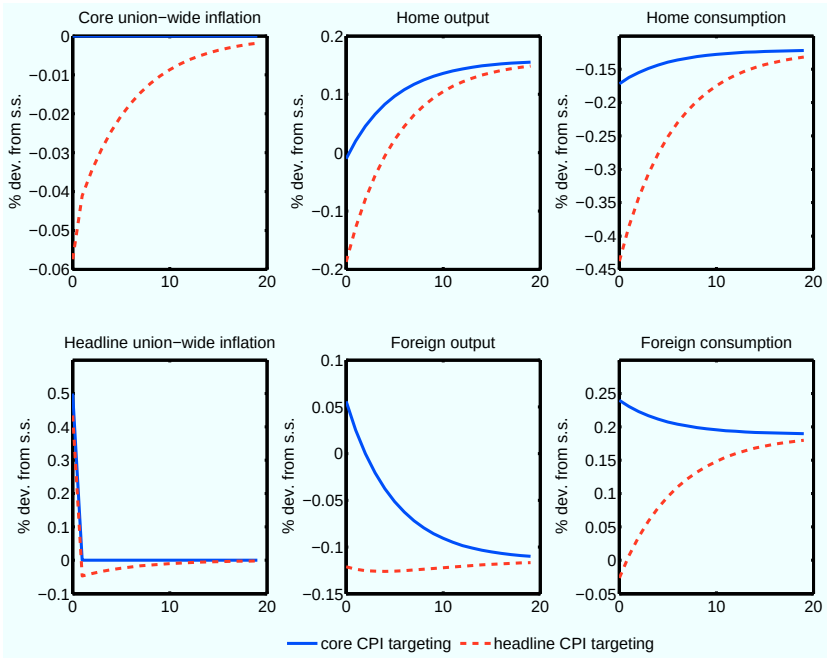


Figure 5: Short-run effects of the tax shift - anticipation of fiscal policy (complete markets)

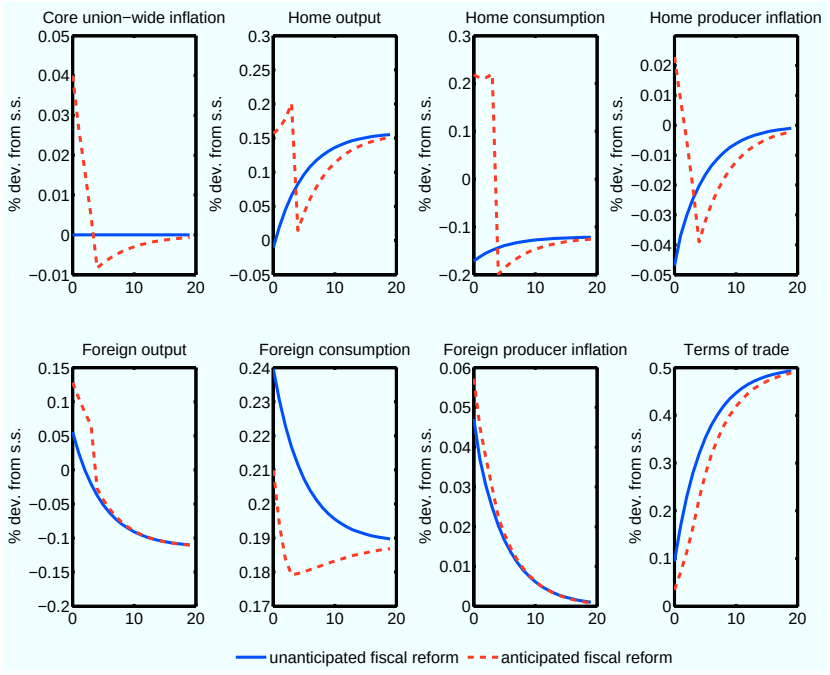


Figure 6: Short-run effects of the tax shift - target of monetary policy (incomplete markets)

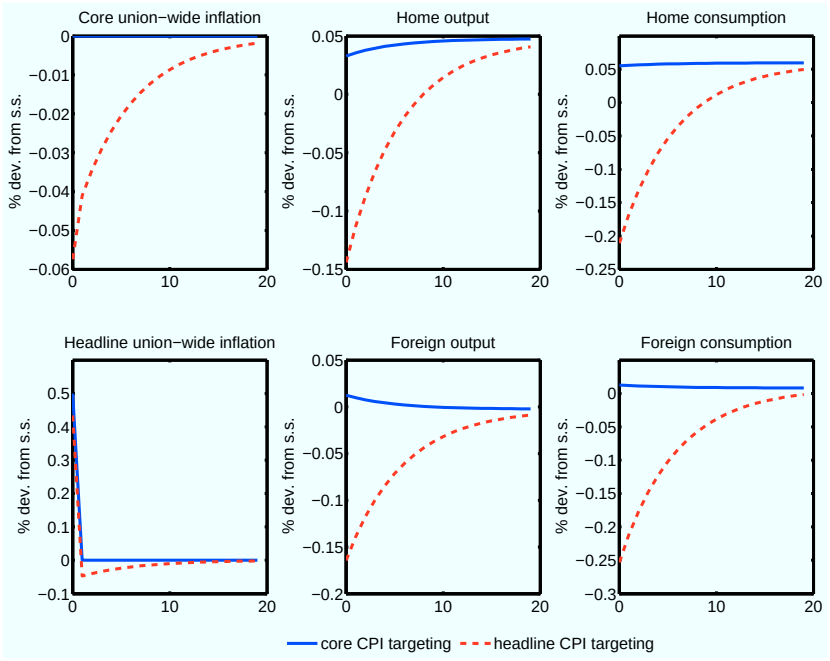


Figure 7: Short-run effects of the tax shift - anticipation of fiscal policy (incomplete markets)

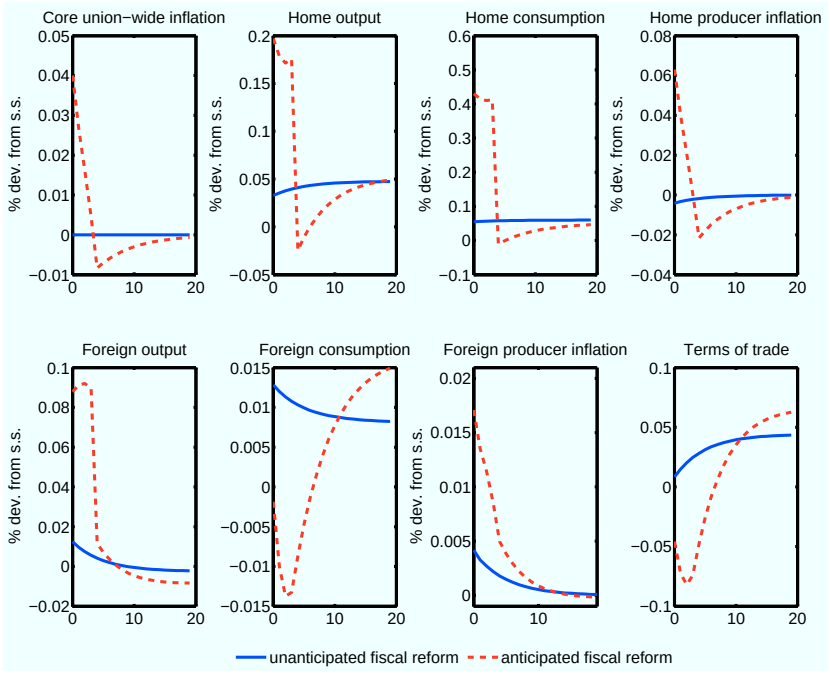


Figure 8: Short-run effects of the tax shift - sticky wages (complete markets)

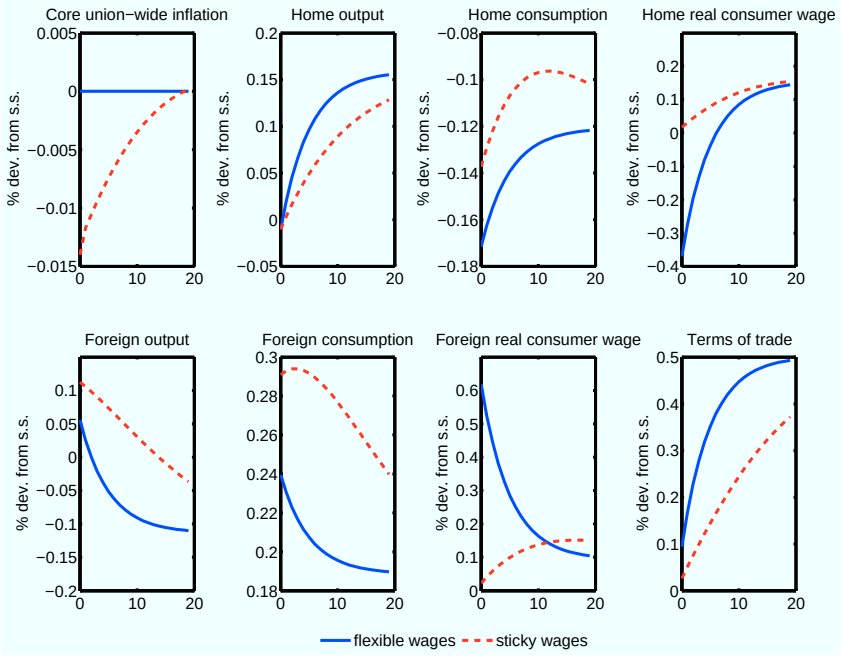
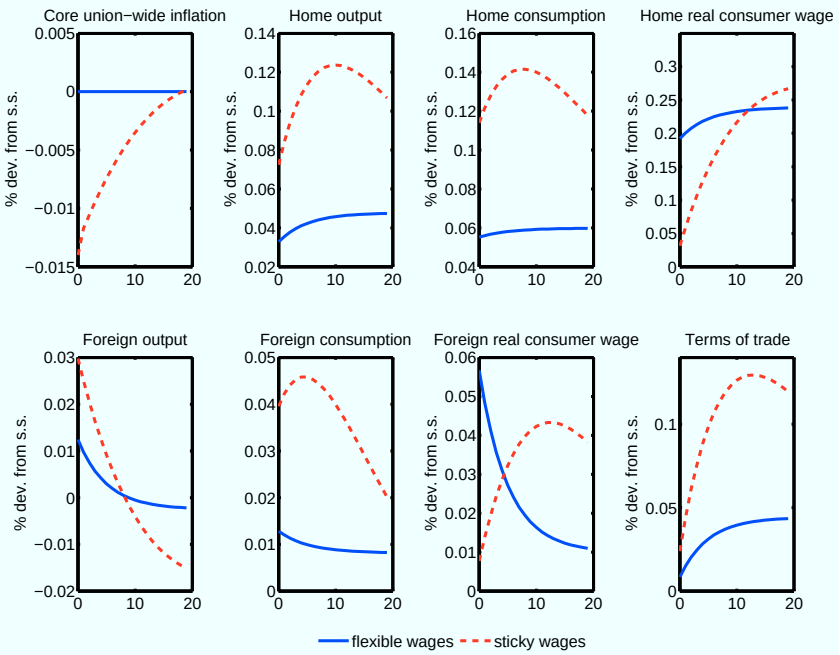


Figure 9: Short-run effects of the tax shift - sticky wages (incomplete markets)



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