

External shocks, trade margins and macroeconomic dynamics

Abstract

This paper studies the role of exchange rate regimes for the pattern of trade. It first provides VAR evidence that a rise in external productivity shifts trade away from new products, and more so in fixed regimes. Then, it presents a model with firm dynamics in line with this evidence. We argue that exchange rate policy can affect firms' entry decisions with consequences for the competitiveness of a country's exports well beyond the short run. In our setup, *fixed exchange rates* can foster the competitiveness of firms that trade new products, while flexible rates favor firms that produce mature products.

Keywords: Trade margins, Firm entry, Exchange rate policy, International business cycle, Panel VAR, DSGE model, Comparative advantage.

JEL Classification: E31; E32; E52

1 Introduction

This paper belongs to a recent line of research that incorporates endogenous changes in the composition of trade into dynamic macroeconomic models.¹ In departing from the workhorse international business cycle model, which typically considers an exogenous number of traded goods and a constant share of exporting firms, these studies stress the role of foreign market access for the international propagation of shocks. Entry (exit) implies the creation (destruction) of new trade relations, in the form of brand new products and trade of previously non-traded goods. This is known as the extensive margin of trade.

Our focus will be on the role of the exchange rate regime for trade of new products. Previous studies have mainly considered how exchange rate variability affects the decision to access foreign markets in the first place.² It is now well-understood that fixed rates stimulate entry in foreign markets because a low exchange rate risk increases the expected revenue of investing in a new trade relationship. A few contributions stress the role of exchange rates for inducing relocations of production across sectors.³ We follow this lead to investigate a number of questions that have been overlooked so far. Specifically, we focus on the evolution of trade over the business cycle: does exchange rate variability affect the capacity of firms to adjust trade at the intensive and at the extensive margin in response to shocks? What are the consequences of changes in the composition of trade for international prices and the transmission of shocks worldwide? Our contribution is twofold.

First, we provide VAR evidence about the dynamics of trade margins in the wake of external shocks, contrasting the transmission mechanism in fixed and floating exchange rate regimes.⁴ The analysis is based on a panel VAR model with exogenous factors (VARX for short) in a sample of 22 developed economies over the period 1988-2011. The vector of endogenous includes bilateral exports at the extensive and the intensive margin together with a measure of the relative country size. The vector of exogenous, common to all panels, includes productivity, aggregate demand and

¹Seminal studies stressing the macroeconomic implications of tradability include Atkeson and Burstein (2008) and Ghironi and Méltitz (2005). In the context of DSGE models, a non-exhaustive list of contributions includes Auray et al. (2012), Cavallari (2013a), Bergin and Corsetti (2015) and Cacciatore et al. (2015). de Blas and Russ (2015) analyse foreign market entry in a Ricardian model.

²See Russ (2007), Russ (2012) and Cavallari (2010).

³Flexible exchange rates may induce relocations of production in and out of the export sector that help explain the positive correlation between the relative prices of traded and non-traded goods observed in the data (Naknoi, 2008). In a setup where all goods are traded, Bergin and Corsetti (2015) show that monetary stabilization under free floating can induce relocations toward sectors producing differentiated goods and foster a country's competitive advantage in these sectors. We share with this work the emphasis on firm dynamics across sectors, yet we focus on relocations in and out of the export sector.

⁴Early studies have documented a positive relation between a country's extensive margin of exports and its terms of trade (Cavallari and D'Addona, 2015), and a positive relation with external demand shocks (Cavallari and D'Addona, 2017).

monetary policy shocks in the United States. These reflect unexpected changes in external cyclical conditions. The shocks are identified with a combination of long-run and sign restrictions. The model is estimated separately for country pairs that adopt fixed exchange rates (“peggers”) and for country pairs under free floating (“floaters”).

We find that a rise in external productivity has a negative impact on exports of new products (the extensive margin), and more so in fixed regimes. On average, the extensive margin of exports drops by 1 and 1.5 percent below the mean in, respectively, the sample of floaters and the sample of peggers. Interestingly, the shock has no consequences for the average volume of exports (the intensive margin). In contrast, a rise in external demand increases exports mostly at the intensive margin. The average trade volume rises by almost 9 percent above the mean among peggers and by 3 percent among floaters. The responses to a monetary policy contraction are either insignificant (for intensive margins) or negligible (for extensive margins the impact effect ranges between 0.25 and 0.6 percent below the mean in, respectively, fixed and floating regimes). Overall, the evidence suggests that trade of new products responds mainly to productivity shocks, while trade of previously traded goods responds mainly to demand shocks. The extent of these responses is affected by the exchange rate regime.

Second, we develop a model with endogenous tradability that helps explain the role of exchange rates for trade of new products. The model builds on Cavallari (2013a), which we extend to incorporate non-tradable goods and allow for relocations between the export and the nontraded sector. Potential exporters face firm-specific trade costs, which are paid at the beginning of the period, on a period by period basis, and are independent of the volume of exports. A domestic producer decides to export its products abroad whenever export profits cover trade costs.

We find that exchange rate variability affects the pattern of trade in a number of dimensions. First, a rise in domestic productivity increases the share of exporters under fixed exchange rates far more than under flexible rates. In the partner economy, the shock leads to a sharp fall in the share of exporters. Second, the volatility of the extensive margin of exports to and from the home country is, respectively, 41 and 42 percent higher when exchange rates are fixed. Finally, our model captures important properties of trade margins observed in the data: i) the extensive margin of imports and exports are more volatile than output; ii) they are negatively correlated between each other; iii) extensive margins are procyclical relative to output of the exporting country; iv) the volatility of the extensive margin of exports increases in fixed regimes.

These dynamics reflect a strong incentive to adjust trade at the extensive margin in fixed regimes: firms relocate production to and from the export sector in response to aggregate productivity shocks. In order to see why, consider an increase in domestic productivity: the price of domestic goods

(sluggishly) falls in all markets, and more so in foreign markets because the domestic currency depreciates. As a consequence, home producers will find it convenient to export their products, and particularly so when markups are insulated from exchange rate risk. Hence, the share of exporters is higher under fixed exchange rates. The opposite occurs in the partner economy, where flexible rates provide a natural hedge against the external shock (the rise in home productivity). With a fixed exchange rate, in fact, the only way for foreign exporters to keep up with cheaper home goods is to reduce their markups. Foreign producers are therefore induced to relocate to the domestic market.

An important contribution of our analysis is to clarify that exchange rates, by affecting entry dynamics in and out of the export sector, can have an impact on a country's international competitiveness well beyond the short run. In our setup, high-productivity economies have lower prices and therefore a comparative advantage in sectors that produce new products and previously nontraded goods. *Fixed rates*, by leading more producers to become exporters, can strengthen a country's comparative advantage in these sectors. This may appear at odds with Bergin and Corsetti (2015), who show that *flexible rates* can foster the competitiveness of firms that produce differentiated goods compared to firms in sectors that produce homogeneous goods. The contrast is, however, only apparent. In their model, all goods - both homogeneous and differentiated - are traded and exchange rates have no impact on the decision to export in the first place. We suggest a complement view, which is based on endogenous fluctuations in tradability. In our setup, exchange rate variability affects the incentive to relocate production between the export and the nontraded sectors, and implies a strong incentive to adjust trade at the extensive (intensive) margin in fixed (floating) regimes. In high-productivity countries, fixed exchange rates have the effect to induce more trade of new products, while they favour trade of mature products and previously traded goods in low-productivity economies.

The paper is organized as follows. Section 2 provides the VAR evidence. Section 3 presents the model and Section 4 discusses the simulation results. Section 5 concludes.

2 VAR evidence

This section provides VAR evidence on the dynamics of export margins in response to external shocks, contrasting the transmission mechanism in fixed and floating regimes. In earlier work (Cavallari and D'Addona, 2015 and Cavallari and D'Addona, 2017), we have focused on the shock absorption properties of flexible exchange rates by considering the dynamics of output and trade margins in the wake of, respectively, shocks to the terms of trade of a country and shocks to global demand factors. In both cases flexible rates are found to stabilize output by reducing the response of the

extensive margin. Here, we focus on the dynamics of trade margins in response to a wide range of external shocks, including productivity shocks at the heart of international business cycle models. The scope of the analysis is descriptive.

2.1 Data

Our sample includes 22 developed countries over the period from 1988 to 2011 together with the United States. GDP - measured in domestic currency at constant prices and logged - is from the OECD StatExtracts database.

Export margins are calculated from bilateral trade data made available by the World Bank through the World Integrated Trade Solution website⁵. Trade categories are defined according to the the four-digit Standard International Trade Classification maintained by the United Nations⁶.

We follow Hummels and Klenow (2005) in calculating the extensive margin of exports for a country-pair as the weighted sum of exported categories relative to all categories exported in the importer country, using the relevance of each category in world's export as weights. Namely:

$$XM_m^j = \frac{\sum_{i \in I_m^j} X_{m,i}^W}{X_m^W} \quad (1)$$

where $\sum_{i \in I_m^j} X_{m,i}^W$ is the sum across categories of the values of world exports toward country m , I_m^j is the set of categories where a positive value of exports is recorded from country j to country m , and X_m^W is the aggregate value of world exports to country m . The extensive margin is, by construction, a number between zero and one, increasing with the variety of categories exported.

Similarly, the intensive margin of exports is the value of j 's exports to country m relative to the weighted categories in which country j exports to country m :

$$IM_m^j = \frac{X_m^j}{\sum_{i \in I_m^j} X_{m,i}^W} \quad (2)$$

where X_m^j is the total export value from country j to country m . By definition the intensive margin has a lower bound at 0 and is increasing in the volume of exports of previously traded categories.

2.2 VAR specification

We consider a panel VAR model with a vector of exogenous variables (VARX for short). The model includes 3 endogenous variables and 5 exogenous variables. Endogenous variables are measured

⁵<http://wits.worldbank.org/wits/>

⁶<https://unstats.un.org/unsd/trade/sitcrev4.htm>

on a country-pair basis where $j = 1, 2, \dots, 22$ denotes the exporting country, $m = 1, 2, \dots, 22$ with $m \neq j$ denotes the destination country (including the United States), and t indicates time. They include relative GDP and bilateral exports, measured at the extensive and the intensive margin. The exogenous vector represents global factors that do not depend on the dynamics of any of the endogenous variables. It is common to all panels and comprises innovations to productivity, real GDP, inflation, energy prices and monetary policy rates in the United States.

The model is given by:

$$Y_{j \times m, t} = \alpha_{j \times m} + \beta(L)Y_{j \times m, t-1} + \gamma(L)X_t + \varepsilon_{j \times m, t} \quad (3)$$

where $Y_{j \times m, t} = (\frac{GDP_{j,t}}{GDP_{m,t}}, XM_{j \times m, t}, IM_{j \times m, t})$ is the vector of endogenous variables; $\alpha_{j \times m}$ captures country-pair fixed effects; $\beta(L)$ and $\gamma(L)$ are matrix polynomials in the lag operator; X_t is the vector of exogenous shocks as defined right below, and $\varepsilon_{j \times m, t}$ is the vector of errors in the system.

Exogenous shocks are obtained from the model:

$$y_t = a + b(L)y_{t-1} + e_t \quad (4)$$

where y_t includes total factor productivity, real output, consumer price inflation, energy prices and the Federal funds rate, $y_t = (\log TFP, \log GDP_t, \Delta \log CPI_t, \Delta \log Energy_t, FFR_t)$; a is a vector of intercepts; $b(L)$ is a matrix polynomial in the lag operator; e_t is the vector of exogenous errors with variance $E(e_t e_t') = \Sigma$ for all t .⁷ Energy prices, which help forecast future inflation, are included to avoid a price puzzle, namely a rise in inflation after a restrictive monetary policy.

Notice that the structural shocks are by construction orthogonal to any of the endogenous variables in the system and can be therefore treated as exogenous in (3), though US variables may in principle be correlated with the export margins of US trading partners.

The structural shocks are identified with a combination of long-run and sign restrictions. Since Blanchard and Quah (1989), many studies use long-run restrictions for identifying shocks that have permanent effects, as technology shocks in Galí (1999). We draw on this idea to identify productivity as the only force in our system that has a permanent effect on output. By contrast, monetary policy is neutral and innovations to the policy rate have no long-run impact on output, either directly or through any other variable in the system. Real demand shocks are identified with sign restrictions, which select a minimum set of common predictions by an ample class of theoretical models, including our own model. In this sense, the strategy is based on a simple intuition: demand shocks move quantities and nominal prices in the same direction while supply shocks move them in opposite

⁷The exogenous VAR model is estimated over the period 1970-2011 for efficiency reasons.

directions. Hence, an increase in aggregate demand leads to a rise in both output and prices while an increase in productivity is associated with a rise in output and a drop in prices. The restrictions are summarized in Table 1.

[Table 1 about here.]

Operationally, the sign restrictions remain in place for 5 years, reflecting a prior of fairly persistent shocks. The long run restrictions refer to the cumulated effect of the shock over the entire horizon.

The model is estimated separately for countries with fixed and for countries with floating rates. Country pairs are classified using the IMF de facto classification (see Born et al., 2013), updated to match our sample period. For each year, a country pair is classified in the sample of “peggers” if both countries have adopted a regime of “peg within horizontal bands”, or tighter, within the year. In all other cases, the country pair is classified in the sample of “floaters”. The sample of peggers comprises only European country pairs, and reflects intra-EMU trade. The complete list of “peggers” and “floaters” is reported in Appendix B.2 ⁸.

Finally, we estimate the model (3) using the bootstrap-bias corrected estimator (BSBC) in Pesaran and Zhao (1999) and Everaert and Pozzi (2007). The bootstrap sampling is modified to suit our unbalanced panel as in Fomby et al. (2013). In this way, we address concerns about the consistency of the least-squares dummy variable (LSDV) estimator in dynamic models with a small time dimension (Nickell, 1981).

2.3 Results

We consider the mean responses of the extensive and intensive margins in the sample of peggers and floaters in the wake of supply, demand and monetary policy shocks. The supply shock is a one standard deviation increase in US productivity; the demand shock is a one standard deviation increase in US GDP, and the monetary policy shock is a one standard deviation increase in the Federal funds rate.

Figures 1 and 2 report the impulse response functions of, respectively, the extensive and intensive margins together with 90% confidence intervals, generated by Monte Carlo simulations with 1000 replications. The top row of each figure shows the mean responses in the sample of peggers while the bottom row refers to the mean responses in the sample of floaters.

We document a significant effect of productivity on extensive margins. On impact, the extensive margin of exports falls by 1 and 1.5 percent below the mean in, respectively, the sample of floaters

⁸We refer to Cavallari and D’Addona (2017) for an extensive discussion of the reasons for adopting a dichotomous classification with country-pair data.

and the sample of peggers. The effect is quite persistent and takes up to 6 years before vanishing. The drop reflects relocations away from sectors that produce new products and previously non-traded goods. Interestingly, productivity shocks have only negligible effects on the average volume of exports per product. Except for a small increase on impact in flexible regimes, the response of the intensive margin is not different from zero. Therefore, adjustment to external productivity shocks occurs mainly at the extensive margin, and more so in fixed regimes.

Aggregate demand shocks, in contrast, have negligible effects on extensive margins. A rise in external demand boosts trade mainly at the intensive margin. The average volume of exports rises by almost 9 percent above the mean among peggers and by 3 percent among floaters. In the sample of peggers, the demand boost is accommodated also through a moderate increase in the number of products (0.35 percent on impact). Monetary policy shocks have a moderate impact. The responses of the intensive margins are not significantly different from zero throughout the whole transition in all samples. The extensive margins drop on impact, by 0.25 and 0.6 percent below the mean in, respectively, fixed and floating regimes, and quickly revert to the mean.

To gauge the statistical relevance of differences in the transmission mechanism across exchange rate regimes, we bootstrap the samples for which we compute the difference in the responses of peggers and floaters as is done in Born et al. (2013). Results are shown in Figure 3. Extensive margins are indeed more sensitive to real shocks in fixed regimes compared to floating regimes and these differences are significant at the 90% level. As regard monetary policy shocks, we find no significant differences in the coefficient of the impulse responses between fixed and floating regimes.

[Figure 1 about here.]

[Figure 2 about here.]

[Figure 3 about here.]

3 The model

The model is based on Cavallari (2013a) and is modified as in Cavallari and D’Addona (2015) to account for the endogenous selection of exporters. In what follows we present linearized equations while Appendix A describes the complete model. To save on space we describe only the home economy with the understanding that similar relations hold in the foreign country. A star superscript denotes a foreign variable.

3.1 Demand block

Households in each country consume an identical basket of imported and domestic goods, $C = (C_D)^\gamma (C_X)^{1-\gamma}$ and $C^* = (C_D^*)^\gamma (C_X^*)^{1-\gamma}$, whose value is P in the home country and P^* in the foreign country. Each basket contains imperfectly substitutable varieties of mass N_t (N_t^*) for home (foreign) domestic varieties and N_{Xt}^* (N_{Xt}) for home (foreign) imported varieties. Each variety corresponds to a firm, so N_t is also the number of home firms and N_{Xt} is the number of home exporters, and similarly for N_t^* and N_{Xt}^* . The elasticity of substitution among all varieties is constant and equal to $\theta > 1$.

Households hold home and foreign riskless bonds B_t and B_t^* , which are denominated in the local currency and yield a gross nominal interest rate i_t and i_t^* respectively, and shares in a mutual fund of domestic firms. Notice that in contrast to bonds, shares cannot be traded internationally.

Inter-temporal optimization requires that the marginal rate of substitution between current and one-period ahead consumption equals the real return on bonds and shares. A first set of Euler equations, one for each country, therefore describes the link between current and expected one-period ahead consumption and relate it to the risk-free return in units of consumption. A second set of Euler equations, again one for each country, relates the dynamics of consumption to the real return on shares. The real value of the firm ν_t , equal to the entry cost in equilibrium, is the forward solution to the Euler equations on shares.

The bond Euler equation in the Home country is:

$$E_t \widehat{C}_{t+1} = \widehat{C}_t + \frac{1}{\rho} \left(\widehat{i}_t - E_t \pi_{t+1}^C \right) \quad (5)$$

where a hat over a variable denotes the log-deviation from the steady state, $\pi_{t+1}^C = \ln \frac{P_{t+1}}{P_t} - 1$ is consumer price inflation and $\rho > 0$ is the the inter-temporal elasticity.

The Euler on shares is:

$$E_t \widehat{C}_{t+1} = \widehat{C}_t + \widehat{\nu}_t + \frac{1}{\rho} E_t \left(\frac{i + \delta}{1 + i} \widehat{d}_{t+1} - \frac{i - \delta}{1 + i} \widehat{\nu}_{t+1} \right)$$

where d are dividends, and δ is the exogenous probability of firm exit.

International trade in bonds implies the uncovered interest parity condition $E_t \Delta \widehat{\varepsilon}_{t+1} = \widehat{i}_t - \widehat{i}_t^*$, linking the expected nominal exchange rate to interest rate differentials across countries.⁹ Notice that bond trade provides a useful means for sharing consumption risk: movements in the real exchange

⁹The nominal exchange rate is defined as units of home currency per one unit of foreign currency. The real exchange rate is defined as $q = \varepsilon P^*/P$. An increase in both q and ε is therefore a depreciation. The home terms of trade are the price of home exports relative to the price of home imports $ToT = p(h)/p(f)$.

rate mimic changes in relative consumption $\hat{q}_t = \rho(\hat{C}_t - \hat{C}_t^*)$.

3.2 Supply block

The supply block comprises the pricing and entry decisions of firms, together with labor supply and equilibrium conditions in goods and financial markets.

Markets are monopolistically competitive. Each firm produces a unique variety $h \in (0, N_t)$ in the home country and $f \in (0, N_t^*)$ in the foreign country, and sets the price of its product in its own currency, $p(h)$ and $p^*(f)$. Export prices entail melting transport costs so that for one unit of a good to reach the foreign market $1 + \tau$ units must be shipped. They vary with the exchange rate at a constant elasticity η .¹⁰ So, the home-currency price of the imported good f is $p_t(f) = \varepsilon_t^\eta (1 + \tau) p_t^*(f)$.

All nominal prices are staggered à la Calvo and in each period a fraction α of firms in each country faces pre-determined prices. Define the relative price of variety $i = (h, f)$ in units of good $j = (D, X)$ as $\rho_j(i) = p(i)/P_j$. For instance, $\rho_{D,t}(h) \equiv \frac{p_t(h)}{P_{D,t}}$ indicates the price of variety h relative to the aggregate price of domestic goods. In a symmetric equilibrium where $p(h) = p$ and $p(f) = p^*(1 + \tau)\varepsilon^\eta$, real price fluctuations are driven by:

$$\begin{aligned}\hat{\rho}_{D,t} &= \frac{\alpha}{1 - \alpha} \pi_t^D + \frac{1}{(1 - \alpha)(\theta - 1)} \hat{N}_t - \frac{\alpha}{(1 - \alpha)(\theta - 1)} \hat{N}_{t-1} \\ \hat{\rho}_{X,t} &= \frac{\alpha}{1 - \alpha} \pi_t^X + \frac{1}{(1 - \alpha)(\theta - 1)} \hat{N}_{X,t}^* - \frac{\alpha}{(1 - \alpha)(\theta - 1)} \hat{N}_{X,t-1}^*\end{aligned}\quad (6)$$

where $\pi_t^D = \ln \frac{P_{D,t+1}}{P_{D,t}} - 1$ is producer price inflation, and $\pi_t^X = \ln \frac{P_{X,t+1}}{P_{X,t}} - 1$ is imported inflation. With $\alpha = 0$, an increase in the range of available varieties leads to a fall in aggregate prices (the so-called variety effect) which is higher the lower the elasticity of substitution θ . This effect is dampened when prices are sticky, $\alpha > 0$, implying a relative price distortion.

The Phillips curve is:

$$\begin{aligned}\pi_t^D &= \frac{(1 - \alpha\beta(1 - \delta))(1 - \alpha)}{\alpha} \left(\widehat{W}_t - Z_t \right) + \beta(1 - \delta) E_t \pi_{t+1}^D + \frac{\beta(1 - \delta)}{\theta - 1} E_t \hat{N}_{t+1} - \frac{1 + \alpha\beta(1 - \delta)}{\theta - 1} \hat{N}_t \\ &\quad + \frac{1}{\theta - 1} \hat{N}_{t-1}\end{aligned}\quad (7)$$

where β is the discount factor, W is the nominal wage, and Z is the aggregate productivity shock.¹¹ Inflation is driven by marginal costs and expected inflation, as in the traditional forward-looking

¹⁰With symmetric demand elasticity, the optimal strategy is to set prices in the producers' currency and let the final price vary with exchange rate at a constant rate (Corsetti and Pesenti (2005)).

¹¹The derivation of the Phillips curve draws on Cavallari (2013a).

Phillips curve, and also by changes in the variety of goods available for consumption. These changes reflect entry of new firms and have the effect of increasing the persistence of inflation.

Inflation for imported goods is given by:

$$\pi_t^X = \eta \widehat{\varepsilon}_t + \frac{1}{\theta - 1} \left(\widehat{N}_{X,t}^* - \widehat{N}_{X,t-1}^* \right) + \pi_t^{*D}$$

It depends on foreign inflation, on fluctuations in the nominal exchange rate (recall that these are passed-through into final prices at the rate η) as well as on changes in the variety of imported goods.

Entry is subject to an exogenous sunk cost so that in each period potential entrants N_e must purchase f_e units of the consumption basket to set up a new firm. Notice that entry costs are constant in consumption units.¹² Start-up investments are tied to output Y through the aggregate resource constraint. Equilibrium in international financial markets requires that bonds are in zero net supply worldwide, implying that world output must be equal to world spending (consumption plus investments). Borrowing and lending in international markets allows countries to run current account imbalances. The home current account implies:

$$\widehat{N}_{e,t} = \frac{\theta(1 - \beta(1 - \delta))}{\beta\delta} \widehat{Y}_t + \left(1 - \frac{\theta(1 - \beta(1 - \delta))}{\beta\delta} \right) \widehat{C}_t - \widehat{\nu}_t - \frac{(1 - \delta)}{\delta} \widehat{nfa}_t \quad (8)$$

where net foreign assets $\widehat{nfa}_t = \widehat{b}_t - \frac{1}{\beta} \widehat{b}_{t-1}$ and $b_t = \frac{B_t^t - \varepsilon_t B_t^*}{Y_t P_t}$. Clearly net foreign assets in the foreign country are $-\widehat{nfa}_t$. Notice that the aggregate constraint implies a trade-off between start-up investments and consumption (the coefficient on C is negative).

The dynamics of entry is based on Ghironi and Mélitz (2005): entrants start producing with a one-period lag and all firms entered in each period are subject to an exogenous exit shock δ . The law of motion of firms is:

$$\widehat{N}_t = (1 - \delta) \widehat{N}_{t-1} + \delta \widehat{N}_{e,t-1} \quad (9)$$

The selection of exporters among the firms operating in the domestic market draws on Cavallari and D'Addona (2015). We assume that firms must pay a fixed export cost f_x for accessing foreign markets, which is independent of the volume of exports and is paid on a period by period basis. Export costs are firm-specific and drawn from a Pareto distribution with lower bound $f_{x\min}$ and shape parameter $\varkappa > \theta - 1$.¹³ Each firm decides to export whenever export profits are higher than

¹²Cavallari (2013a) and Cavallari and D'Addona (2015) consider asymmetric consumption and investment baskets that imply time-varying entry costs. See also Cavallari (2013b) for an assessment of the role of entry costs for business cycle transmission.

¹³The idea of firm-specific trade costs is borrowed from Bergin and Glick (2009).

trade costs. The share of exporting firms is given by:

$$\widehat{N}_{X,t} - \widehat{N}_t = \varkappa (\widehat{\mu}_{X,t} + \gamma(\pi_t^{D*} - \pi_t^{X*})) \quad (10)$$

where export markups $\widehat{\mu}_{X,t}$ are: ¹⁴

$$\widehat{\mu}_{X,t} = \widehat{\mu}_t = \alpha\beta(1-\delta)(E_t\widehat{\rho}_{X,t+1} - \widehat{\rho}_{X,t} + E_t\pi_{t+1}^X)$$

An increase in markups $\widehat{\mu}_{X,t}$ and/or in the relative price of foreign goods (the second addend in the expression above) will boost export profits and raise the share of producers who will be able to cover export costs. Note that the share of exporters would be constant in a flexible price environment. With flexible prices, in fact, exporters are able to stabilize profits in their own currency and have no incentive to relocate production in and out of the export sector.

Labor supply is derived from the consumers' optimization condition:

$$\widehat{L}_t = -\rho\varphi\widehat{C}_t + \varphi(\widehat{W}_t - \pi_t^C) \quad (11)$$

where $\varphi > 0$ is the inverse of the Frisch elasticity.

Finally, goods market clearing reads:

$$\widehat{Y}_t = \gamma \left[(1-\varrho)\widehat{C}_t + \varrho(\widehat{N}_{et} + f_x\widehat{N}_{Xt}) \right] + (1-\gamma) \left[(1-\varrho)\widehat{C}_t + \varrho(\widehat{N}_{et}^* + f_x\widehat{N}_{Xt}^*) + \widehat{q}_t \right]$$

where $\varrho = \frac{\delta\beta}{\theta(1-\beta)(1-\delta)}$. The terms in the first square bracket represent domestic demand for consumption and investment purposes, while the terms in the second square bracket refer to foreign demand.

3.3 Exchange rate regimes

The model is closed with the interest rate rule. We consider fixed and floating exchange rate regimes. Under flexible exchange rates, monetary policy follows a symmetric Taylor rule with interest rate smoothing, $\widehat{i}_t = \phi\widehat{i}_{t-1} + \phi_\pi\pi_t^C + \phi_y\widehat{y}_t$ in the home country and $\widehat{i}_t^* = \phi\widehat{i}_{t-1}^* + \phi_\pi\pi_t^{*C} + \phi_y\widehat{y}_t^*$ in the foreign economy. The Taylor principle, $\phi_\pi > 1$, ensures determinacy (Taylor, 1993). The fixed regime is a unilateral (hard) peg to the Home currency with a fixed exchange rate at all dates. The home monetary policy is the Taylor rule described above while the foreign interest rule is $\widehat{i}_t^* = \widehat{i}_t - \varsigma\widehat{\varepsilon}_t$ with

¹⁴We refer to Cavallari and D'Addona (2015) for algebraic details.

$\varsigma > 0$. The exchange rate target (normalized to zero) ensures determinacy.

4 Numerical simulations

This section illustrates the properties of the model by means of numerical simulations. We first consider the impulse responses generated by fluctuations in productivity, and contrast the transmission mechanism at work in the model when exchange rates are fixed and when they are floating. Then, we assess the quantitative performance of the model at replicating key facts in the data.

4.1 Calibration

The Home country is calibrated on the US, while the Foreign country is an aggregate of 22 OECD economies in our sample. The parametrization reflects a quarterly frequency as is usual in business cycle studies. We set $\gamma = 0.4$ to match the degree of openness in the US economy. The parametrization of preferences is based on Bilbiie et al. (2012) for ease of comparison: the intertemporal elasticity of substitution is $\rho = 1$, the Frisch elasticity is $\varphi = 4$, the disutility of labour is normalized so that the steady state level of employment is equal to one and the elasticity of substitution across varieties is $\theta = 3.8$. The choice of θ implies a markup as high as 35 percent in steady state. Many studies suggest a higher θ and a lower markup for aggregate data. Rotemberg and Woodford (1999), for instance, document a markup of about 18 percent in US data. We have checked that using $\theta = 7.8$ so as to reproduce a steady state markup of 18 percent does not affect the qualitative properties of the model. The discount factor is $\beta = 0.99$, in line with an annual interest rate of 4%.

The rate of firm exit is $\delta = 0.025$ to match a 10 percent rate of job destruction per year in US data. The entry cost f_e and the level parameter of the distribution of export costs $f_{x \min}$ are inconsequential for the dynamics of the model and can be normalized to unity without loss of generality. The shape parameter reproduces the average standard deviation of the extensive margin in our sample, implying $\varkappa = 2.6$.¹⁵ The iceberg cost is $\tau = 0.49$ in the middle of the range of values suggested by Corsetti et al. (2013).

The degree of nominal rigidity is $\alpha = 0.59$ per year, implying an average duration of nominal contracts of about 7 months. This value is the middle point of the range of estimates found by Galì et al. (2001) for major developed countries. The degree of exchange rate pass-through is $\eta = 0.6$ to match the average degree of long-run pass-through documented by Campa and Goldberg, 2005

¹⁵The shape parameter is such that $\sqrt{\frac{\varkappa(f_{x \min})^2}{(\varkappa-1)^2(\varkappa-2)}} = 6.5$, where 6.5 is the average standard deviation of the extensive margin in our sample.

for developed economies. Under free floating, monetary policy in each country follows a Taylor rule with parameters $\phi_i = 0.8$, $\phi_y = 0$ and $\phi_\pi = 0.3$ as in Bilbiie et al. (2007). These parameters imply a long-run response to inflation equal to 1.5 and no role for output stabilization. Under fixed exchange rates, only the Home country follows the Taylor rule.

The parameters of the US productivity process, $Z_t = \rho_Z Z_{t-1} + \epsilon_{Z,t}$, are from King and Rebelo (1999) with degree of persistence $\rho_z = 0.979$ and standard deviation $\sigma_z = 0.0072$. For ease of comparison with early studies, we also allow for international spillovers and consider a cross-correlation equal to 0.025 as in Backus et al. (1992).

4.2 Impulse responses

We consider a one percent productivity rise in the home economy and simulate the model in the benchmark calibration with symmetric Taylor rules, flexible exchange rates and no technology spillovers. Figures 4, 5 and 6 report the responses of key variables. In all figures, the y-axes report percent deviations from the steady state while the x-axes display the periods (years) after the shock. Solid lines refer to home variables and dashed lines to foreign variables.

[Figure 4 about here.]

[Figure 5 about here.]

[Figure 6 about here.]

The productivity rise creates a favorable business environment that stimulates the creation of new firms. Over time, entry translates into a prolonged, U-shaped rise in the number of producers, which reaches a peak after 10 years. As long as more varieties are available in the home market, the relative price of domestic goods P_D/P_X , the “internal terms of trade”, drops and shifts demand away from imported goods. Since not all firms are able to revise the price of their products in each period, aggregate prices move sluggishly. Lower marginal costs (not shown in the figures) imply a deflationary pressure on producers’ prices in the early part of the transition. Consumer prices, on the contrary, display a temporary hike because of imported inflation and the depreciation of the home currency.

Notice that absorption (consumption plus investment in new firms) raises above output, implying a deficit in the current account of the balance of payments. Since initial financial wealth is zero, net exports drop on impact and then gradually return toward the steady state. Counter-cyclical movements of net exports as in Figure 6 are documented by ample evidence (see, among others,

Engel and Wang, 2011). The external deficit is financed by borrowing from abroad, i.e. with an increase in net foreign liabilities.

The productivity rise spread its effects abroad through changes in international prices as well as in the pattern of trade. The home terms of trade deteriorate, switching world expenditure towards home products. Traditional analysis based on the Mundell-Fleming model suggests that expenditure switching is favoured in flexible regimes, since the depreciation of the domestic currency fosters the international competitiveness of a country's products. As it will be clear soon, this may not hold in our setup with endogenous tradability. Exchange rate variability, in fact, can affect the extent to which firms relocate production across sectors. In our model, the productivity rise induces a larger share of domestic firms to export their products abroad, relocating production away from the non-tradable sector. This in turn implies a fall in the relative price of new products and previously non-traded goods, and therefore a competitive advantage for these sectors. The opposite is true in low-productivity countries (the foreign economy in the simulation), where firms relocate toward mature products and the nontraded sector.

To see the point, it is useful to contrast the dynamics of trade margins in fixed and flexible regimes. Figure 7 reports the responses of the extensive margin (number of new products and previously non-traded goods), of the intensive margin (the volume of exports per traded good), and of export markups. Solid lines now represent the responses in floating regimes while dashed lines refer to fixed exchange rates.

[Figure 7 about here.]

Qualitatively, the impact of the shock is similar in fixed and floating regimes: in the home country, the extensive margin rises above the steady state while the intensive margin falls below the steady state for most of the transition. The composition of trade therefore shifts toward new products and previously nontraded goods, reflecting the “comparative advantage” in these sectors. The productivity rise leads to an expansion in the relative supply of new goods and hence a drop in their price. Notice that the price of new products falls compared to that of mature products (the internal terms of trade in Figure 5) as well as compared to the price of imports (the terms of trade). Clearly, in low-productivity countries (the foreign country in the simulation) the composition of trade moves in the opposite direction, and foreign firms relocate production toward mature products and previously traded goods.

The exchange rate regime indeed affects the strength of these responses: the rise (fall) in the home (foreign) extensive margin is more than twice as large under fixed than under floating rates on impact and it is far less smooth over the entire horizon. Export markups, on the contrary, are

smoother when exchange rates are fixed. This suggests a strong incentive to adjust trade at the extensive margin in fixed regimes, favouring relocations of production to and from the traded sector. By contrast, flexible regimes imply an incentive to adjust trade at the intensive margin, through changes in the scale of production of the firms that operate in the traded sector.

These outcomes shed new light on the debate about exchange rate policy. The conventional argument stresses the competitive gains from currency devaluations. Competitive devaluations, however, are not viewed as viable policy recommendations because they bear risks of retaliation and currency wars. In addition, they can deteriorate the short-run trade-offs between inflation and unemployment and worsen a country's terms of trade. Our analysis stresses a dimension of comparative advantage linked to the composition of a country's output: endogenous changes in tradability may offset the competitive gains of currency devaluations and weaken the case for flexible rates. This is indeed the case for the the sectors that produce new goods and previously nontraded goods relative to sectors that produce mature products and previously traded goods.

The finding that *fixed rates* may strengthen a country's competitiveness in sectors that produce new products appears in contrast to what found by Bergin and Corsetti (2015). They show that *fixed rates* reduce the share of differentiated products in the overall exports of a country to the US, in line with the predictions of a model where all goods are traded and entry is free in the sector that produces differentiated goods. Their argument is that monetary stabilization, by reducing markup uncertainty, stimulates entry and fosters the competitiveness of firms operating in sectors that produce differentiated goods compared to firms in homogeneous goods sectors. On the contrary, constraining policy with an exchange rate peg shifts production away from differentiated goods (toward homogeneous goods) and weakens a country's comparative advantage in these sectors. We provide a complement argument, which is based on the ability of fixed exchange rates to induce relocations of production to and from the export sector.

Observing a lower share of differentiated goods in a country's exports *per se* is far from decisive. It may reflect relocations of production between homogeneous and differentiated goods sectors, but it may also reflect an increase in the share of products that are traded. In other words, we might observe a decline in the share of differentiated goods exports in fixed regimes because fixed rates favour relocations toward the traded sector and increase the overall array of products that a country exports. This is exactly the argument we suggest. Specifically, in our setup with endogenous tradability fixed exchange rates induce a larger (smaller) share of domestic producers to trade previously nontraded products in response to a rise in domestic (external) productivity. Our mechanism - which is based on relocations to and from the traded sector - is consistent with the evidence documented above that trade adjusts mainly at the extensive margin in response to productivity shocks, and more

so in fixed regimes. An important message of these contributions is that exchange rate policy can induce relocations of production across sectors. What are the sectors involved in these relocations and what are their effects for the composition of a country's exports are challenging questions for future empirical research.

4.3 Second moments

We now evaluate the quantitative performance of the model in capturing key properties in the data. Table 2 reports the statistics of selected theoretical variables, drawn from stochastic simulations of a first-order approximation of the model evaluated in the standard calibration with flexible exchange rates. The reported moments are the medians of 500 simulations, each 2100 periods long, and all variables are detrended with the HP filter and smoothing parameter 1600. The first panel refers to home variables, the second panel reports the correlation between home and foreign variables and the third panel considers trade variables. All variables that in the model are measured in variety units are multiplied by the relative price of the corresponding variety for consistence with the data (see Bilbiie et al., 2012).

[Table 2 about here.]

The model matches key facts of the business cycle. The volatility and persistence of consumption, labor and investments are close to the data. Notice that investments in our setup represent the creation of new businesses and do not entail adjustment costs.¹⁶ The comovements with output are plausible, although the correlation of consumption is much higher than in the data. An excessively procyclical consumption is a common outcome in dynamics macroeconomic models, reflecting a strong incentive to smooth consumption over time.

The model captures also important aspects of the international business cycle. Output and consumption are positively correlated across countries, although the correlation of consumption is high compared to the data.¹⁷ Once again this is a consequence of a strong incentive to smooth out consumption fluctuations. Notice that international bond trade provides a useful means for smoothing consumption: the home country runs a current account deficit and home consumers borrow from abroad to finance a rise in imports well above the rise in exports (imports are more procyclical than exports). Net exports are countercyclical as in the data (see, among others, Engel

¹⁶Investments and entry variables behave similarly in the data (Chatterjee and Cooper, 1993). For a recent assessment of the cyclical properties of business formation see Cavallari (2015).

¹⁷Backus et al. (1992) find cross-correlations of output and consumption between US and Europe are, respectively, 0,66 and 0,51. In a large sample of developed economies, Ambler et al. (2004) document even smaller cross-country comovements.

and Wang, 2011). The model is less successful in capturing the comovements of investments. These reflect the incentive to create new businesses where the returns of starting up a new firm are higher, and behave similarly to investments in a standard real business cycle model.

Interestingly, the model matches key features of trade margins found in the data. Using US trade data on more than 10.000 products and 99 trading partners, Naknoi (2015) documents the business cycle properties of the extensive margin of exports to the US (corresponding to the variable N_X^* in the model), the extensive margin of imports from the US (the variable N_X in the model) and the intensive margins of exports and imports (the variables y_X and y_X^* defined in the Appendix). She concludes that reasonable models of trade dynamics should yield the following properties: i) The extensive margin of exports and the extensive margin of imports are more volatile than output; ii) the extensive margin of exports is negatively correlated with the intensive margin of exports; iii) The extensive margin of exports is procyclical (relative to output in the exporting country). Our model is able to match all these facts. The correlation between the extensive and the intensive margin of exports (not shown in the Table) is -0.53.

We now provide some statistics that help clarify the role of the exchange rate regime in our model. Table 3 reports standard deviations and correlations with output under fixed and floating exchange rates. In the first column, the monetary authorities in both countries follow symmetric Taylor rules and exchange rates are flexible, in the second column the home country follows the Taylor rule and the foreign country adopts an exchange rate peg.

[Table 3 about here.]

Three facts stand out. First, the volatility of output and its components is higher in fixed regimes both in absolute and relative terms (except for consumption which is smoother in fixed regimes). The stabilization properties of flexible rates are by no means new, what is surprising is the magnitude of the effect. Constraining monetary policy with a peg more than doubles the standard deviation of output compared to a situation where monetary policy can actively contrast the shocks. Second, exports are more volatile under fixed rates: the standard deviation of the extensive margin of exports to and from the home country increases by, respectively, 41 and 42 percent compared to floating regimes, while that of the intensive margin increases by, respectively, by 46 and 47 percent.¹⁸ Third, export markups are smoother under fixed regimes.

These facts suggest that monetary policy matters for entry dynamics and the composition of trade. An unconstrained policy with flexible exchange rates helps stabilize the prospective revenues

¹⁸In a sample of European data, Auray et al. (2012) document a rise in the extensive margin of exports of intra-EMU trade as large as 21 percent after the European monetary unification.

of startup investments and reduce their volatility. It also mitigates production relocations to and from the export sectors. How these relocation mechanisms affect the competitiveness of a country's exports are left to future research.

5 Conclusions

This paper has addressed the role of exchange rate variability for the composition of trade between new and mature products from both a theoretical and an empirical perspective.

In the empirical part, we consider bilateral exports at the intensive and at the extensive margin among 22 OECD economies over the period from 1988 to 2011. Drawing on a panel VAR model with exogenous factors, we document that a rise in external productivity shifts trade away from new products and previously non-traded goods, and more so in fixed regimes.

Then, we propose a DSGE model with firm dynamics in line with this evidence. The model is characterized by the endogenous determination of the number of products and the endogenous selection of the share of products that will be exported. Simulations show that a rise in domestic productivity induces the creation of new products in the home market and leads a higher share of domestic firms to export their products abroad. In the partner economy, on the contrary, the variety of foreign products declines and a lower share of foreign firms become exporters. Therefore trade relocates toward new products and previously non-traded goods in high-productivity countries, and toward mature products and previously traded goods in low-productivity countries. These effects are particularly strong in fixed regimes.

Our analysis has relevant implications for exchange rate policy. In particular, we stress that exchange rate variability, by affecting entry dynamics in export markets, can affect a country's competitiveness well beyond the short run. In our model, *fixed exchange rates* foster the competitiveness of firms that trade new products and previously non-traded goods. The relocation mechanisms at work in the model provide challenging questions for empirical research, and suggest rethinking the way we look at the trade effects of exchange rate variability. A testable implication of our model, which we leave to future research, is that exchange rate variability should have a negative impact on trade of new products, especially in high-productivity economies. It should have, on the contrary, a positive effect on trade of mature products, and the more so for low-productivity economies.

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Appendix A

A.1 The complete model

A.1.1 Households

Lifetime utility of the representative home household is:

$$\Omega_t = E_t \left[\sum_{s=t}^{\infty} \beta^{s-t} \left(\frac{(C_t)^{1-\rho}}{1-\rho} - \frac{\varphi\chi}{1+\varphi} (L_t)^{\frac{1+\varphi}{\varphi}} \right) \right] \quad (12)$$

and the consumption bundle comprises domestic and imported goods $C = (C_D)^\gamma (C_X)^{1-\gamma}$, with:

$$\begin{aligned} C_D &= \left[\int_0^N C(h)^{\frac{\theta-1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}} \\ C_X &= \left[\int_0^{N_X^*} C(f)^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}} \end{aligned} \quad (13)$$

and $\theta > 1$. The corresponding consumer price index is $P = (P_D)^\gamma (P_X)^{1-\gamma}$ while the indexes for producer and imported prices are:

$$\begin{aligned} P_D &= \left[\int_0^N p(h)^{1-\theta} dh \right]^{\frac{1}{1-\theta}} \\ P_X &= \left[\int_0^{N_X^*} p(f)^{1-\theta} df \right]^{\frac{1}{1-\theta}} \end{aligned} \quad (14)$$

and $p(h)$ and $p(f)$ denote the home-currency price of, respectively, domestic and foreign products (similarly, $p^*(f)$ and $p^*(h)$ are foreign-currency prices). Exports prices are $p_t(f) = \varepsilon_t^\eta (1 + \tau) p_t^*(f)$ and $p_t^*(h) = \varepsilon_t^{-\eta} (1 + \tau) p_t(h)$.

The household budget constraint is:

$$\frac{B_t}{P_t} + \frac{\varepsilon_t B_t^*}{P_t} + s_t (N_t + N_{e,t}) v_t = \frac{B_{t-1}}{P_t} i_{t-1} + \frac{\varepsilon_t B_{t-1}^*}{P_t} i_{t-1}^* + s_{t-1} N_t (v_t + d_t) + \frac{W_t}{P_t} L_t - C_t \quad (15)$$

where s_t is the share of a mutual fund of domestic firms including incumbent firms, N_t , and entrants, $N_{e,t}$. Note that only $(1 - \delta) (N_t + N_{e,t})$ of these firms will survive and pay dividend at the end of the period, but since households do not know which firm will survive, they finance all of them during period t .

Consumer' first order conditions are:

$$\beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{i_t}{(1 + \pi_{t+1}^C)} \right] = 1 \quad (16)$$

$$E_t \left[\frac{C_{t+1}^{-\rho}}{(1 + \pi_{t+1})} \left(i_t - \frac{\varepsilon_{t+1} i_t^*}{\varepsilon_t} \right) \right] = 0 \quad (17)$$

$$(C_t)^{-\rho} = \beta (1 - \delta) E_t \left[\frac{d_{t+1} + v_{t+1}}{v_t} (C_{t+1})^{-\rho} \right] \quad (18)$$

$$\frac{W_t}{P_t} = \chi (L_t)^{\frac{1}{\varphi}} (C_t)^\rho \quad (19)$$

Combining the bond Euler equation for Home households (17) with the equivalent condition for Foreign households and using the uncovered interest parity $E_t(\varepsilon_{t+1}/\varepsilon_t) = (i_t)/(i_t^*)$ yields the risk-sharing condition:

$$\left(\frac{C_t}{C_t^*} \right)^\rho = q_t$$

Notice that the purchasing power parity, PPP, does not hold in our setup. PPP would require no export costs, $\tau = 0$ and $\eta = 1$. In these conditions, all firms will export and all goods will be traded, $N_t = N_{X,t}$ and $N_t^* = N_{X,t}^*$, and $q_t = 1$ in all periods.

Intra-temporal substitution implies the following demands:

$$\begin{aligned} C_{D,t}(h) &= \rho_{D,t}(h)^{-\theta} \gamma \left(\frac{P_{D,t}}{P_{X,t}} \right)^{\gamma-1} C_t \\ C_{X,t}(f) &= \rho_{X,t}(f)^{-\theta} (1 - \gamma) \left(\frac{P_{D,t}}{P_{X,t}} \right)^\gamma C_t \end{aligned} \quad (20)$$

where $\rho_{D,t}(h) = \frac{p_t(h)}{P_{D,t}}$, $\rho_{X,t} = \frac{p_t(f)}{P_{X,t}}$, and the price $\frac{P_{D,t}}{P_{X,t}}$ represents the “internal terms of trade”.

A.1.2 Firms

Firms face a linear technology in the labor factor:

$$y_t(h) = Z_t L_t(h) \quad (21)$$

where Z is a country-specific shock to labor productivity. All firms produce for the domestic market while only a subset of these firms serve foreign markets. We first determine the number of firms in the economy, N_t . Given N_t , we then determine the share of exporters.

Given the exogenous sunk entry cost f_e , entrants start a new firm whenever its real value ν_t , equal to the present discounted value of the expected stream of profits $\{d_s\}_{s=t+1}^\infty$ and expected capital gains, covers entry costs:

$$\nu_t = E_t \left[\sum_{s=t+1}^{\infty} \beta (1 - \delta) \left(\frac{C_{s+1}}{C_s} \right)^{-\rho} (d_s + \nu_s) \right] = f_e \quad (22)$$

The timing of entry and the one-period production lag imply the usual law of motion for producers:

$$N_t = (1 - \delta) (N_{t-1} + N_{e,t-1}) \quad (23)$$

We can now determine the subset of firms that export their products abroad, $N_{X,t}$. Access to foreign markets is subject to a period, firm-specific trade cost $f_{x,t}(h)$ which is drawn from a Pareto distribution with cumulative density function $\Gamma = 1 - \left(\frac{f_{x,t}}{f_{x \min}} \right)^{-\varkappa}$. The cut-off exporting firm, i.e. the last firm with export costs low enough to earn profits, is determined by the zero-profit condition:

$$\bar{d}_{X,t}(h) = \left(\frac{\varepsilon p_t^*(h)}{P_t} - \frac{W_t(1 + \tau)}{P_t Z_t} \right) y_{X,t}^*(h) = f_{x,t}(h) \quad (24)$$

where $y_{X,t}^*(h)$ is foreign demand for good h . The share of exporters is therefore given by:

$$\frac{N_{X,t}}{N_t} = \left[1 - \left(\frac{\bar{d}_{X,t}}{f_{x \min}} \right)^{-\varkappa} \right] \quad (25)$$

The share of exporters is an increasing function of the profit threshold $\bar{d}_{X,t}$: all firms with profits higher than the threshold will serve foreign markets. For the property of the Pareto distribution, a small fraction of firms operating in domestic markets will decide to export after a large rise in export profits (or a large fall in export costs).

A.1.3 Price setting

Firms are monopolistic competitors.

A firm h faces the following demand in the domestic market:

$$y_D(h) = (\rho_{D,t}(h))^{-\theta} \gamma \left(\frac{P_{D,t}}{P_{X,t}} \right)^{\gamma-1} (C_t + f_e N_{e,t} + f_{x,t} N_{X,t}) \quad (26)$$

and in the foreign market:

$$y_X(h) = (\rho_{X,t}^*(h))^{-\theta} (1 - \gamma) \left(\frac{P_{D,t}^*}{P_{X,t}^*} \right)^{\gamma} (C_t^* + f_e^* N_{e,t}^* + f_{x,t}^* N_{X,t}^*) \quad (27)$$

She will set the price for its product so as to maximize the present discounted value of future profits, taking into account market demand (26) and (27) as well as the probability that she might not be able to change the price in the future. Optimal pricing gives:

$$p_t(h) = \frac{\theta}{\theta - 1} \frac{E_t \sum_{k=0}^{\infty} (\alpha\beta(1-\delta))^k \frac{W_{t+k} y_{t+k}(h)}{Z_{t+k} P_{t+k} C_{t+k}^{-\rho}}}{E_t \sum_{k=0}^{\infty} (\alpha\beta(1-\delta))^k \frac{y_{t+k}(h)}{P_{t+k} C_{t+k}^{-\rho}}} \quad (28)$$

where $y_{t+k}(h) = y_{D,t+k}(h) + y_{X,t+k}(h)$.

With $\alpha = 0$ optimal pricing implies a constant markup $\frac{\theta}{\theta-1}$ on marginal costs, while time-varying markups emerge when prices are sticky. The producer price index is given by:

$$(P_{D,t})^{1-\theta} = \alpha \frac{N_t}{N_{t-1}} (P_{D,t-1})^{1-\theta} + (1-\alpha) N_t (p_t(h))^{1-\theta} \quad (29)$$

Notice that an increase in the number of producers reduces aggregate prices because of love for variety: more varieties imply a higher value of consumption per unit of expenditure and hence lower producer prices.

Similarly, the price index for imported goods is:

$$(P_{X,t})^{1-\theta} = \alpha \frac{N_{X,t}^*}{N_{X,t-1}^*} (P_{X,t-1})^{1-\theta} + (1-\alpha) N_{X,t}^* (p_t(f))^{1-\theta}$$

A.1.4 Equilibrium and aggregate accounting

Assuming symmetry in asset holdings in each economy (so that, $s_t = s_{t-1}$ and $s_t^* = s_{t-1}^*$), and defining home GDP as $Y_t \equiv \int_0^{N_t} \rho_{D,t}(h) y_t(h) dh$ and foreign GDP as $Y_t^* \equiv \int_0^{N_t^*} \rho_{D,t}^*(f) y_t(f) df$, a competitive equilibrium is defined as a sequence of quantities:

$$\{Q_t\}_{t=0}^{\infty} = \{Y_t, Y_t^*, C_t, C_t^*, L_t, L_t^*, N_{e,t}, N_{e,t}^*, N_t, N_t^*, N_{X,t}, N_{X,t}^*, d_t, d_t^*, d_{X,t}, d_{X,t}^*, B_t, B_t^*, B_{*t}, B_{*t}^*\}_{t=0}^{\infty}$$

where B_{*t}, B_{*t}^* denote foreign holdings of home and foreign bonds, respectively, and a sequence of prices:

$$\{P_t\}_{t=0}^{\infty} = \left\{ \rho_{D,t}(h), \rho_{D,t}^*(f), \rho_{X,t}(h), \rho_{X,t}^*(f), \frac{W_t}{P_t}, \frac{W_t^*}{P_t^*}, \frac{P_{D,t}}{P_{X,t}}, \frac{P_{D,t}^*}{P_{X,t}^*}, \nu_t, \nu_t^*, q_t, T o T_t \right\}_{t=0}^{\infty}$$

such that, for a given sequence of shocks $\{Z_t, Z_t^*\}_{t=0}^{\infty}$, and conditional on given monetary policies in the two economies:

- 1) for a given $\{P_t\}_{t=0}^{\infty}$, the sequence $\{Q_t\}_{t=0}^{\infty}$ satisfies first order conditions of domestic and foreign households and maximizes domestic and foreign firms' dividends;
- 2) for a given $\{Q_t\}_{t=0}^{\infty}$, the sequence $\{P_t\}_{t=0}^{\infty}$ guarantees the equilibrium of goods markets:

$$\begin{aligned}
Y_t &= \gamma \left(\frac{P_{D,t}}{P_{X,t}} \right)^{\gamma-1} (C_t + N_{e,t}f_{e,t} + N_{x,t}f_{x,t}) + \left(\frac{P_{D,t}^*}{P_{X,t}^*} \right)^{\gamma} (1 - \gamma) (C_t^* + f_{e,t}^*N_{e,t}^* + f_{x,t}^*N_{x,t}^*) \quad (30) \\
Y_t^* &= \gamma \left(\frac{P_{D,t}^*}{P_{X,t}^*} \right)^{\gamma-1} (C_t^* + N_{e,t}^*f_{e,t}^* + N_{x,t}^*f_{x,t}^*) + \left(\frac{P_{D,t}}{P_{X,t}} \right)^{\gamma} (1 - \gamma) (C_t + N_{e,t}f_{e,t} + N_{x,t}f_{x,t})
\end{aligned}$$

the equilibrium of labor markets:

$$\begin{aligned}
L_t &\geq \int_0^{N_t} \frac{y_t(h)}{Z_t} dh \\
L_t^* &\geq \int_0^{N_t^*} \frac{y_t(f)}{Z_t^*} df
\end{aligned} \quad (31)$$

and the equilibrium of financial markets:

$$\begin{aligned}
B_t + B_{*,t} &= 0 \\
B_t^* + B_{*,t}^* &= 0
\end{aligned}$$

Aggregating the budget constraint across households and assuming zero initial financial wealth in both economies, the accounting equations read:

$$\begin{aligned}
Y_t - C_t - N_{e,t}v_t &= \frac{B_t - \varepsilon_t B_t^*}{P_t} \\
Y_t^* - C_t^* - N_{e,t}^*v_t^* &= -\frac{B_t - \varepsilon_t B_t^*}{\varepsilon_t P_t^*}
\end{aligned} \quad (32)$$

where the RHS is the net foreign asset position.

A.2 Steady state

The model is solved in log-deviation from a symmetric steady state where all shocks are muted and inflation is zero. For reasons of determinacy, we solve the steady state under the assumption of

an exogenously given share of exporters equal to $\psi = 0.2$. It is immediate to verify that symmetry implies $q = \varepsilon = T o T = 1$. The steady state number of firms is obtained from:

$$\frac{(1 - \beta(1 - \delta))\theta N}{\beta(1 - \delta)} = \left(\frac{\theta}{(\theta - 1)}\right)^{\frac{1}{\varphi}} \left(\frac{\psi^{\frac{1}{\theta-1}}}{1 + \tau}\right)^{2\varphi(1-\gamma)} N^{\frac{\varphi-\theta}{\theta-1} - \varphi\rho} \left(\frac{\theta(1 - \beta(1 - \delta)) - \delta\beta}{\beta(1 - \delta)}\right)^{-\varphi\rho}$$

Other variables are given by:

$$\begin{aligned} i &= \frac{1 - \beta}{\beta}, & \frac{P_D}{P_X} &= \frac{\psi^{\frac{1}{\theta-1}}}{1 + \tau}, & v &= 1, & d &= \frac{(1 - \beta(1 - \delta))}{\beta(1 - \delta)}, & \mu &= \frac{\theta}{(\theta - 1)}, & \rho_D &= N^{\frac{1}{\theta-1}} \\ \rho_X &= N_X^{\frac{1}{\theta-1}}, & C &= \theta N \left[\frac{1 - \beta(1 - \delta)}{\beta(1 - \delta)} - \frac{\delta}{\theta(1 - \delta)} \right], & L &= \theta d N^{\frac{2-\theta}{1-\theta}}, & Y &= \theta d N, & N_e &= \frac{\delta}{(1 - \delta)} N \end{aligned}$$

A.3 Loglinear model

Loglinearized conditions for households are:

$$\begin{aligned} E_t \widehat{C}_{t+1} &= \widehat{C}_t + \frac{1}{\rho} \left(\widehat{i}_t - E_t \pi_{t+1}^C \right) \\ E_t \widehat{C}_{t+1}^* &= \widehat{C}_t^* + \frac{1}{\rho} \left(\widehat{i}_t^* - E_t \pi_{t+1}^{*C} \right) \\ E_t \widehat{C}_{t+1} &= \widehat{C}_t + \widehat{v}_t + \frac{1}{\rho} E_t \left(\frac{i + \delta}{1 + i} d_{t+1} + \frac{1 - \delta}{1 + i} \widehat{v}_{t+1} \right) \\ E_t \widehat{C}_{t+1}^* &= \widehat{C}_t^* + \widehat{v}_t^* + \frac{1}{\rho} E_t \left(\frac{i + \delta}{1 + i} d_{t+1}^* + \frac{1 - \delta}{1 + i} \widehat{v}_{t+1}^* \right) \\ \widehat{L}_t &= -\rho\varphi \widehat{C}_t + \varphi \left(\widehat{W}_t - \pi_t^C \right) \\ \widehat{L}_t^* &= -\rho\varphi \widehat{C}_t^* + \varphi \left(\widehat{W}_t^* - \pi_t^{*C} \right) \end{aligned}$$

Loglinearized conditions for firms are:

$$\begin{aligned}
\widehat{N}_t &= (1 - \delta) \widehat{N}_{t-1} + \delta \widehat{N}_{e,t-1} \\
\widehat{N}_t^* &= (1 - \delta) \widehat{N}_{t-1}^* + \delta \widehat{N}_{e,t-1}^* \\
\widehat{N}_{X,t} &= \widehat{N}_t + \varkappa (\widehat{\mu}_{X,t} + \gamma(\pi_t^{D*} - \pi_t^{X*})) \\
\widehat{N}_{X,t}^* &= \widehat{N}_t^* + \varkappa (\widehat{\mu}_{X,t}^* + \gamma(\pi_t^D - \pi_t^X)) \\
\widehat{\mu}_t &= \alpha\beta(1 - \delta) (\widehat{\rho}_{Dt+1} - \widehat{\rho}_{Dt} + E_t\pi_{t+1}^D) \\
\widehat{\mu}_t^* &= \alpha\beta(1 - \delta) (\widehat{\rho}_{Dt+1}^* - \widehat{\rho}_{Dt}^* + E_t\pi_{t+1}^{*D}) \\
\widehat{\mu}_{X,t} &= \alpha\beta(1 - \delta) (\widehat{\rho}_{Xt+1}^* - \widehat{\rho}_{Xt}^* + E_t\pi_{t+1}^{*X}) \\
\widehat{\mu}_{X,t}^* &= \alpha\beta(1 - \delta) (E_t\widehat{\rho}_{Xt+1} - \widehat{\rho}_{Xt} + E_t\pi_{t+1}^X) \\
\pi_t^D &= \frac{(1 - \alpha\beta(1 - \delta))(1 - \alpha)}{\alpha} (\widehat{W}_t - Z_t) + \beta(1 - \delta) E_t\pi_{t+1}^D + \\
&\quad \frac{\beta(1 - \delta)}{\theta - 1} E_t\widehat{N}_{t+1} - \frac{1 + \alpha\beta(1 - \delta)}{\theta - 1} \widehat{N}_t + \frac{1}{\theta - 1} \widehat{N}_{t-1} \\
\pi_t^{*D} &= \frac{(1 - \alpha\beta(1 - \delta))(1 - \alpha)}{\alpha} (\widehat{W}_t^* - Z_t^*) + \beta(1 - \delta) E_t\pi_{t+1}^{*D} + \\
&\quad \frac{\beta(1 - \delta)}{\theta - 1} E_t\widehat{N}_{t+1}^* - \frac{1 + \alpha\beta(1 - \delta)}{\theta - 1} \widehat{N}_t^* + \frac{1}{\theta - 1} \widehat{N}_{t-1}^*
\end{aligned}$$

Other log-linear equilibrium conditions are:

$$\begin{aligned}
\widehat{\rho}_{Dt} &= \frac{\alpha}{1-\alpha} \pi_t^D + \frac{1}{(1-\alpha)(\theta-1)} \widehat{N}_t - \frac{\alpha}{(1-\alpha)(\theta-1)} \widehat{N} \\
\widehat{\rho}_{Dt}^* &= \frac{\alpha}{1-\alpha} \pi_t^{*D} + \frac{1}{(1-\alpha)(\theta-1)} \widehat{N}_t^* - \frac{\alpha}{(1-\alpha)(\theta-1)} \widehat{N}_{t-1}^* \\
\widehat{\rho}_{Xt} &= \frac{\alpha}{1-\alpha} \pi_t^X + \frac{1}{(1-\alpha)(\theta-1)} \widehat{N}_{X,t}^* - \frac{\alpha}{(1-\alpha)(\theta-1)} \widehat{N}_{X,t-1}^* \\
\widehat{\rho}_{Xt}^* &= \frac{\alpha}{1-\alpha} \pi_t^{*X} + \frac{1}{(1-\alpha)(\theta-1)} \widehat{N}_{X,t} - \frac{\alpha}{(1-\alpha)(\theta-1)} \widehat{N}_{X,t-1} \\
\pi_t^X &= \eta \widehat{\varepsilon}_t + \frac{1}{\theta-1} \left(\widehat{N}_{Xt}^* - \widehat{N}_{Xt-1}^* \right) + \pi_t^{*D} \\
\pi_t^{*X} &= -\eta \widehat{\varepsilon}_t + \frac{1}{\theta-1} \left(\widehat{N}_{Xt} - \widehat{N}_{Xt-1} \right) + \pi_t^D \\
\pi_t^C &= \gamma \pi_t^D + (1-\gamma) \pi_t^X \\
\pi_t^{*C} &= \gamma \pi_t^{*D} + (1-\gamma) \pi_t^{*X} \\
\widehat{Y}_t &= \gamma \left[(1-\varrho) \widehat{C}_t + \varrho (\widehat{N}_{e,t} + f_x \widehat{N}_{X,t}) \right] + (1-\gamma) \left[(1-\varrho) \widehat{C}_t + \varrho \left(\widehat{N}_{e,t}^* + f_x \widehat{N}_{X,t}^* \right) + \widehat{q}_t \right] \\
\widehat{Y}_t^* &= \gamma \left[(1-\varrho) \widehat{C}_t^* + \varrho (\widehat{N}_{e,t}^* + f_x \widehat{N}_{X,t}^*) \right] + (1-\gamma) \left[(1-\varrho) \widehat{C}_t^* + \varrho \left(\widehat{N}_{e,t} + f_x \widehat{N}_{X,t} \right) - \widehat{q}_t \right] \\
\widehat{N}_{e,t} &= \frac{\theta(1-\beta(1-\delta))}{\beta\delta} \widehat{Y}_t + \left(1 - \frac{\theta(1-\beta(1-\delta))}{\beta\delta} \right) \widehat{C}_t - \widehat{v}_t - \frac{(1-\delta)}{\delta} \widehat{nfa}_t \\
\widehat{N}_{e,t}^* &= \frac{\theta(1-\beta(1-\delta))}{\beta\delta} \widehat{Y}_t^* + \left(1 - \frac{\theta(1-\beta(1-\delta))}{\beta\delta} \right) \widehat{C}_t^* - \widehat{v}_t^* + \frac{(1-\delta)}{\delta} \widehat{nfa}_t \\
\widehat{nfa}_t &= \widehat{Y}_t - \left(1 - \frac{\beta\delta(1-\delta)}{\theta(1-\beta(1-\delta))} \right) \widehat{C}_t - \frac{\beta\delta(1-\delta)}{\theta(1-\beta(1-\delta))} \widehat{N}_{e,t} - \pi_t^C \\
E_t \Delta \widehat{\varepsilon}_{t+1} &= \widehat{i}_t - \widehat{i}_t^* \\
\widehat{v}_t &= \widehat{v}_t^* = 0 \\
\widehat{q}_t &= \rho \left(\widehat{C}_t - \widehat{C}_t^* \right) \\
\widehat{q}_t &= \widehat{q}_{t-1} + \widehat{\varepsilon}_t - \widehat{\varepsilon}_{t-1} + \pi_t^{*C} - \pi_t^C \\
\widehat{ToT}_t &= \Delta \widehat{\varepsilon}_t + \pi_t^{*X} - \pi_t^X
\end{aligned}$$

The model is closed with the interest rate rules indicated in the text.

Appendix B

B.1 Data

[Table 4 about here.]

B.2 Peggers and floaters

[Table 5 about here.]

Figure 1: Extensive margins

Mean responses of extensive margins to external shocks in fixed regimes (top row) and in flexible regimes (bottom row).

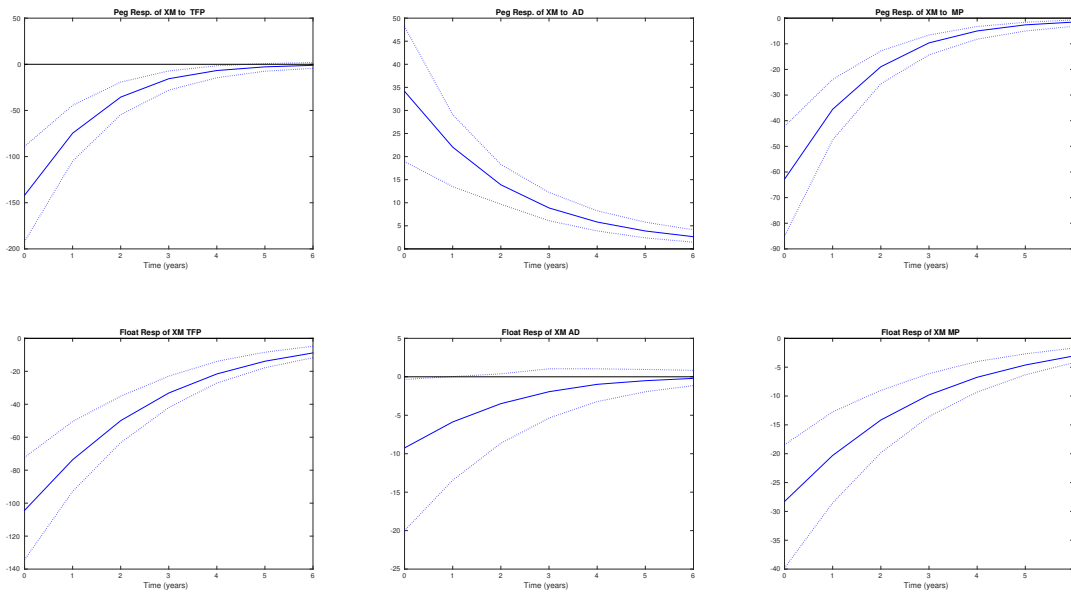


Figure 2: Intensive margins

Mean responses of intensive margins to external shocks in fixed regimes (top row) and in flexible regimes (bottom row).

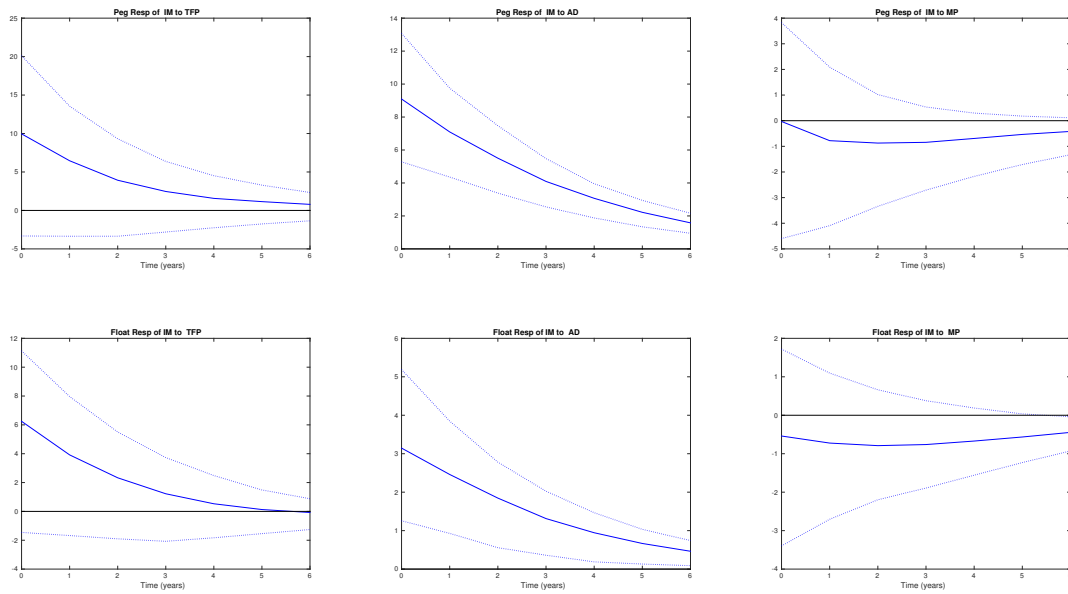


Figure 3:

Differences of responses in the sample of peggers and in the sample of floaters.

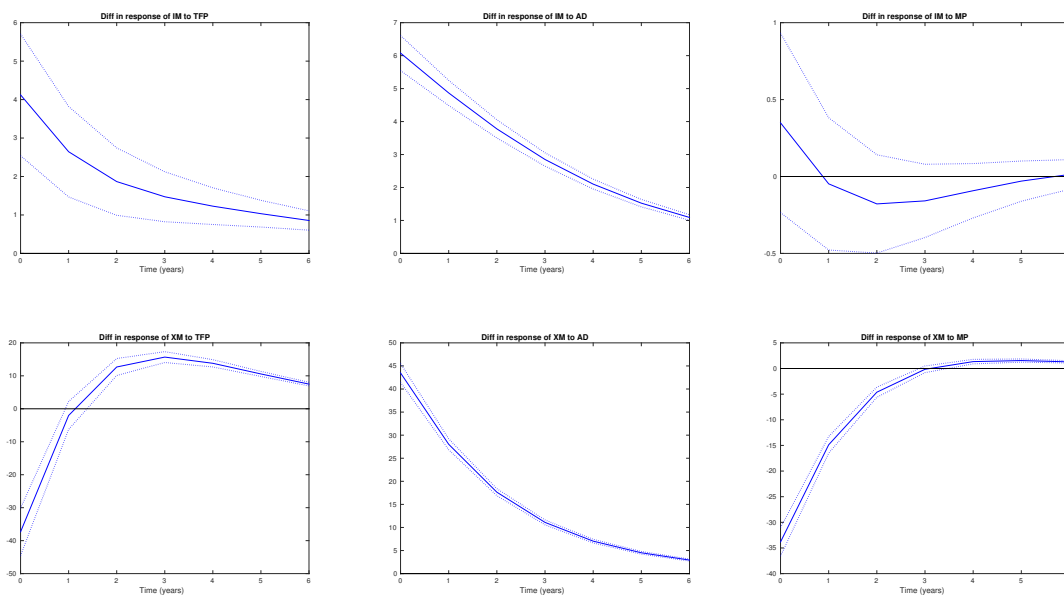


Figure 4:

IRF to a 1% rise in home productivity. Solid (dashed) lines refer to home (foreign) variables.

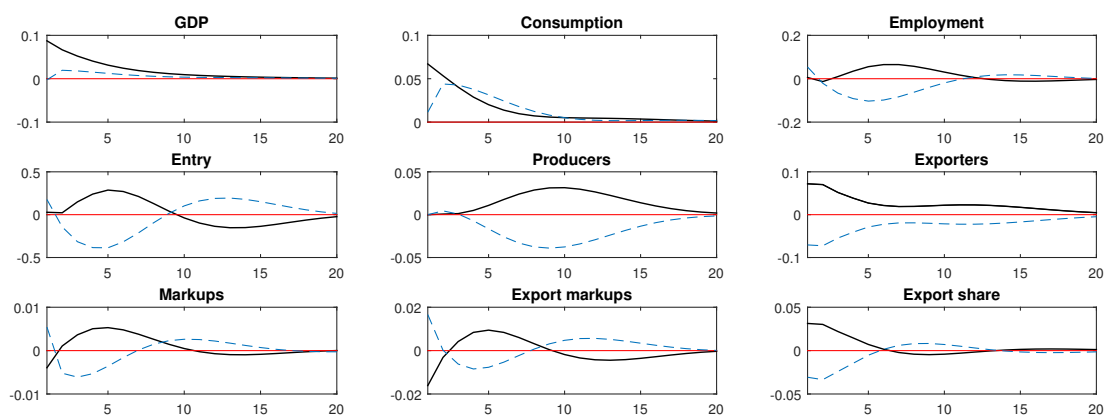


Figure 5:

IRF to a 1% rise in home productivity. Solid (dashed) lines refer to home (foreign) variables.

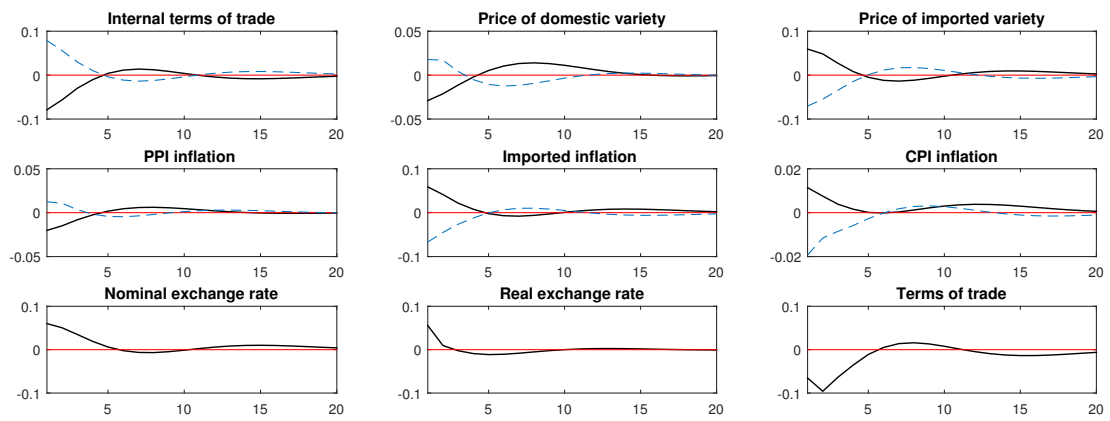


Figure 6:

IRF to a 1% rise in home productivity. Solid (dashed) lines refer to home (foreign) variables.

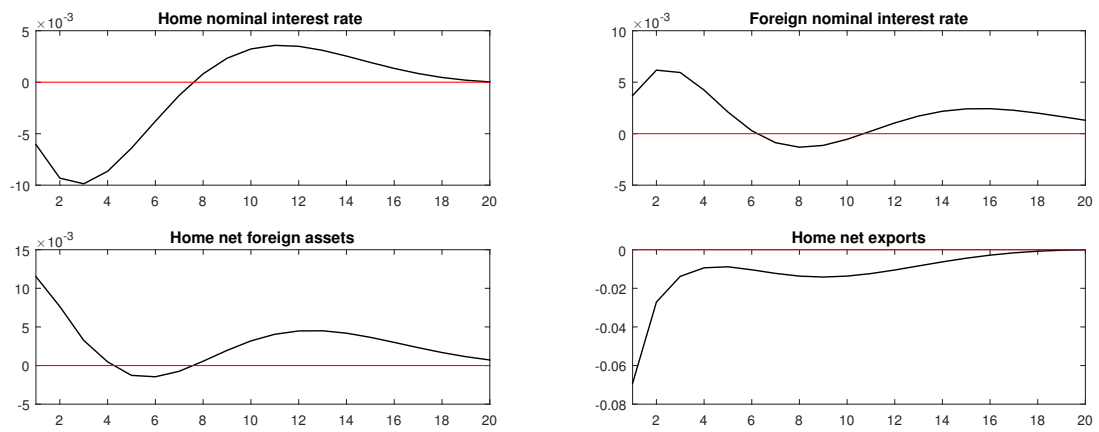


Figure 7:

IRF to a 1% rise in home productivity in flexible regimes (solid lines) and in fixed regimes (dashed lines).

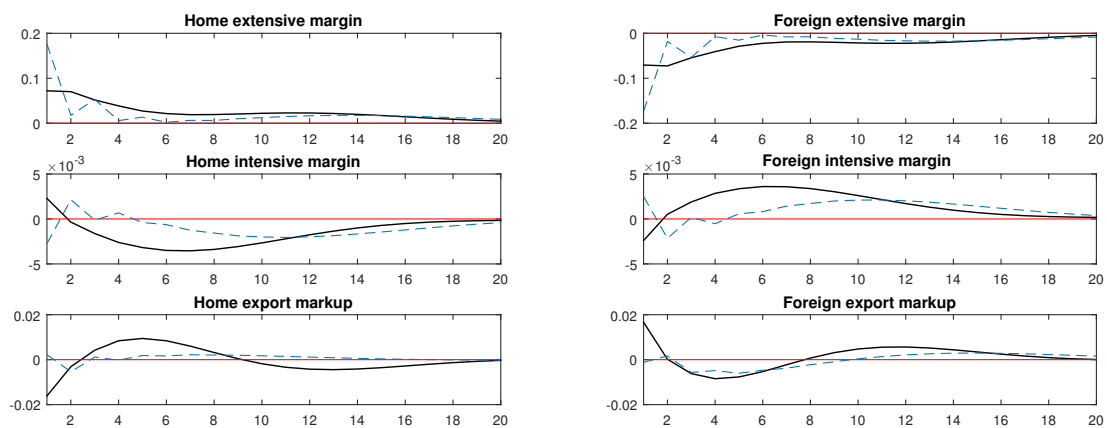


Table 1: Sign and long-run restrictions

5 year/Long Run response of vbl. in column to a positive shock					
	productivity	GDP	inflation	energy price	FFR
TFP shock	+	+	-	-	no restr
AD shock	0	+	+	+	no restr
FFR shock	0	0	-	no restr	no restr

Table 2: Business cycle

A. home variables			
	stand. dev. (ratio to Y)	corr. with Y	auto-correlation
C	0.92	0.95	0.73
L	1.46	0.46	0.71
νN_e	4.05	0.59	0.88
B. cross-correlation of home and foreign variables			
	Y and Y^*	C and C^*	νN_e and νN_e^*
	0.42	0.97	-0.98
C. Trade variables			
N_X	1.26	0.52	0.67
N_X^*	1.28	-0.53	0.67
<i>Net exports</i>	0.52	-0.51	0.73

Table 3: Fixed and flexible regimes

	standard deviation		rel. stand. dev.		correlation with Y	
	Float	Peg	Float	Peg	Float	Peg
Y	0.81	1.74	1	1	1	1
C	0.75	1.03	0.92	0.59	0.95	0.88
L	1.18	3.34	1.46	1.92	0.46	-0.66
νN_e	3.28	9.42	4.05	5.41	0.59	-0.62
N_X	1.26	2.18	1.56	1.25	0.52	0.90
N_X^*	1.28	2.30	1.58	1.26	-0.53	-0.90
y_X	1.91	3.57	2.35	2.05	0.33	-0.81
y_X^*	1.35	2.55	1.67	1.47	0.82	0.47
μ_X	0.15	0.19	0.19	0.11	0.19	-0.83
μ_X^*	0.36	0.29	0.44	0.17	-0.21	0.57

Table 4: Data

Original series	Source	Data transformation
Peggery and Floaters Nominal GDP	OECD.StatExtracts	log difference after deflating with the GDP Deflator
Peggery and Floaters GDP Deflator	OECD.StatExtracts	None
Peggery and Floaters Export Price index	IFS-IMF database	Used to calculate the terms of trade
Peggery and Floaters Import Price index	IFS-IMF database	Used to calculate the terms of trade
Peggery and Floaters Trade Margins	UN Comtrade database	none

Table 5: Data

Peggers	Floaters
Belgium	Australia
Denmark	Canada
Finland	Czech Republic
France	Iceland (After 2001)
Germany	Japan
Iceland Before 2001	Mexico
Italy	New Zealand
Luxembourg	Norway
Netherlands	South Korea
Portugal	Sweden
Spain	Switzerland
	United Kingdom
	United States
