Fiscal Devaluations in a Monetary Union with Endogenous Entry and Tradability*

Stéphane Auray† Aurélien Eyquem‡ Xiaofei Ma§

First version: June 2014
This version: June 2016

Abstract

We quantify the effects of fiscal devaluations within a two-country monetary union model with endogenous entry and endogenous tradability. As expected, the effects of fiscal devaluations on output, consumption, hours worked and the trade balance are positive but extensive margins provide additional transmission mechanisms. Endogenous tradability magnifies the effects on trade flows. Endogenous entry boosts variety creation in both countries, which amplifies the positive dynamics of domestic output, consumption and hours worked, and turns the response of foreign output from negative to positive.

Keywords: Fiscal devaluations, endogenous tradability, endogenous varieties, monetary union, taxes.
JEL Class.: E32, E52, F41.

*We would like to thank Fabio Ghironi and Andrea Ferrero for useful comments. We also thank participants to the Open Macro workshop in Aix-Marseille, the T2M Berlin conference, the CES-ENS Cachan & RITM-UPSud seminar and the 2nd IMAC Workshop in Rennes. The authors gratefully acknowledge financial support of the Chair ACPR/Risk Foundation: "Regulation and Systemic Risk".

†CREST-Ensai and ULCO; e-mail: stephane.auray@ensai.fr.

‡CREST-Ensai and Université de Lyon, Université Lumière Lyon 2, CNRS (GATE UMR 5824); e-mail: aurelien.eyquem@ens-lyon.fr.

§CREST-Ensai and Université de Lyon, Université Lumière Lyon 2, CNRS (GATE UMR 5824); e-mail: xiaofei.ma@ensai.fr.

1 Introduction

Fiscal devaluations have recently attracted a lot of attention among policymakers of the Eurozone. The constraint on nominal exchange rates imposed by monetary unification makes the reduction of external imbalances more difficult, which has become more problematic since the 2008 Great Recession and the subsequent Eurozone crisis. Fiscal devaluations – a rise in tax rates affecting the consumption of goods (typically VAT) along with a fall in labor income tax or payroll tax rates – have appeared as a potential cure. Portugal recently announced that a fiscal devaluation would be implemented. Some countries such as Denmark (in 1987), Germany (in 2007) or France (2012) already proceeded to shifts in the tax burden from labor income to consumption taxation. The effects expected from such policies are a reduction in labor costs, production costs and a change in the relative price of tradable goods, leading to an expenditure switching effect towards domestic goods that improves the trade balance, with positive effects on output and employment.

In this paper, we investigate the effects of fiscal devaluations on key macroeconomic aggregates and welfare using a two-country monetary-union model with endogenous varieties and endogenous tradability.[1] The model derives from Auray, Eyquem & Poutineau (2012) and Cacciatore & Ghironi (2014). As usual, endogenous tradability is introduced by a threshold condition on export profits. However, endogenous entry is introduced in a more intuitive way than Auray et al. (2012) and Cacciatore & Ghironi (2014), as it derives directly from profitability conditions on the domestic market, providing a more straightforward interpretation of the effects at work.[2] Carefully calibrated to countries of the Euro Area and driven by standard productivity and monetary policy shocks, the model successfully replicates a large set of business cycle moments. We thus use the model to account for the effects of fiscal devaluations engineered through a temporary rise in VAT and a fall in the payroll tax rate that keeps the government budget balanced.

The theoretical channels through which fiscal devaluations can affect the economy were recently studied by Farhi, Gopinath & Itskhoki (2014). They show that allocations implied by nominal exchange rate devaluations may be replicated under an extensive set of assumptions regardless of the size of the targeted devaluation, and provided governments have access to a sufficiently large number of tax instruments. Hence, changes in the tax mix can help governments affect the terms of trade and real exchange rates within a monetary union, and may generate

[1] The paper thus belongs to the open-economy literature with heterogeneous firms and/or endogenous tradability along the lines of Bergin & Glick (2009), Bergin & Lin (2012), Naknoi (2008), or Roriguez-Lopez (2011) among others.

[2] Auray et al. (2012) borrow from Ghironi & Melitz (2005) and assume that entry depends on financial conditions, as the value of firms' equity is arbitraged by households. Cacciatore & Ghironi (2014) consider that entry is based on a cost minimization by final goods producers. Our entry condition only depends on the perspectives of profits on the domestic market.

external re-balancing effects and a rise in GDP through exports and the rise of hours worked.[3] In line with the literature, we find that a unilateral fiscal devaluation boosts output, consumption, hours worked and exports while imports are depressed. Net exports are significantly improved in the short run. Our results thus comforts existing studies about the overall effects of fiscal devaluations.[4]

However, most papers focusing on the effects of fiscal devaluations or fiscal policy in open economies disregard the potential effects that fiscal devaluations might have on the patterns of trade, limiting their scope to the effects on the intensive margin of trade, *i.e.* expenditure switching and international wealth effects (see Bosca et al. (2013), Lipinska & von Thadden (2012) or Langot & Lemoine (2014)). Since Ghironi & Melitz (2005) however, we know that changes in terms of trade not only induce expenditure-switching or wealth effects, but also impact the number of traded varieties, altering the overall degree of trade openness in the economy.[5] Hence, any change in the taxation of goods and labor that affects terms of trade should translate into significant effects on the number of produced varieties and on the number of exported varieties. In this paper, we show that endogenous tradability magnifies the trade effects of fiscal devaluations, and is therefore an important transmission channel of such tax reforms. The reason is that a fiscal devaluation not only lowers the relative price of domestic exports but also leads to a rise in the number of traded varieties, that contributes to raise exports. An opposite effect is at work for foreign exports (domestic imports) that lowers the number of imported varieties and deepens the fall in imports resulting from a fiscal devaluation.

In addition, we uncover an important and undocumented transmission channel of fiscal devaluations that relies on business creation. Endogenous business creation and the introduction of new varieties of products has long been identified as an important source of economic fluctuations.[6] We show that allowing for endogenously produced varieties enhances the response of domestic output, investment, consumption and hours worked to a fiscal devaluation. Most importantly, this channel leads to a much larger rise in private consumption and hours worked in the domestic economy, and amplifies the fall in the real wage. Further, this assumption induces a positive transmission to the foreign economy (output in particular) while the transmission is negative when the number of produced varieties is held constant. The mechanism at work is

[3]Relatedly, Langot, Patureau & Sopraseuth (2014) analyze the optimal taxation scheme in an open economy with search labor market frictions.

[4]A recent study by the European Commission (2013) uses general equilibrium models to quantify the effects of fiscal devaluations and concludes that fiscal devaluations induce an expansion of employment and GDP, while the trade balance reacts positively in the short-run. Bosca, Domenech & Ferri (2013) develop a general equilibrium model of a small open economy with search and matching frictions calibrated to Spain. They show that a fiscal devaluation may be effective in stimulating output, hours worked and the trade balance. Engler, Ganelli, Tervala & Voigts (2014) propose a New-Keynesian model with Ricardian and Non-Ricardian households and sticky wages and find similar results.

[5]See also the recent contribution of Imura (2016).

[6]See Bilbiie, Ghironi & Melitz (2012) and references therein for the importance of business creation in closed economies and Auray & Eyquem (2011) in open economies.

quite simple to grasp: the joint fall in domestic and foreign real wages lowers entry thresholds and triggers additional entries in both countries.

Our contribution to this literature is twofold. First, we show that endogenous tradability strengthens quite significantly the effects of fiscal devaluations on trade flows and on the resulting dynamics of the trade balance. Second, we show that fiscal devaluations boost business creation through the entry of new firms because they produce significant downward pressures in both domestic and foreign real wages, a key factor in the profitability condition that determines the creation of new business in our model. These additional transmission channels are absent form usual open-economy models and play an important role in the dynamics of key macroeconomic aggregates and welfare gains and losses that result from fiscal devaluations.

We perform two types of sensitivity analyzes. The first one investigates the effects of pre-announcement of the fiscal devaluation on the implied economic dynamics and welfare gains/losses. The resulting adjustment patterns change radically the short-run dynamics and welfare effects of fiscal devaluations compared to unexpected reforms. The timing of announcement thus matters for the way welfare gains/losses materialize over time, and can be manipulated by policymakers. The second one perform a more sensitivity analysis indicating that our results are fairly robust to changes in key parameters.

The paper is organized as follows. Section 2 presents the model used to analyze fiscal devaluations. Section 3 presents the calibration of the model. Section 4 comments on the dynamics implied by fiscal devaluations whether they are unexpected or pre-announced. The welfare effects are also reported and analyzed. Section 5 concludes.

2 Model

As in Auray et al. (2012), we consider a model of endogenously produced and traded varieties along the lines of Ghironi & Melitz (2005), and incorporate sticky prices in the retail sector. However, as in Cacciatore & Ghironi (2014), we consider an intermediate sector producing goods that serve as inputs in the production of final goods, and that are used to pay entry and export costs. We depart from all those contributions in assuming more intuitive entry conditions, based on intertemporal profitability conditions on domestic and export markets. Fiscal policy instruments are the VAT and payroll tax rates and thus alter the conditions of production in the intermediate and final sectors with strong implications on entry in domestic and export markets, and with general equilibrium consequences.

2.1 Households

Each country is populated with a representative household. In the home country, the representative household maximizes a welfare index:[7]

$$\mathcal{W}_t = \mathrm{E}_t \left[\sum_{s=t}^{\infty} \beta^{s-t} u\left(c_s, \ell_s\right) \right] \tag{1}$$

subject to the budget constraint:

$$b_t + p_t\left(c_t + ac_{b,t}\right) = r_{t-1} b_{t-1} + w_t \ell_t + p_t\left(\kappa_t + \upsilon_t\right) - tax_t \tag{2}$$

and to the appropriate transversality conditions. In the above expressions, β is the subjective discount factor, c_t is the aggregate consumption bundle, ℓ_t is the quantity of labor supplied. Domestic households have access to a nominal bond issued in the monetary union in quantity b_t, that pays a risk-free nominal interest rate r_{t-1} between periods $t-1$ and t. Trading bonds requires the payment of adjustment costs $ac_{b,t} = \phi^b \left(b_t/p_t - b/p\right)^2/2$. Further, p_t denotes the CPI in the domestic country in period t, κ_t is the total amount of real profit received from monopolistic final goods producers and υ_t the amount of real profits received from the retail sector. Variable tax_t is a lump-sum tax. In period t, the household determines the optimal consumption c_t, labor supply ℓ_t, and the amount of bonds b_t. Combining first-order conditions yields:

$$\mathrm{E}_t \left[\beta_{t,t+1} \frac{r_t}{\pi_{t+1}\left(1 + \phi^b\left(b_t/p_t - b/p\right)\right)} \right] = 1 \tag{3}$$

$$u_{\ell t} + u_{ct} w_t / p_t = 0 \tag{4}$$

where $\beta_{t,t+1} = \beta u_{ct+1}/u_{ct}$ is an adjusted discount factor and where $\pi_t = p_t/p_{t-1}$ is the CPI inflation rate. The first condition is the Euler condition on bonds and the second is the labor supply equation. Aggregate consumption is a bundle of the different local varieties ω of retail goods:

$$c_t = \left(\int_0^1 c_t\left(\omega\right)^{\frac{\eta-1}{\eta}} d\omega \right)^{\frac{\eta}{\eta-1}} \tag{5}$$

and the corresponding CPI is

$$p_t = \left(\int_0^1 p_t\left(\omega\right)^{1-\eta} d\omega \right)^{\frac{1}{1-\eta}} \tag{6}$$

which produces the following demand functions

$$c_t\left(\omega\right) = \left(\frac{p_t\left(\omega\right)}{p_t} \right)^{-\eta} c_t \tag{7}$$

[7] We do not describe in details relations characterizing the foreign economy. However, similar conditions hold.

Bond adjustment costs $ac_{b,t}$ and public spending g_t are also expressed in units of this bundle and add-up to total demand.

2.2 Firms

The retail sector aggregates n_t domestic varieties and $n^*_{x,t}$ foreign varieties according to

$$y_t(\omega) = \left(\int_0^{n_t} y_{d,t}(z,\omega)^{\frac{\theta-1}{\theta}} dz + \int_0^{n^*_{x,t}} y^*_{x,t}(z,\omega)^{\frac{\theta-1}{\theta}} dz \right)^{\frac{\theta}{\theta-1}} \tag{8}$$

where $\theta > 1$ is the elasticity of substitution between different varieties.[8] The nominal marginal cost attached to this bundle is:

$$mc_t(\omega) = mc_t = \left(\int_0^{n_t} p_{d,t}(z)^{1-\theta} dz + \int_0^{n^*_{x,t}} p^*_{x,t}(z)^{1-\theta} dz \right)^{\frac{1}{1-\theta}} \tag{9}$$

where $p_{d,t}(z)$ is the price of domestic varieties and $p^*_{x,t}(z)$ the domestic price of imported varieties. Optimal good demands respectively from domestic and foreign retailers are

$$y_{d,t}(z,\omega) = \left(\frac{p_{d,t}(z)}{mc_t} \right)^{-\theta} y_t(\omega) \text{ and } y^*_{x,t}(z,\omega) = \left(\frac{p^*_{x,t}(z)}{mc_t} \right)^{-\theta} y_t(\omega) \tag{10}$$

$$y^*_{d,t}(z,\omega) = \left(\frac{p^*_{d,t}(z)}{mc^*_t} \right)^{-\theta} y^*_t(\omega) \text{ and } y_{x,t}(z,\omega) = \left(\frac{p_{x,t}(z)}{mc^*_t} \right)^{-\theta} y^*_t(\omega) \tag{11}$$

Each variety of retail good ω is sold at price $p_t(\omega)$ subject to Rotemberg adjustment costs. Optimal pricing thus solves

$$\underset{p_t(\omega)}{Max} \mathrm{E}_t \sum_{s=t}^{\infty} \beta_{t,s} \left(p_s(\omega) y_s(\omega) \left(1 - \phi \left(p_s(\omega)/p_{s-1}(\omega) - 1 \right)^2/2 \right) - mc_s y_s(\omega) \right), \phi \geq 0 \tag{12}$$

at time t to the demand functions given by Eq. (7), which gives

$$(\eta - 1)\left(1 - \phi(\pi_t - 1)^2/2\right) + \phi\left(\pi_t(\pi_t - 1) - \mathrm{E}_t\left[\beta_{t,t+1}\pi_{t+1}(\pi_{t+1} - 1) y_{t+1}/y_t\right]\right) = \eta mc^r_t \tag{13}$$

where $mc^r_t = mc_t/p_t$ is the real marginal cost in the retail sector.

The production sector is made of intermediate goods producers and final goods producers. In the intermediate sector, a unit mass of producers use labor to produce an intermediate input

[8] As will become clear in the next section, n_t varieties are produced in the domestic (resp. n^*_t in the foreign economy) and only a subset $n_{x,t}$ (resp. $n^*_{x,t}$) of the total number of varieties is actually traded.

that they sell competitively. Their production function is

$$x_t = a_t \ell_t \tag{14}$$

where the total factor productivity a_t evolves as $\log a_t = \rho_a \log a_{t-1} + \epsilon_t^a$. The CPI-based real marginal cost φ_t at which intermediate output is sold is

$$\varphi_t = \frac{(1 + \tau_{\ell t})(w_t/p_t)}{a_t} \tag{15}$$

as hiring units of labor incurs the payment of a payroll tax $\tau_{\ell t}$.

In the final good sector, there is a continuum of heterogeneous firms that differentiate intermediate goods. The sector allows for endogenous entry and endogenous tradability. Over the entire space of potential varieties, only a subset will actually be created and commercialized. Firms have specific random productivity draws z that remain fixed once firms have been created. Variety creation incurs a once and for all sunk cost f_e, paid in units of intermediate goods. At each period t, there are two types of firms: n_t firms that are already productive at the beginning of the period and $n_{e,t}$ firms that are newly created – but nonproductive yet – within the period. At the end of the period a fraction $\delta \in [0, 1]$ of all existing firms is exogenously affected by an exit shock. The total number of varieties thus evolves according to:

$$n_t = (1 - \delta)(n_{t-1} + n_{e,t-1}) \tag{16}$$

Among the firms created, only the most productive address the export market. Entry in the export market is subject to a repeated payment of a cost f_x, also paid in units of intermediate goods, and incurs the payment of iceberg melting costs τ.[9] So firms need to be productive enough to cover the entry and transportation costs. Firm-specific productivity z has a Pareto distribution with lower bound $z_{\min}$ and shape parameter $\varepsilon > \theta - 1$. The probability density function of z is $g(z) = \varepsilon z_{\min}^{\varepsilon} / z^{\varepsilon+1}$ and the cumulative density function is $G(z) = 1 - (z_{\min}/z)^{\varepsilon}$. Over the total number of potential firms only a subset will actually be created and their number will be

$$n_t = (1 - G(z_{d,t})) = (z_{\min}/z_{d,t})^{\varepsilon} \tag{17}$$

where $z_{d,t}$ will be determined by a free-entry condition. In addition, among the total number of firms addressing the local market, the number of exporting firms $n_{x,t}$ will be those that are productive enough to cover the additional various export costs and their number is:

$$n_{x,t} = 1 - G(z_{x,t}) = (z_{\min}/z_{x,t})^{\varepsilon} \tag{18}$$

[9] Out of a quantity y produced and shipped, only $y/(1 + \tau)$ actually arrive. Firms need to produce $(1 + \tau) y$ to sell y.

where $z_{x,t}$ is the individual productivity of the cut-off exporting plant. Let $\kappa_t(z)$ denote the total current profits of a firm with productivity z and $\varphi_t(z)$ its specific production cost, defined as $\varphi_t(z) = \varphi_t/z$. Total current profits are composed of domestic profits $\kappa_{d,t}(z)$ and export profits $\kappa_{x,t}(z)$

$$\kappa_{d,t}(z) = \left(\frac{p_{d,t}(z)}{(1+\tau_{vt})p_t} - \frac{\varphi_t}{z}\right) y_{d,t}(z) \tag{19}$$

$$\kappa_{x,t}(z) = \left(\frac{p_{x,t}(z)}{(1+\tau^*_{vt})p_t} - \frac{(1+\tau)\varphi_t}{z}\right) y_{x,t}(z) - f_x\varphi_t \tag{20}$$

where τ_{vt} and τ^*_{vt} are respectively the domestic and foreign VAT rates.[10] Optimal pricing conditions are derived subject to the demand function given by Eqs. (10)-(11) and optimal prices imply

$$\rho_{d,t}(z) = \frac{p_{d,t}(z)}{p_t} = \mu(1+\tau_{vt})\frac{\varphi_t}{z} \text{ and } \rho_{x,t}(z) = \frac{p_{x,t}(z)}{p^*_t} = (1+\tau)\mu(1+\tau^*_{vt})\frac{\varphi_t}{q_t z} \tag{21}$$

where we have used the fact that $q_t = p^*_t/p_t$ is the real exchange rate and where $\mu = \theta/(\theta-1)$. Entry occurs one period before production can start and the productivity draw of the last firm is determined by a profitability condition. The entry productivity cut-off $z_{d,t}$ is obtained by equating the expected discounted sum of domestic profits (starting in $t+1$) of the last firm entering in period t, *i.e.* drawing its productivity level in t, to the initial entry cost paid in units of intermediate goods:

$$\mathrm{E}_t\left[\sum_{s=t+1}^{\infty}(\beta_{t,s}(1-\delta))^{s-t}\kappa_{d,s}(z_{d,t})\right] = f_e\varphi_t \tag{22}$$

A recursive formulation combined with optimal pricing conditions gives

$$\mathrm{E}_t\left[\beta_{t,t+1}(1-\delta)\left(\left(\frac{1}{\theta(1+\tau_{vt+1})}\right)^{\theta}\left(\frac{\varphi_{t+1}}{(\theta-1)z_{d,t}}\right)^{1-\theta}y_{t+1} + f_e\varphi_{t+1}\right)\right] = f_e\varphi_t \tag{23}$$

This equation shows the determinants of firms entry. Higher entry (lower threshold $z_{d,t}$) occurs when current marginal costs are low, market size is large, when VAT is low and when current entry costs are low or expected discounted entry costs higher than current costs. Among the firms that produce, only the most productive can profitably enter the export market given that addressing the export market requires paying the iceberg melting cost and the repeated export costs. Hence the export productivity cut-off is $\kappa_{x,t}(z_{x,t}) = 0$ or, after using the optimal pricing conditions,

$$z_{x,t} = \frac{(1+\tau)}{(\theta-1)}\left(\frac{\theta(1+\tau^*_{vt})\varphi_t}{q_t}\right)^{\frac{\theta}{\theta-1}}\left(\frac{f_x}{y^*_t}\right)^{\frac{1}{\theta-1}} \tag{24}$$

[10] Notice that the foreign VAT rate applies to exports of domestic firms.

As in the case of firms' entry, the equation shed lights on the determinants of entry in the export market: low trade costs, low marginal costs, low fixed export costs, low foreign VAT and large foreign markets.

2.3 Aggregation, Governments and Monetary Policy

Let us first define the average productivity of firms addressing the domestic market as $\widetilde{z}_d = \nabla z_{d,t}$ where $\nabla = (\varepsilon/(\varepsilon-(\theta-1)))^{\frac{1}{\theta-1}}$ and the average productivity of firms addressing both markets as $\widetilde{z}_{x,t} = \bigtriangledown z_{x,t}$.

Average prices. Defining the average price of a domestic good as $\widetilde{\rho}_{d,t} = p_{d,t}(\widetilde{z}_{d,t})/p_t$ and the average price of an exported good as $\widetilde{\rho}_{x,t} = p_{x,t}(\widetilde{z}_{x,t})/p_t^*$, we obtain real average prices:

$$\widetilde{\rho}_{d,t} = \mu(1+\tau_{vt})\varphi_t/(\bigtriangledown z_{d,t}) \text{ and } \widetilde{\rho}_{x,t} = (1+\tau)\mu(1+\tau_{vt}^*)\varphi_t/(q_t \bigtriangledown z_{x,t}) \tag{25}$$

where $q_t = p_t^*/p_t$ is the real exchange rate.

Variety effect. From the form of the marginal costs in the retail sector, we uncover the following variety effects:

$$n_t\widetilde{\rho}_{d,t}^{1-\theta} + n_{x,t}^*\widetilde{\rho}_{x,t}^{*1-\theta} = (mc_t^r)^{1-\theta}, \text{ and } n_t^*\widetilde{\rho}_{d,t}^{*1-\theta} + n_{x,t}\widetilde{\rho}_{x,t}^{1-\theta} = (mc_t^{r*}/p_t^*)^{1-\theta} \tag{26}$$

Goods market clearing. Intermediate goods serve as inputs of final goods producers. When final goods producers are more efficient they need less intermediate input to satisfy the demands from the domestic and foreign retail sectors. Further, the various entry costs are paid in intermediate goods. The market clearing condition is thus

$$a_t\ell_t = \left(\frac{mc_t^r}{\widetilde{\rho}_{d,t}}\right)^\theta \frac{n_t y_t}{\bigtriangledown z_{d,t}} + (1+\tau)\left(\frac{mc_t^{r*}}{\widetilde{\rho}_{x,t}}\right)^\theta \frac{n_{x,t}y_t^*}{\bigtriangledown z_{x,t}} + n_{e,t}f_e + n_{x,t}f_x \tag{27}$$

The market clearing condition for the final goods sector is

$$y_t^c = n_t(mc_t^r)^\theta \widetilde{\rho}_{d,t}^{1-\theta} y_t + n_{x,t}(mc_t^{r*})^\theta \widetilde{\rho}_{x,t}^{1-\theta} y_t^* \tag{28}$$

Net foreign assets. Net foreign asset dynamics is obtained aggregating all budget constraints with market clearing conditions:

$$b_t^r - r_{t-1}b_{t-1}^r/\pi_t = q_t n_{x,t}(mc_t^{r*})^\theta \widetilde{\rho}_{x,t}^{1-\theta} y_t^* - n_{x,t}^*(mc_t^r)^\theta \widetilde{\rho}_{x,t}^{*1-\theta} y_t \tag{29}$$

Inflation rates. Finally, using the definition of average prices, the dynamics of domestic and export goods inflation rates is given by

$$\pi_{d,t}/\pi_t = \widetilde{\rho}_{d,t}/\widetilde{\rho}_{d,t-1} \text{ and } \pi_{x,t}/\pi_t^* = \widetilde{\rho}_{x,t}/\widetilde{\rho}_{x,t-1} \tag{30}$$

Governments. Governments have a balanced budget every period. Distorsionary and lump-sum taxes exactly finance a constant provision of public expenditure $g_t = g$, expressed in units of final goods

$$\tau_{\ell t}\left(w_t/p_t\right)\ell_t + \left(\tau_{vt}/\left(1+\tau_{vt}\right)\right)\left(n_t\widetilde{\rho}_{d,t}^{1-\theta} + n_{x,t}^{*}\widetilde{\rho}_{x,t}^{*1-\theta}\right)\left(mc_t^r\right)^{\theta} y_t + tax_t = g \tag{31}$$

Monetary Policy. The common central bank controls the nominal interest rate, and commits to the following rule

$$\log\left(r_t/r\right) = \rho_r \log\left(r_{t-1}/r\right) + \left(1-\rho_r\right)\left(d_\pi \log\left(\widetilde{\pi}_t^u/\widetilde{\pi}^u\right) + d_y \log\left(\widetilde{y}_t^u/\widetilde{y}_{t-1}^u\right)\right) + \epsilon_t^r \tag{32}$$

where $\widetilde{\pi}_t^u = \widetilde{\pi}_t^{1/2}\widetilde{\pi}_t^{*1/2}$ is the union-wide average (data-consistent) inflation rate, $\widetilde{y}_t^u = \widetilde{y}_t^{1/2}\widetilde{y}_t^{*1/2}$ is the data-consistent output and ϵ_t^r is a monetary policy shock.[11]

3 Calibration

Table 1 reports the value of our calibrated parameters.

Table 1: Parameter values.

Discount factor	$\beta = 0.99$
Risk-aversion	$\gamma = 2$
Consumption / leisure weight	χ adjusted to get $\overline{\ell} = 0.35$
Entry cost	f_e adjusted to get $n = 1$
Export cost	f_x adjusted to get $n_x/n = 0.2$
Exogenous death rate	$\delta = 0.025$
Elasticity of substitution between varieties of final goods	$\theta = 3.8$
Elasticity of substitution between varieties of retail goods	$\eta = 6$
Pareto curvature parameter	$\varepsilon = 4.87$
Price stickiness parameter	$\phi = 80$
Steady-state trade costs	$\tau = 0.10$
Portfolio adjustment costs on bonds	$\phi^b = 0.0007$
Steady-state VAT rate	$\tau_v = 0.15$
Steady-state payroll tax rate	$\tau_\ell = 0.3$
Nominal interest rate persistence	$\rho_r = 0.87$
Reaction to aggregate inflation	$d_\pi = 1.93$
Reaction to aggregate output growth	$d_y = 0.075$

Households. The calibration is identical in both countries. Target countries are those that belong to the Euro Area. The model is quarterly. The discount factor is $\beta = 0.99$. The utility function is:

$$u\left(c_t, \ell_t\right) = \frac{\left(c_t^{\chi}\left(1-\ell_t\right)^{1-\chi}\right)^{1-\gamma}}{1-\gamma} \tag{33}$$

[11] In models with an extensive margin of activity and love for variety, the theoretical measures of price indices and macroeconomic aggregates do not have an empirical counterpart. They must therefore be adjusted to be consistent with the data. See Ghironi & Melitz (2005) and Appendix A for an extensive discussion.

The risk-aversion parameter is set to $\gamma = 2$ and the value of χ is adjusted to obtain a steady-state value of hours worked of $\overline{\ell} = 0.35$, in line with the share of hours worked in total awake time in Euro area countries according to OECD figures.

The production sector. The values of f_e and f_x are determined endogenously to match respectively the steady-state number of varieties n and the number of traded varieties n_x. Without loss of generality, we impose $n = 1$. Based on European data from the SDBS Database, firms' death rate is consistent with $\delta = 0.025$. Further, we follow Cacciatore, Fiori & Ghironi (2016) and calibrate the elasticity of substitution between varieties at $\theta = 3.8$. Incidentally, a value of $\theta = 3.8$ implies rather high steady state markups over marginal costs. However, given the presence of fixed costs, markups over average costs are in line with values found in the literature.[12] As in Cacciatore et al. (2016), the price stickiness parameter is set to $\phi = 80$.

The trade sector. Based on French data, Berman, Martin & Mayer (2012) report that the share of exporting firms is around 20%, implying $n_x/n = 0.2$. We impose this number in the steady state through an adjustment of the export cost f_x. Eaton, Kortum & Kramarz (2011) estimate Pareto parameters governing the distribution of french firms and their best estimate is $\varepsilon = 4.87$. We impose this precise value, and set $\tau = 0.1$, which yields a degree of intra-zone trade openness of 21%, close to the data. Our calibration implies that exporters are 39.16% more productive than non-exporters, and that domestic prices are 15.01% higher than export prices (including iceberg trade costs). Finally, as in Schmitt-Grohé & Uribe (2003), the international bond adjustment cost parameter is $\phi_b = 0.0007$.

Tax rates and monetary policy. Our analysis will be conducted through changes in the VAT rate and in the payroll tax rate. The steady-state VAT rate is $\tau_{vt} = 0.15$ and the steady-state payroll tax rate is $\tau_{\ell t} = 0.30$. Both figures match Euro Area averages. The share of public spending in final output is $s_g = 0.2$. Monetary policy parameters are calibrated after the values reported in Cacciatore et al. (2016): $\rho_r = 0.87$, $d_\pi = 1.93$ and $d_y = 0.075$.[13]

4 The effects of fiscal devaluations

4.1 Baseline case

We start our analysis with the effects of a temporary (8 quarters) unilateral increase in VAT $\Delta\tau_{vt} > 0$ raising fiscal revenues by 1 pp of ex-ante GDP together with a reduction in the payroll tax rate $\Delta\tau_{\ell t}$ that keeps the government budget balanced each period. The corresponding increase

[12] See Bilbiie, Ghironi & Melitz (2008) for an extensive discussion.

[13] Appendix A shows that our calibration matches business cycle moments quite accurately. In particular, the volatility, persistence and cyclicality of gross and net trade flows at the business cycle frequency are remarkably well matched: the trade balance is counter-cyclical, imports are more strongly correlated with output than exports and both exports and imports are more volatile than output. The persistence of the real exchange rate is also well reproduced although as in Ghironi & Melitz (2005), its volatility is not correctly matched.

in VAT is 1.25 pp, that will translate into an approximate 2.5 pp fall in the payroll tax rate. As shown in Farhi et al. (2014), such a tax reform mimics the effects of a nominal exchange rate devaluation.

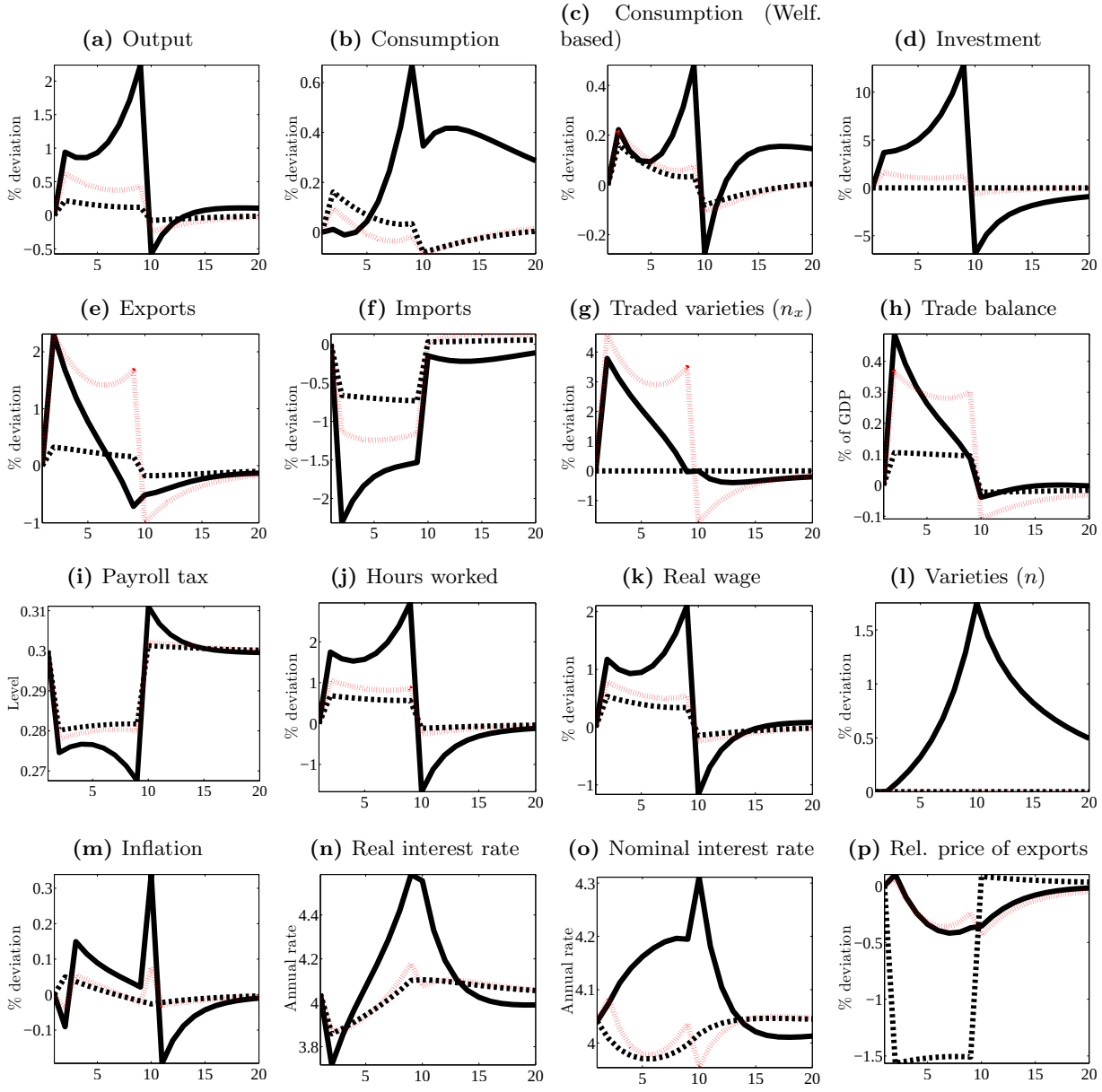
In Figures 1 and 2 below, we consider three alternative models: the baseline model, the model with a constant number of produced varieties and the model with constant produced and traded varieties. When the number of produced varieties is constant, Equation (23) and its foreign equivalent are replaced by $n_t = n_t^* = \overline{n} = 1$. When the number of traded varieties is constant, Equation (24) and its foreign equivalent are replaced by $n_{x,t} = n_{x,t}^* = \overline{n}_x = 0.2\overline{n}$.

In all cases, the model is solved under perfect foresight using a non-linear Newton-type algorithm with the set of parameter values reported in Table 1. We report mostly data-consistent variables in those graphs unless stated otherwise, as this is typically what policymakers would observe after such a policy change. Indeed, as explained in Ghironi & Melitz (2005), our simulated aggregates have to be deflated by a price index capturing the aggregate variety effect. Defining $p_t = (n_t + n_{x,t})^{\frac{1}{1-\theta}} \widetilde{p}_t$, real data-consistent variable x_t writes $x_t^r = p_t x_t / \widetilde{p}_t$, $\forall x$. In addition, average (data-consistent) inflation rates are defined as $\widetilde{\pi}_t = (p_t/p_{t-1}) / (\widetilde{p}_t/\widetilde{p}_{t-1})$, and terms of trade as $\widetilde{q}_t = \widetilde{p}_t^*/\widetilde{p}_t$. However, the quantification of the impact on welfare will be conducted using welfare-based variables to capture accurately the potential benefits or losses from the perspective of households.

Let us start with the baseline model and focus on the domestic economy reported in Figure 1. The tax reform implies a rise in VAT and a fall in the payroll tax rate, with opposite effects on consumption. The rise in VAT increases the price of domestically produced goods as well as the price of imports, which tends to depress consumption. On the contrary, the fall in the payroll tax rate lowers the production cost which increases output and labor demand, pushing real wages up. The fall in the production cost fosters business creation (the extensive margin) while the rise of labor income potentially contributes to the intensive margin of consumption. Overall, welfare-based consumption goes up mostly due to the contribution of the extensive margin and data-consistent consumption (its intensive margin) is muted in the first periods before rising as well. The dynamics of varieties is interpreted through Equation (23). It shows that the reform has potentially opposite effects on firms' entry: the rise in VAT should depress business creation while the fall in the production cost and the rise in (welfare-based) domestic demand should push entries in the opposite direction. In equilibrium, after a fiscal devaluation, the second effect dominates and the total number of varieties rises significantly, driving investment up as well. The net effect on output is positive because total demand (consumption plus investment in the creation of new firms) goes up.

Concerning the export sector, the trade reform has unambiguously positive effects. The relative price of exported goods falls and foreign demand grows, which boosts both the intensive

Figure 1: The home effects of a domestic fiscal devaluation



Solid black: baseline model, Dotted red: fixed n, Dashed black: fixed n and n_x. Variables are reported in a data-consistent manner unless specified otherwise.

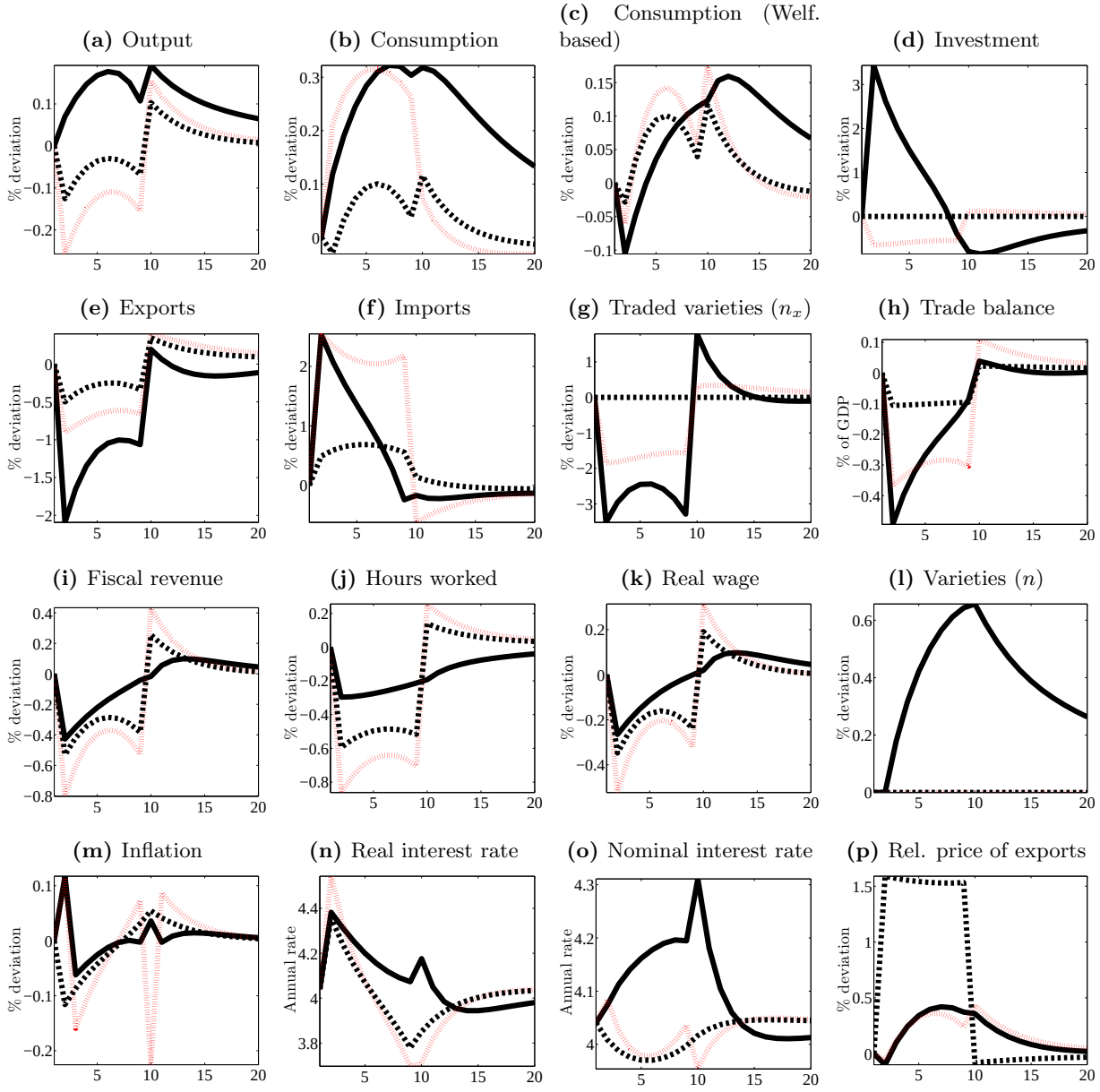
margin and the extensive margin of exports. Imports fall dramatically because their relative price goes up very much and because the number of foreign exporters falls dramatically. The net effects on the trade balance are positive. The latter is improved by 0.5% of GDP on impact and tracks the dynamics of exports, that return to their steady-state value after 5 quarters. Quantitatively speaking, a fiscal devaluation raises output by 1% on impact, and by more than 2% after 8 quarters. It progressively increases (data-consistent) consumption from basically zero on impact to almost 0.7% after 8 quarters, and raises hours worked by 2% on impact and up to 2.5% after 8 quarters. The the real wage increases by 1% on impact and by around 2% after a few quarters. The number of firms goes up progressively and raises by more than 1.5%.

When the reform is undone after 8 quarters, there is a reversal in the dynamics of many variables. In particular, exports fall below their initial steady-state value – a 0.5% fall after the initial 2% rise – and imports return to the steady state. The trade surplus observed in the first periods thus turns into a trade deficit that represents less than 0.1% of GDP. The intensive margin of consumption slowly returns to the steady state after a gradual rise, and welfare-based consumption reverses down below its initial steady-state value. Varieties go back slowly to their steady-state value.

What are the differences with respect to alternative models? The most striking difference between the model with endogenous entry and models with constant varieties pertains to the dynamics of output, the real wage, hours worked, consumption and inflation. Allowing for endogenously produced varieties magnifies the response of these variables and leads, among other things, to a much larger rise in consumption and hours worked in the domestic economy. Allowing for endogenously traded varieties produces only minor differences in the key variables listed above but makes a significant difference in the dynamics of trade flows and trade balances. In particular, with a constant number of produced varieties and and endogenous tradability, the rise in exports and the associated improvement of the trade balance are both more persistent after a fiscal devaluation. However, the impact of this sustained improvement of the trade balance on GDP remains quite small compared to the contribution of consumption and investment when the number of produced varieties is endogenous. Overall, endogenously produced varieties make a much larger difference both quantitatively and qualitatively for the dynamics of key domestic variables after a fiscal devaluation. Endogenous tradability makes a smaller difference on those variables, but contributes to exaggerate the response of the trade sector.

In addition, the model with a constant number of produced varieties has radically different implications for the transmission to the foreign economy, in particular for the dynamics of GDP. The dynamics of foreign variables implied by our fiscal devaluation experiment are reported in Figure 2. Starting with our baseline model again, we find that a domestic fiscal devaluation generates a substantial and persistent increase in output (up to 0.2%). The relative price of foreign exports rises, which triggers an expenditure switching effect towards domestic goods in

Figure 2: The foreign effects of a domestic fiscal devaluation



Solid black: baseline model, Dotted red: fixed n, Dashed black: fixed n and n_x. Variables are reported in a data-consistent manner unless specified otherwise.

the short run. This negative supply shock is illustrated by a fall in foreign exports (that mimics the fall in domestic imports) and by a substantial fall in the number of exported varieties. In addition to these effects on trade, the negative supply shock reduces the foreign real wage along with foreign hours worked, inducing an indirect positive spillover: the entry threshold falls and tends to boost business creation. Hence, the domestic fiscal devaluation affects the foreign economy through a negative shock on the intensive margin but through a positive shock on the extensive margin. Indeed, while existing firms reduce the intensive margin, new firms enter the market, as shown by the rising dynamics of the total number of varieties. This rise is responsible for the persistent rise in output, consumption and of course investment. When the number of produced varieties is held constant, the dynamics of output are negative, the real wage falls more and drives hours worked further down. Consumption still goes up because the relative price of imports falls but a fiscal devaluation with a constant number of varieties has a negative effect on the productive sector of the foreign economy.

The above experiment shows that the assumptions of endogenous varieties and endogenous tradability crucially matter when investigating the effects of fiscal devaluations, as the domestic and foreign effects of such a tax reform are critically dependent on these assumptions.

4.2 Welfare analysis

Given the above dynamics, what will be the welfare implications of the tax reform analyzed? We quantify the welfare gains by computing the Hicksian consumption equivalent that makes households indifferent between experiencing the reform and remaining at the initial steady state. This Hicksian equivalent is computed at different horizons, for the three models, whether the reform is implemented unilaterally or jointly. Its calculation is made using the utility function with simulated paths for welfare-based consumption and hours worked. The most relevant computation is the one that is made over an infinite horizon but the associated numbers should be small in all cases, since the reform is temporary and lasts only 8 quarters. In the short run, in the domestic economy, the tax reform raises hours worked and welfare-based consumption, a combination that yields unclear welfare effects. In the longer run, consumption remains above its steady-state value for quite some time while hours worked fall below their steady-state value, so the reform should generate welfare gains. In the foreign economy, the short-run and long-run welfare effects should be positive given the joint increase in consumption and fall in hours worked. How big are these welfare gains/losses? Do alternative models produce different welfare effects? What are the welfare effects of a joint reform?

Table 2 shows that a fiscal devaluation generates a 0.37% welfare loss for domestic households on impact and a small 0.03% gain for foreign households in our baseline model. After 8 quarters, the welfare effects are amplified both for domestic and foreign households. Over the medium run (32 quarters), the reform has long been undone – remember, in quarter 8 – but still affects

Table 2: Welfare effects of fiscal devaluations, in percents

	Baseline			Cst. n			Cst. n and n_x		
Horizon	H	F	Joint	H	F	Joint	H	F	Joint
1	−0.37	0.03	−0.24	−0.19	0.21	0.01	−0.11	0.15	0.02
4	−0.60	0.10	−0.39	−0.30	0.37	0.03	−0.19	0.27	0.04
8	−0.76	0.15	−0.55	−0.34	0.42	0.04	−0.23	0.31	0.04
32	−0.06	0.12	0.05	−0.08	0.10	0.02	−0.06	0.08	0.01
60	−0.01	0.06	0.05	−0.04	0.05	0.01	−0.03	0.04	0.01
∞	0.01	0.02	0.02	−0.01	0.02	0.00	−0.01	0.01	0.00

Note: A negative sign indicates a welfare loss.

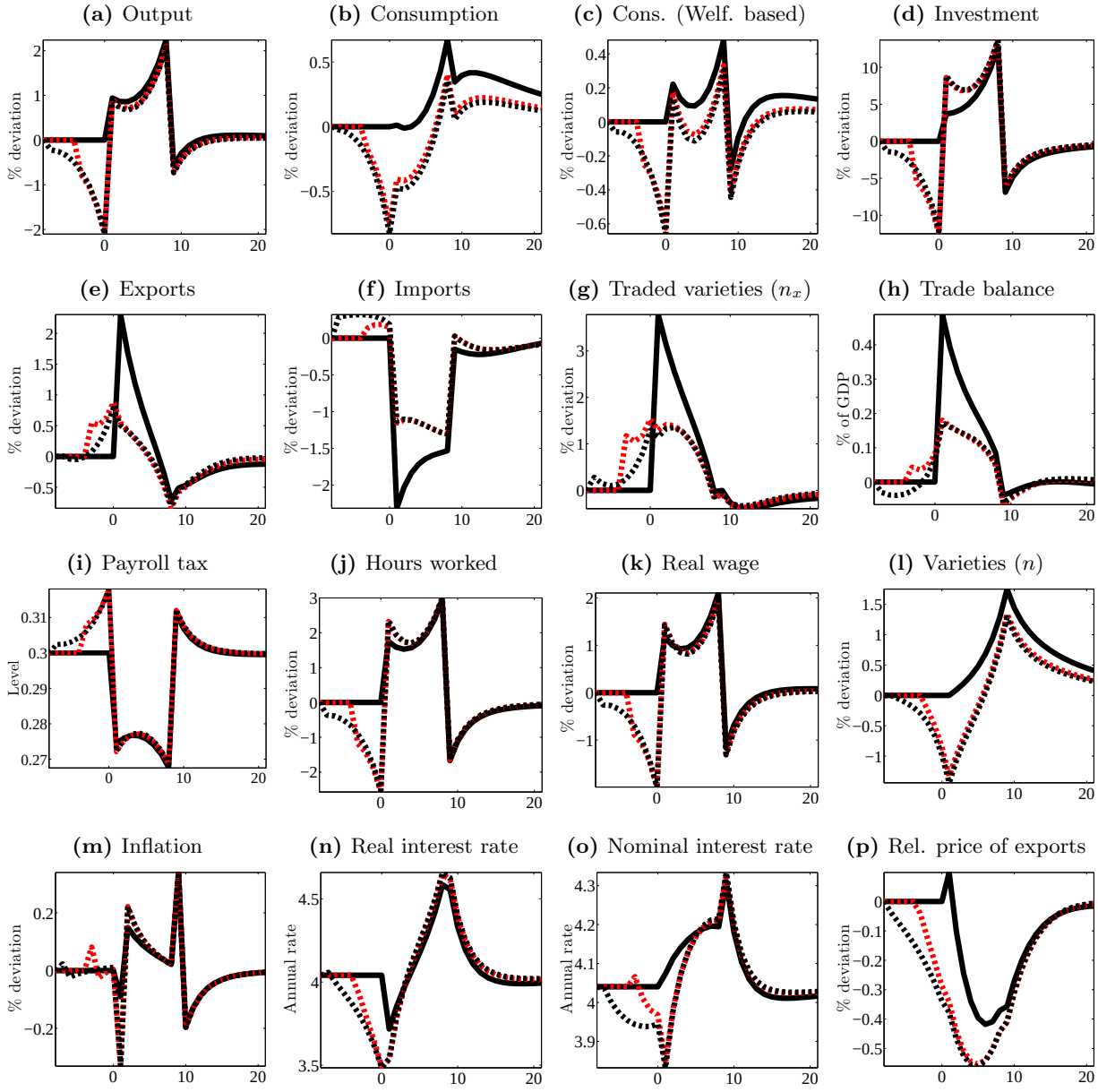
households welfare. Undoing the reform generates an instantaneous welfare gain that contributes to lower the intertemporal contribution of the initial loss. Domestic households still endure a 0.06% welfare *loss* and foreign households experience a 0.12% welfare *gain* at this horizon. Taking into account the full transition path (∞ line of Table 2) delivers the true lifetime welfare impact of the reform. Its positive effects that go through the extensive margin of output and trade generate small welfare gains for everyone (0.01% in the home economy and 0.02% in the foreign economy). While these numbers might seem small, it should be recalled that the total welfare losses from business cycle fluctuations in this kind of models is rarely larger than 0.01% or 0.02% of consumption equivalent. So the welfare benefits from an 8-quarters temporary tax reform might be as large as the total welfare costs from business cycles.

The effects of joint reforms roughly average welfare gains and losses of unilateral reforms. When the number of produced varieties is held constant, the model with endogenous tradability and the model with constant tradability produce very similar results: welfare losses at all horizons for domestic households and welfare gains of a similar magnitude at all horizons for foreign households. Only the model with endogenously produced and traded varieties generates different results: losses in the short and medium run for domestic households and small welfare gains over the same horizons for foreign households, and small welfare gains for everyone in the long run. In a nutshell, when used to assess the welfare gains from fiscal devaluations, alternative models tend to under-estimate the welfare losses in the short-run while they suggest that fiscal devaluations are zero-sum games. Our baseline model concludes that fiscal devaluations produce relatively larger welfare losses in the short-run with long term gains.

4.3 Unexpected vs. expected fiscal devaluations

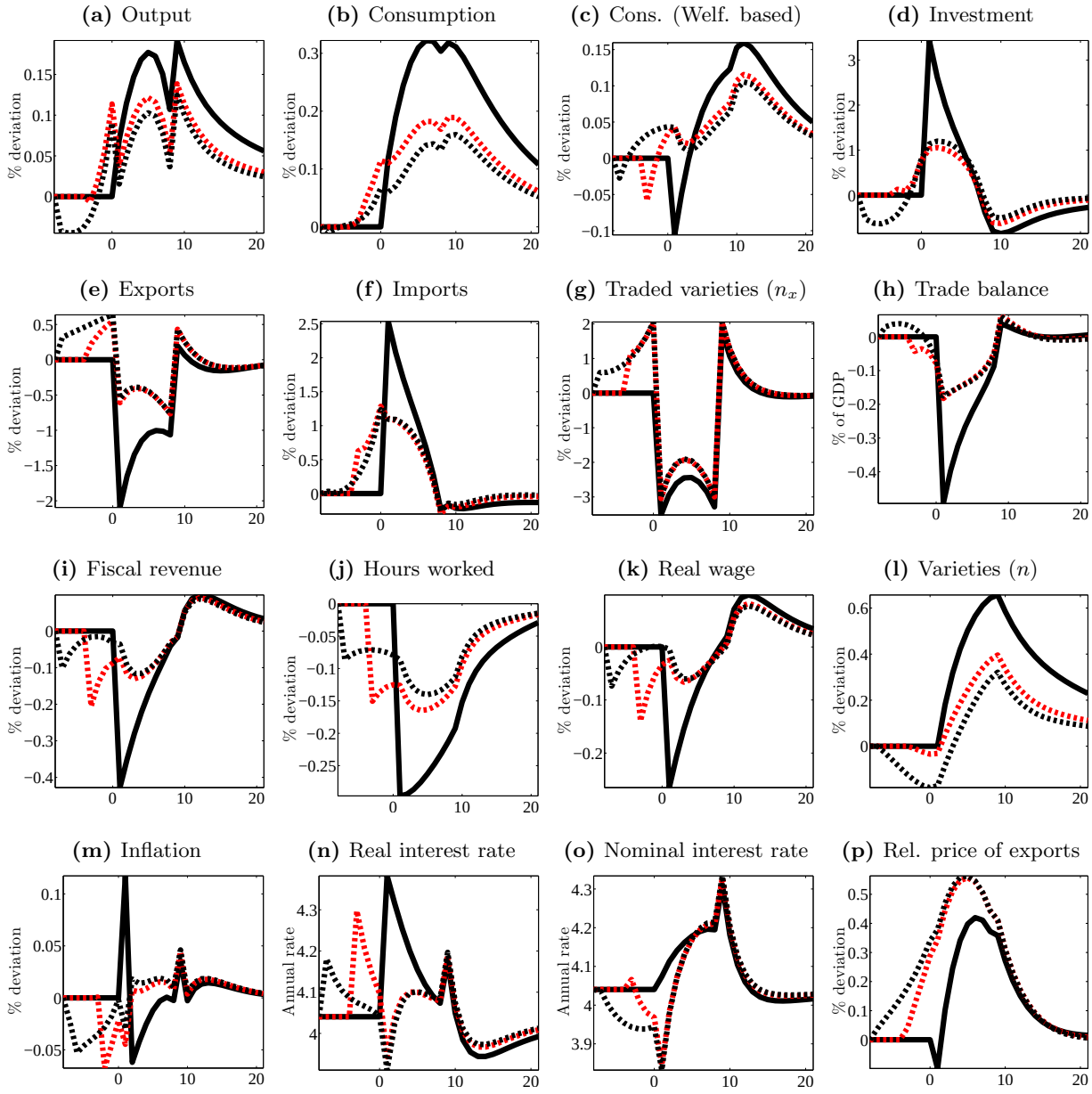
We now investigate the extent to which the timing of announcement matters when implementing fiscal devaluations, given that most fiscal reforms are pre-announced. From the literature, we know that news shocks have very different implications than unexpected immediate shocks and this should also be the case here. Figure 3 to 4 below report the effects of a domestic unilateral fiscal devaluation effective in period 1 announced 4 or 8 quarters ahead. It also reports the effects of an immediate, unexpected, fiscal devaluation, as in Section 4.1.

Figure 3: The home effects of a domestic fiscal devaluation - Announced vs. Unexpected



Solid black: baseline model unexpected, Circled red: announced 4 quarters ahead, Dashed black: announced 8 quarters ahead. Variables are reported in a data-consistent manner unless specified otherwise.

Figure 4: The foreign effects of a domestic fiscal devaluation - Announced vs. Unexpected



Solid black: baseline model unexpected, Circled red: announced 4 quarters ahead, Dashed black: announced 8 quarters ahead. Variables are reported in a data-consistent manner unless specified otherwise.

Let us first focus on the domestic effects of pre-announced reforms. Within the quarter of the announcement, households and firms know for certain that VAT will rise and that the payroll tax will fall in 4 and 8 quarters respectively. The expected fall in the payroll tax lowers the future cost of building varieties – through the effect on the real wage – leading firms to postpone entry. Produced varieties thus fall immediately, leading the demand for intermediate goods to drop as well, lowering labor demand (hours and the real wage both drop when the reform is pre-announced). This movement is large enough to lower consumption. The relative price of exported goods falls but this is due to internal real wage deflation. Transmission to the foreign economy occurs through this fall in the relative price imported goods, foreign imports increase, but the foreign productive sector is depressed by the fall in hours worked. Real wages fall but not as much as when the reform is unexpected and the movements in consumption and hours worked are dampened.

This analysis reveals that the timing of announcement and implementation of fiscal devaluations crucially affects the resulting short-run dynamics. Because pre-announced fiscal devaluations may lead to very different adjustment paths they should also result in very different welfare effects in the short run. Overall, announced fiscal devaluations should have positive welfare effects in the short run for domestic households and unclear effects on foreign households' welfare, as hours worked fall (positive effects on welfare) but welfare-based consumption falls (negative effects on welfare).

Table 3: Welfare effects of unilateral fiscal devaluations (Expected vs. unexpected), in percents

	Unexpected		Expected (4Q)		Expected (8Q)	
Horizon	H	F	H	F	H	F
1	−0.37	0.03	0.20	0.01	0.07	0.01
4	−0.60	0.10	0.45	0.05	0.14	0.04
8	−0.76	0.15	−0.20	0.08	0.29	0.05
32	−0.06	0.12	−0.11	0.09	−0.12	0.08
60	−0.01	0.06	−0.05	0.05	−0.06	0.05
∞	0.01	0.02	−0.02	0.02	−0.02	0.02

Note: A negative sign indicates a welfare loss.

Table 3 confirms that the long run effects of fiscal devaluations are almost independent of the announcement scheme. In the short run however, pre-announced unilateral fiscal devaluations produce substantial welfare gains for the domestic economy in the first periods, up to 0.20% of consumption equivalent, that must be compared to the 0.37% short run welfare loss when the fiscal devaluation is unexpected. In the medium and long run, welfare gains and losses are less sensitive to the announcement scheme. Pre-announcement is thus crucial for the way welfare gains or losses attached to fiscal devaluations materialize over time. In addition, the timing of fiscal devaluations can be manipulated by governments to produce non-negligible short-run welfare gains instead of welfare losses. Announcing fiscal devaluations might produce large welfare gains in the short-run while postponing the welfare losses (for instance after re-election).

4.4 Robustness

We finally conduct a series of robustness checks and sensitivity analyzes. First, we investigate the effects of permanent fiscal devaluations. Contrary to nominal exchange rate devaluations, fiscal devaluations can be permanent and have permanent effects. Second, we analyze the sensitivity of the welfare gains and losses from fiscal devaluations to changes in the calibrated steady-state value of hours worked, that determines the Frisch elasticity of labor supply. This should matter because the response of labor supply tailors the size of equilibrium responses of hours worked and the real wage, two variables that are crucial in the above analysis. Third, we also check the sensitivity of our results to setting a much higher degree of risk-aversion $\gamma = 5$. Last, we inspect the effects of using the consumption tax rate τ_c instead of the VAT rate to implement the tax reform. This is what many papers do, even though the consumption tax rate (excise tax for instance) is clearly not the most obvious policy variable that governments may use to engineer fiscal devaluations, as opposed to VAT. In this last case, the rise in the consumption tax rate should be 1.25 pp to generate an equivalent transfer of fiscal revenue for the consumption tax to the payroll tax (that is 1pp of ex-ante GDP). In each of these cases, we simply report the attached welfare gains or losses, computed with our baseline model with flexible export prices. The results can be found in Table 4 below.

Table 4: Welfare effects of unilateral fiscal devaluations (Robustness), in percents

	Baseline		Permanent		$\ell = 0.25$		$\gamma = 5$		Using τ_c	
Horizon	H	F	H	F	H	F	H	F	H	F
1	−0.37	0.03	−0.62	0.08	−0.66	0.05	−0.16	0.03	−0.83	0.09
4	−0.60	0.10	−1.00	0.19	−0.99	0.16	−0.26	0.07	−1.36	0.21
8	−0.76	0.15	−1.14	0.26	−1.35	0.23	−0.32	0.09	−1.59	0.27
32	−0.06	0.12	−1.37	0.26	−0.08	0.14	−0.02	0.08	−0.04	0.16
60	−0.01	0.06	−1.45	0.23	−0.01	0.07	0.00	0.05	0.04	0.05
∞	0.01	0.02	−1.55	0.22	0.01	0.02	0.01	0.02	0.06	−0.01

Note: A negative sign indicates a welfare loss.

A permanent reform yields welfare losses at all horizons for the domestic households, between 0.62% on impact and 1.55% in the long run. Welfare gains are observed for the foreign households, ranging from 0.08% on impact to 0.22% in the long run. In this case, the reform reduces consumption at the intensive margin since the price of domestic consumption goods raises permanently. It also decreases the production cost while hours worked increase. Foreign households enjoy positive spillovers from the reform as hours worked fall, inducing a fall in the real wage that triggers entries and an increase in the total number of varieties.

Assuming a lower level of steady-state hours worked ($\overline{\ell} = 0.25$) or a larger degree of risk-aversion ($\gamma = 5$) only affects the quantitative implications of the exercise. Welfare gains and losses increase for higher degrees of risk-aversion while welfare gains and losses decrease for less elastic labor supply. Qualitatively, the pattern highlighted in the previous sections remains the same: welfare losses for domestic households and welfare gains for the foreign households in the

short run, small welfare gains both for domestic and foreign households in the long run. Finally, using the consumption tax rate instead of the VAT rate to engineer the fiscal devaluation yields quite similar welfare patterns, although the short run dynamics are somewhat different (not reported). The main difference with respect to our baseline model is that welfare losses are larger in the short run and that welfare gains materialize earlier in the medium run for domestic households. Finally, positive spillovers (welfare gains) for foreign households are larger in the short run than in our baseline model using VAT.

5 Conclusion

This paper is, to our knowledge, the first attempt to quantify the effect of fiscal devaluations in a monetary union characterized by both endogenous entry and tradability. Countries that decide to follow these types of policies unilaterally experience positive outcome on output, consumption, hours worked and the trade balance. For trade partners of the monetary union, they generate positive output and consumption spillovers.

Our results suggest that endogenous tradability amplifies the size of the trade effects of the reform. Further, the assumption of endogenous business formation also alters the effects of fiscal devaluation. In this environment, fiscal devaluations boost business creation both for the country that implements the reform and for other members of the monetary union. Our results also indicate that the pre-announcement scheme of fiscal devaluations crucially alters the resulting dynamics. Taking into account the dynamics of produced and exported varieties, two realistic features of the data, thus proves to be essential in accounting for the effects of fiscal devaluations.

References

Auray, S. & Eyquem, A. (2011), 'Do Changes in Product Variety Matter for Business Cycles and Monetary Policy in Open Economies?', *International Finance* **14**(3), 507–539.

Auray, S., Eyquem, A. & Poutineau, J.-C. (2012), 'The Effect of a Common Currency on the Volatility of the Extensive Margin of Trade', *Journal of International Money and Finance* **31**(5), 1156–1179.

Bergin, P. R. & Glick, R. (2009), 'Endogenous Tradability and Some Macroeconomic Implications', *Journal of Monetary Economics* **56**(8), 1086–1095.

Bergin, P. R. & Lin, C.-Y. (2012), 'The Dynamic Effects of a Currency Union on Trade', *Journal of International Economics* **87**(2), 191–204.

Berman, N., Martin, P. & Mayer, T. (2012), 'How do Different Exporters React to Exchange Rate Changes?', *Quarterly Journal of Economics* **127**(1), 437–492.

Bilbiie, F. O., Ghironi, F. & Melitz, M. J. (2008), Monetary Policy and Business Cycles with Endogenous Entry and Product Variety, *in* 'NBER Macroeconomics Annual 2007, Volume 22', NBER Chapters, National Bureau of Economic Research, Inc, pp. 299–353.

Bilbiie, F. O., Ghironi, F. & Melitz, M. J. (2012), 'Endogenous Entry, Product Variety, and Business Cycles', *Journal of Political Economy* **120**(2), 304–345.

Bosca, J., Domenech, R. & Ferri, J. (2013), 'Fiscal Devaluations in EMU', *Review of Public Economics* **206**(3), 27–56.

Cacciatore, M., Fiori, G. & Ghironi, F. (2016), 'Market Deregulation and Optimal Monetary Policy in a Monetary Union', *Journal of International Economics* **99**(C), 120–137.

Cacciatore, M. & Ghironi, F. (2014), Trade, Unemployment and Monetary Policy, Technical report, HEC Montreal and University of Washington.

Eaton, J., Kortum, S. & Kramarz, F. (2011), 'An Anatomy of International Trade: Evidence From French Firms', *Econometrica* **79**(5), 1453–1498.

Engler, P., Ganelli, G., Tervala, J. & Voigts, S. (2014), Fiscal Devaluation in a Monetary Union, IMF Working Papers 14/201, International Monetary Fund.

European Commission (2013), Study on the Impacts of Fiscal Devaluation, Taxation Papers 36, Directorate General Taxation and Customs Union.

Farhi, E., Gopinath, G. & Itskhoki, O. (2014), 'Fiscal Devaluations', *Review of Economic Studies* **81**(2), 725–760.

Ghironi, F. & Melitz, M. J. (2005), 'International Trade and Macroeconomic Dynamics with Heterogeneous Firms', *Quarterly Journal of Economics* **120**(3), 865–915.

Imura, Y. (2016), 'Endogenous Trade Participation with Price Rigidities', *Journal of International Economics* **100**, 14–33.

Langot, F. & Lemoine, M. (2014), Strategic Fiscal Revaluation or Devaluation: Why Does the Labor Wedge Matter?, Document de Travail 516, Banque de France.

Langot, F., Patureau, L. & Sopraseuth, T. (2014), Fiscal Devaluation and Structural Gaps, Document de travail 508, Banque de France.

Lipinska, A. & von Thadden, L. (2012), On the (In)effectiveness of Fiscal Devaluations in a Monetary Union, Finance and Economics Discussion Series 2012-71, Board of Governors of the Federal Reserve System (U.S.).

Naknoi, K. (2008), 'Real Exchange Rate Fluctuations, Endogenous Tradability and Exchange Rate Regimes', *Journal of Monetary Economics* **55**(3), 645–663.

Roriguez-Lopez, J. A. (2011), 'Prices and Exchange Rates: A Theory of Disconnect', *Review of Economic Studies* **78**(3), 1135–1177.

Schmitt-Grohé, S. & Uribe, M. (2003), 'Closing Small Open Economy Models', *Journal of International Economics* **61**(1), 163–185.

Smets, F. & Wouters, R. (2005), 'Comparing Shocks and Frictions in US and Euro Area Business Cycles: A Bayesian DSGE Approach', *Journal of Applied Econometrics* **20**(2), 161–183.

Appendix

Business cycle properties of the model

In this paragraph, business cycles are generated by productivity and monetary policy shocks. We follow the estimates of Smets & Wouters (2005) and impose $std(\epsilon^r) = 0.25\%$. In addition, as in Smets & Wouters (2005), we set the persistence of productivity shocks at $\rho_a = 0.99$. Finally we adjust $std(\epsilon^a) = 0.99\%$ to match the standard deviation of GDP, with a cross-country correlation of innovations $\rho\left(\epsilon^a, \epsilon^{a^*}\right) = 0.5$. Using those numbers and the calibration reported in Table 1, we solve the model using a first-order approximation around the deterministic steady state, and compare the business cycle moments computed on simulated HP-filtered time series – using $\lambda = 1600$ – to the business cycle moments computed on observed HP-filtered time series. As explained in Ghironi & Melitz (2005), our artificial time series have to be deflated by a price index capturing the aggregate variety effect. Defining $p_t = (n_t + n_{x,t})^{\frac{1}{1-\theta}} \widetilde{p}_t$, real data-consistent variable x_t writes $x_t^r = p_t x_t / \widetilde{p}_t$, $\forall x$. In addition, average (data-consistent) inflation rates are defined as $\widetilde{\pi}_t = (p_t/p_{t-1}) / (\widetilde{p}_t/\widetilde{p}_{t-1})$, and terms of trade as $\widetilde{q}_t = \widetilde{p}_t^*/\widetilde{p}_t$.

For the data, we use time series for GDP, consumption, investment, exports, imports, and CPIs for Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Spain and Portugal. These series are taken from the OECD Economic Outlook database, and range from 1981Q1 to 2012Q4. GDP, consumption, investment, exports and imports are volume chained, seasonally adjusted, millions of PPP 2005 US dollars. Inflation is the quarterly growth rate of the CPI. CPIs are previously filtered to remove high-frequency movements, and capture "core" movements in price levels. Consumption is the total expenditure of households on consumption goods. Investment is the gross fixed capital formation. Each macroeconomic variable is also computed at the aggregate (euro) level. GDP, consumption, investment, exports and imports are taken in log. Net exports over GDP are computed as exports minus imports divided by GDP. No correction is necessary as quarterly national account variables (GDP, consumption, investment, exports and imports) are all expressed in annualized levels. Terms of trade are computed using CPIs. For each country, terms of trade is the ratio of the aggregate (euro) CPI and the national CPI level. The aggregate CPI is a GDP-weighted average of national CPIs – with time-varying weights. Terms of trade are then taken in log. Time series are all HP-filtered with $\lambda = 1600$ before computing the business cycle moments. Business cycle moments are computed for each country and averaged. The cross-country correlation is the correlation of a macroeconomic variable with the same aggregate (euro) variable. Cross-country correlations are computed for each country and then averaged.

Table 5 below presents the standard deviations or relative standard deviations of data-consistent key macroeconomic aggregates, their first-order auto-correlation, their correlation with GDP and their cross-country correlation.

Table 5: Business cycle moments.

	Data				Model			
$x \downarrow$	σ_x	ρ_x	$\rho_{x,y}$	ρ_{x,x^*}	σ_x	ρ_x	$\rho_{x,y}$	ρ_{x,x^*}
GDP (y_t^r)	1.48	0.84	–	0.83	1.48	0.73	–	0.45
Consumption (c_t^r)	0.85	0.78	0.67	0.66	0.93	0.73	0.90	0.65
Investment (i_t^r)	3.07	0.81	0.78	0.73	3.97	0.64	0.82	0.20
Exports	2.58	0.78	0.69	0.82	1.79	0.61	0.50	0.83
Imports	2.72	0.80	0.77	0.81	1.78	0.60	0.61	0.85
Net exports / GDP	0.23	0.58	−0.01	–	0.16	0.74	−0.19	–
Inflation ($\widetilde{\pi}_t$)	0.33	0.56	0.37	0.70	0.31	0.20	0.01	0.99
Terms of trade ($\widetilde{q}_t$)	0.65	0.68	0.04	–	0.04	0.78	−0.41	–

Note: σ_x is the standard deviation (for GDP, net exports to GDP and terms of trade) or the standard deviation relative to GDP (for consumption, investment, export, and imports). ρ_x is the first-order correlation. $\rho_{x,y}$ is the contemporaneous correlation with GDP. ρ_{x,x^*} is the correlation of a variable with the same variable in the other country of the monetary union.

Table 5 shows that the model correctly reproduces many features of the data. As in the data, consumption is less volatile than GDP while investment is more volatile. Exports and imports are more volatile than GDP, but a little less than in the data. The volatility of net exports to GDP is almost perfectly matched. The volatility of terms of trade is much lower than in the data: as in Ghironi & Melitz (2005), the model does not fully reproduce the volatility of relative prices observed in the data. Other moments are qualitatively well matched: persistences are a bit too low compared to the data and cyclical patterns are broadly correctly matched. In particular exports and imports are positively correlated with output but imports are more strongly correlated which produces counter-cyclical net exports, as in the data. The cross-country correlation of consumption is almost perfectly matched and remains higher than that of GDP, and the cross-country correlation of investment is too low compared to the data. The cross-country correlation of trade flows is almost perfectly matched.

Our model of endogenous business creation and tradability performs quite well in matching the business cycle moments of gross and net trade flows while producing reasonable figures for business cycle moments pertaining to GDP, consumption, investment or inflation. Overall, given its relative simplicity with respect to medium-scale business cycle models – we abstract from habits in consumption, price indexation, variable capital utilization, and focus on a much scarcer number of driving shocks – the model performs rather well and correctly matches a wide range of business cycle moments. We thus consider the model as providing a reliable business cycle representation of countries of the Eurozone, that we wish to consider in the analysis of fiscal devaluations.