

External shocks, trade margins and macroeconomic dynamics

Lilia Cavallari*

Stefano D'Addona[†]

preliminary draft

Abstract

This study addresses the role of the exchange rate regime for the pattern of trade. It first provides VAR evidence that a rise in external productivity shifts trade away from new products and previously non-traded goods, 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, by affecting entry dynamics in export markets, can strengthen a country's comparative advantage well beyond the short run. In our setup, *fixed exchange rates* can foster the competitiveness of firms that trade new products and previously non-traded goods.

Keywords: trade margins, extensive margin of exports, firm entry, international business cycle, panel VAR, DSGE model, exchange rate regime, comparative advantage.

JEL codes: E31; E32; E52

***Corresponding author.** Lilia Cavallari, University of Rome III, Department of Political Sciences, Via Chiabrera, 199, 00145 Rome, Italy, email: lilia.cavallari@uniroma3.it.

[†]Department of Political Science, University of Rome 3, Via G. Chiabrera, 199, I-00145 Rome; +39-06-5733-5331; daddona@uniroma3.it.

1 Introduction

This paper belongs to a line of research focusing on the determinants and evolution of trade patterns and their implications for the international propagation of shocks.¹ In departing from standard open economy macroeconomic models, which generally take the composition of trade and the structure of markets as given, these studies consider the impact of aggregate phenomena on foreign market access. Entry (exit) typically implies the creation (destruction) of new trade relations, namely trade of new products and previously non-traded goods. This is known as the extensive margin of trade.

It is now well-understood that trade at the extensive margin can amplify international spillovers well beyond the short-run and have important consequences for policy.² Yet, while there is abundant evidence on the role of trade volumes for the transmission of shocks worldwide, very few studies consider trade at the extensive margin.³ Moreover, the extent to which adjustments at the extensive margin affect stabilization policies is largely overlooked. This paper aims to shed some lights on both these aspects. First, it provides VAR evidence about the dynamics of average trade volumes as well as of trade of new products in the wake of external shocks, contrasting the transmission mechanism in fixed and floating exchange rate regimes. Then, it presents a model with firm dynamics that helps explain the evidence and clarify the role of the trade pattern for exchange rate policy.

We propose a panel VAR model with exogenous factors (VARX for short) in a sample of 23 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 size of the country of origin and destination of exports. The vector of exogenous refers to the United States as a proxy of the rest of the world and includes aggregate supply, real aggregate demand and monetary policy shocks. The identification strategy combines long-run and sign restrictions in accord with our theoretical model. We document that a rise in productivity in the rest of the world has a negative impact on exports of new products (the extensive margin), and more so in fixed regimes, while having only minor effects on the average volume of exports (the intensive margin). A rise in external demand, on the contrary, increases exports mostly at the intensive margin in both fixed and flexible regimes. Finally, a monetary policy contraction reduces the extensive margin of exports, especially in fixed regimes. This evidence suggests a significant role of supply side and monetary

¹Akteson and Burstein, 2004 and Ghironi and Méltiz (2005) are among the first to consider endogenous changes in the structure of trade in a fully dynamic macroeconomic model. See also Cavallari 2013, Corsetti and Bergin, 2015 and Cacciatore et al. (2015).

²For a discussion of trade liberalization policies in a context with entry see, among others Ghironi and Méltiz (2005). Recently, Cacciatore et al. (2015) discuss the implications of firms' dynamics for labour market reforms.

³Early attempts to document VAR evidence on trade margins include our previous works. In a panel of 22 OECD economies, Cavallari and D'Addona, 2015a document positive correlation between extensive-margin exports and innovations to the terms of trade, and more so in fixed regimes. Cavallari and D'Addona, 2015b find that average extensive-margin exports drop after a US monetary policy contraction.

policy conditions for trade of new products and previously non-traded goods.

Then, we develop a model with endogenous selection of exporters that reproduces the trade dynamics observed in the data. In our setup, based on Cavallari, 2013, firms produce differentiated products in monopolistic competitive markets. All products are sold in domestic markets while only a subset of these products will be exported abroad. Both the range of varieties produced for the domestic market and the range of varieties exported are determined endogenously.

Simulations show that the exchange rate regime indeed affects the pattern of trade. In order to see why, consider a rise in domestic productivity. Favorable business conditions at home lead the number of new exports above the steady state, while the average volume of exports per product drops. The opposite occurs in the partner economy. Therefore, in high-productivity countries, trade shifts toward new products and previously non-traded goods while relocations toward mature products and previously traded goods occur in low-productivity countries. A fixed exchange rate regime, by stabilizing export markups, can strengthen a country's comparative advantage in sectors that produce new products and previously non-traded goods. By contrast, flexible regimes imply a strong incentive to adjust trade at the intensive margin. They can therefore strengthen a country's international competitiveness in sectors that produce mature products and previously traded goods. We stress that the exchange rate regime affects the pattern of trade well beyond the short-run. The mean value of the extensive margin of exports is in fact 1.3 percent larger in fixed than in floating regimes. In addition, it is far more volatile in fixed regimes, as in the data (see Auray et al., 2013).

A contribution of our analysis is to clarify that exchange rate policy, by affecting entry dynamics in export markets, can strengthen a country's comparative advantage well beyond the short run. In our setup, *fixed exchange rates* can foster the competitiveness of firms that trade new products and previously non-traded goods. Bergin and Corsetti, 2015 show that *flexible rates* can foster the competitiveness of firms that produce differentiated goods, including mature and new products. How exchange rate variability affects the composition of exports and comparative advantages is a challenging question for empirical research.

The paper is organized as follows. Section 2 provides VAR evidence. Section 3 presents the model and Section 4 discusses 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, 2015b), we have focused on terms of trade shocks as a way to verify the shock

absorption properties of flexible exchange rates, namely the ability of flexible rates to hedge the economy from an exogenous change in its terms of trade. Here, we focus on a wider range of external shocks, including aggregate supply, real aggregate demand and monetary policy shocks. The scope of the analysis is descriptive.

2.1 Data

Our sample includes 23 developed countries over the period from 1988 to 2011. GDP - measured in domestic currency at constant prices and logged - is from the OECD StatExtracts database.

Export margins are from the UN Comtrade database. They are calculated with the World Integrated Trade Solution of the World Bank from bilateral trade measures at the four-digit Standard International Trade Classification.⁴ Following Hummels and Klenow (2005), the extensive margin of exports from country j to country m is defined as:

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

where $X_{m,i}^W$ is the export value from the world to country m of category i , I_m^j is the set of observable categories in which country j has positive exports to country m , and X_m^W is the aggregate value of world exports to country m . The extensive margin is a weighted sum of country j 's exported categories relative to all categories exported to country m , where categories are weighted by their importance in world's exports to country m . By construction XM_m^j is comprised between 0 and 1, with higher values reflecting a larger variety of categories exported.

The intensive margin of exports from country j to country m is defined as:

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

where X_m^j is the total export value from country j to country m . The intensive margin 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 is defined between 0 and infinity, where 0 means that country j has not previously exported to country m , and higher values reflect a larger volume of exports within previously traded goods. By definition, the country j 's share of world exports to country m is given by the product of intensive and extensive margins:

$$Sh_m^j = \frac{X_m^j}{X_m^W} = XM_m^j IM_m^j \quad (3)$$

⁴<http://wits.worldbank.org/wits/>

The measurement implies that for a given level of a country j 's share in world exports to country m , the extensive margin would be higher if country j exports many different categories of products to country m whereas the intensive margin would be higher if it only export a few categories of products to country m .

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 are measured 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 is time. They include relative GDP, bilateral extensive-margin exports and bilateral intensive-margin exports. 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:

$$Y_{j \times m, t} = \alpha_{j \times m} + \beta(L)Y_{j \times m, t-1} + \gamma(L)X_t + \varepsilon_{j \times m, t} \quad (4)$$

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; $\alpha_{j \times m}$ 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 that will be defined soon and $\varepsilon_{j \times m, t}$ is the vector of errors in the system.

Exogenous shocks are obtained from a parsimonious US model:

$$y_t = a + b(L)y_{t-1} + e_t \quad (5)$$

where y_t includes a measure of productivity, real output, consumer price inflation, energy prices and the Federal funds rate, $y_t = (\log productivity, \log GDP_t, \Delta \log CPI_t, \Delta \log Energy_t, FFR_t)$; 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 .⁵ Energy prices are included in y_t because they belong to the information set of the central bank. As is now well-understood, omitting them can cause a price puzzle, namely a counter-factual rise in inflation after a contractionary monetary policy.

Notice that although US variables may in principle be correlated with the export margins of US trading partners, by construction the structural shocks are orthogonal to any of the endogenous in

⁵The exogenous VAR model is estimated over the period 1970-2011.

the system. They can be therefore treated as exogenous in (4).

In terms of shock identification, we consider 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 on the variables of interest, as technology shocks in Galì, 2009. 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 neutrality implies that innovations to the policy rate have no long-run impact on output, either directly or through any other variable in the system. Long-run restrictions, however, may not be of much use when it comes to identifying real demand shocks. In line with the literature using sign restrictions, our identification strategy consists in selecting 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 straightforward intuition: demand shocks move quantities and nominal prices in the same direction while supply shocks move them in opposite directions. Hence, an increase in aggregate demand is associated with 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 the prior of persistent shocks. The long run restrictions refer to the cumulated effect of the shock over the entire horizon.

Before turning to the results, we note that the model is estimated for countries with fixed and floating rates separately. The sample of “peggers” includes country pairs with a fixed exchange rate regime, i.e. to be included among the peggers both origin and destination countries must adopt fixed exchange rates according to the IMF de facto classification (see Ghosh et al. 2010), which we extend to match our sample period. Specifically, we consider an exchange rate regime of “pegged within horizontal bands” or tighter as a fixed exchange rate (values of 1-7 in the fine classification). All remaining regimes are classified as floating exchange rates. The group of peggers comprises European country pairs and reflects intra-EMU trade. The sample of “floaters” includes pairs with a flexible exchange rate, i.e. to be included among the floaters at least one country must adopt a flexible exchange rate regime in the IMF de facto classification. Appendix B.2 contains the list of peggers and floaters. Note that for our sample the de facto classification gives an identical split as the IMF de jure classification.

Finally, we estimate the model (4) 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 consis-

tence of the least-squares dummy variable (LSDV) estimator in dynamic models with a small time dimension (Nickell (1981)).

2.3 Results

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

We document a significant impact of productivity on extensive margins. On average, the extensive margin of exports falls by 1 and 1.5 percent below the mean in, respectively, the sample of floaters and the sample of peggers. The drop reflects re-locations away from sectors that produce new products and previously non-traded goods. 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.

As for aggregate demand, both real and nominal shocks affect trade margins, although with important qualifications. An unexpected rise in external demand has a positive effect on the intensive margin of exports in all regimes. In the sample of peggers, the demand boost is accommodated also through an increase in the number of products. A monetary policy contraction has a negative impact on the range of products exported, and more so in fixed regimes. The effect on the average export volume per product is negligible in all regimes.

We assess whether the differences in the transmission mechanism across exchange rate regimes are significant by bootstrapping samples for which we compute differences 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 of extensive margins between fixed and floating regimes.

[Figure 1 about here.]

[Figure 2 about here.]

[Figure 3 about here.]

3 Theoretical model

The model draws on Cavallari (2013). The world economy comprises two countries labelled Home, H, and Foreign, F, each populated by a continuum of agents of unit mass. Countries are specialized in the production of one type of good as in Corsetti and Pesenti (2001). Households supply labor services in competitive labor markets and consume a basket of domestic and imported goods. Goods markets are monopolistic competitive. Each firm produces a specific variety $h \in (0, N)$ of the Home good and a variety $f \in (0, N^*)$ of the Foreign good. In departing from Cavallari (2013), all goods are in principle tradable, yet only a subset of these goods, N_X and N_X^* , is actually traded. The number of producers and the share of exporters are determined endogenously in the model. In our notation a star denotes a foreign variable. For ease of exposition, we will refer to Home variables with the understanding that analogue conditions hold for the Foreign economy unless otherwise specified.

3.1 Households

Lifetime utility of the representative household is:

$$\Omega_t = E_t \left[\sum_{s=t}^{\infty} \beta^{s-t} \left(\frac{(C_t)^{1-\rho}}{1-\rho} - \frac{\varphi\chi}{1+\varphi} (L_t)^{\frac{1+\varphi}{\varphi}} \right) \right] \quad (6)$$

where β is the subjective discount factor, $\rho > 0$ is inter-temporal elasticity, $\varphi > 0$ is the Frisch elasticity of labor supply and E denotes the expectation operator. The consumption bundle comprises domestic and imported products :

$$C = \frac{(C_D)^\gamma (C_X)^{1-\gamma}}{\gamma^\gamma (1-\gamma)^{1-\gamma}} \quad (7)$$

where C_D , C_X are given by:

$$\begin{aligned} C_D &= \left[\int_0^N C(h)^{\frac{\theta-1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}} \\ C_X &= \left[\int_0^{N_X^*} C(f)^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}} \end{aligned} \quad (8)$$

and $\theta > 1$ denotes the elasticity of substitution across varieties. The welfare-based consumer price index, CPI, is given by:

$$P = (P_D)^\gamma (P_X)^{1-\gamma} \quad (9)$$

where

$$\begin{aligned} P_D &= \left[\int_0^N p(h)^{1-\theta} dh \right]^{\frac{1}{(1-\theta)}} \\ P_X &= \left[\int_0^{N_X^*} p(f)^{1-\theta} df \right]^{\frac{1}{(1-\theta)}} \end{aligned} \quad (10)$$

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 entail iceberg-type transport costs so that for one unit of a good to reach the foreign market $1+\tau$ units must be shipped. In addition, we assume that firms choose the price for exports in their own currency, recognizing that the final price may vary with the exchange rate at a constant elasticity η .⁶ At each point in time, the home-currency price of foreign products is $p_t(f) = \varepsilon_t^\eta (1 + \tau) p_t^*(f)$ where the nominal exchange rate ε is the price of the foreign currency in terms of the home currency. Similarly, the foreign-currency price of home products is $p_t^*(h) = \varepsilon_t^{-\eta} (1 + \tau) p_t(h)$. The home terms of trade, defined as the price of home exports relative to home imports, are given by $ToT_t = \varepsilon_t P_{X,t}^* / P_{X,t}$. An increase in ToT_t is an appreciation.

Households enter each period with holdings of riskless bonds denominated in Home currency, B_t , and in foreign currency, B_t^* , and a share s_t of a mutual fund of domestic firms. The fund includes incumbent firms, N_t , and entrants, $N_{e,t}$. Only $(1 - \delta)(N_t + N_{e,t})$ of these firms will survive and pay dividend at the end of the period. Since households do not know which firm will be hit by the death shock δ at the end of the period, they finance all incumbents and new entrants during period t . The real value of a share in this fund is ν_t . Households receive labor income, interest income on domestic and foreign bonds at the risk-free gross nominal interest rates i_t and i_t^* , respectively, dividend income d_t on share holdings and the value of selling their initial share position. These resources are allocated between purchases of bonds and shares to be carried into next period and consumption. The budget constraint in real terms is:

$$\frac{B_t}{P_t} + \frac{\varepsilon_t B_t^*}{P_t} + s_t (N_t + N_{e,t}) \nu_t = \frac{B_{t-1}}{P_t} i_{t-1} + \frac{\varepsilon_t B_{t-1}^*}{P_t} i_{t-1}^* + s_{t-1} N_t (\nu_t + d_t) + \frac{W_t}{P_t} L_t - C_t \quad (11)$$

⁶With symmetric demand elasticity, this price strategy is optimal (Corsetti and Pesenti (2005)).

where W_t is the nominal wage.

Utility maximization with respect to C_t , B_t , B_t^* , s_t , and L_t implies the first order conditions:

$$\beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{i_t}{(1 + \pi_{t+1})} \right] = 1 \quad (12)$$

$$E_t \left[\frac{C_{t+1}^{-\rho}}{(1 + \pi_{t+1})} \left(i_t - \frac{\varepsilon_{t+1} i_t^*}{\varepsilon_t} \right) \right] = 0 \quad (13)$$

$$(C_t)^{-\rho} = \beta (1 - \delta) E_t \left[\frac{d_{t+1} + v_{t+1}}{v_t} (C_{t+1})^{-\rho} \right] \quad (14)$$

$$\frac{W_t}{P_t} = \chi (L_t)^{\frac{1}{\varphi}} (C_t)^\rho \quad (15)$$

where $\pi_t = (P_t/P_{t-1}) - 1$ is the CPI inflation rate.

As agents have access to local and foreign bonds, financial markets are perfectly integrated and the uncovered interest parity, UIP, holds, i.e. $E_t(\varepsilon_{t+1}/\varepsilon_t) = (i_t)/(i_t^*)$. Furthermore, combining the bond Euler equation for Home households (13) with the equivalent condition for Foreign households and using UIP yields the risk-sharing condition:

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

where $q_t = P_t^* \varepsilon_t / P_t$ is the real exchange rate.

In our model, purchasing power parity, PPP, would hold absent export costs and imperfect pass-through. Suppose that there are no export costs, that $\tau = 0$ and $\eta = 1$. All firms will export and there will be no non-traded goods: $N_t = N_{X,t}$ and $N_t^* = N_{X,t}^*$. It is immediate to see that $q_t = 1$ in all periods. Assuming further a given number of firms at home and abroad, so that N_t/N_t^* is constant, the model is isomorphic to Corsetti and Pesenti (2001)'s setup. In this framework, the mechanism of international transmission hinges exclusively on the terms of trade. A, say, productivity rise at home spreads its positive effects abroad through the deterioration in the home terms of trade (a fall in ToT_t). Foreign consumption increases for a given level of real income, leaving relative consumption and the real exchange rate unaffected. As it will be evident soon, in our setup the productivity rise induces re-locations toward the tradable sector at home and toward the non-tradable sector in the foreign economy. This in turn depreciates the home currency in real terms (q_t rises) and helps absorbing international consumption spillovers.

Finally, intra-temporal substitution implies the following consumption demands:

$$\begin{aligned} C_{D,t}(h) &= \rho_{D,t}(h)^{-\theta} \gamma \left(\frac{P_{D,t}}{P_{X,t}} \right)^{\gamma-1} C_t \\ C_{X,t}(f) &= \rho_{X,t}(f)^{-\theta} (1 - \gamma) \left(\frac{P_{D,t}}{P_{X,t}} \right)^{\gamma} C_t \end{aligned} \quad (16)$$

where ρ are real prices, so that, for instance, $\rho_{D,t}(h) \equiv \frac{p_t(h)}{P_{D,t}}$. For short, we dub the relative price of domestic and imported goods, $\frac{P_{D,t}}{P_{X,t}}$, the “internal terms of trade”.

3.2 Firms

Firms face a linear technology with labor as the sole factor:

$$y_t(h) = Z_t L_t(h) \quad (17)$$

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.

Prior to entry, firms face an exogenous sunk entry cost in the tradition of Grossman and Helpman (1991) and Romer (1990). Entry requires purchasing $f_{e,t}$ units of the consumption basket at the current price P_t .⁷ Other studies, as Bilbiie et al. (2012) and Cavallari (2007), specify entry costs as wages. As is now well-understood, wage costs have the unappealing consequence of implying a positive relation between firms’ entry and interest rate innovations in contrast to what found in the data.⁸ For this motive, monetary models consider entry costs in units of goods or nominal wage rigidity.

The dynamics of entry follows Ghironi and Mélicitz (2005). All firms entered in a given period are able to produce in all subsequent periods until they are hit by a death shock, which occurs with a constant probability $\delta \in (0, 1)$. Therefore, a firm entered in period t will only start producing at time $t + 1$. In each period, in addition to incumbent firms there is a finite mass of entrants, $N_{e,t}$. Entrants decide to start a new firm whenever its real value, ν_t , given by the present discounted value of the expected stream of profits $\{d_s\}_{s=t+1}^{\infty}$, covers entry costs:

$$\nu_t = E_t \left[\sum_{s=t+1}^{\infty} \beta (1 - \delta) \left(\frac{C_{s+1}}{C_s} \right)^{-\rho} d_s \right] = f_{e,t} \quad (18)$$

⁷For models where the composition of investment and consumption baskets may differ see Cavallari (2013b).

⁸Uuskula (2010) shows that a 1% increase in the Federal Funds rate rate leads to a 0.6% fall in the entry rate. See also Bergin and Corsetti (2008) and Lewis and Poilly (2012).

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

$$N_t = (1 - \delta) (N_{t-1} + N_{e,t-1}) \quad (19)$$

Given the total number of firms in the economy, we determine the subset of these firms that export their products abroad, $N_{X,t}$. Access to foreign markets is subject to a period trade cost $f_{x,t}$ denominated in units of consumption, and independent of the volume of exports.

We consider heterogeneous trade costs as in Bergin and Glick, 2009. Specifically, at the beginning of the period, before production takes place, each firm draws its own cost $f_{x,t}(h)$ from a Pareto distribution with lower bound $f_{x \min}$ and shape parameter $\varkappa > \theta - 1$. The cumulative density function is $\Gamma = 1 - \left(\frac{f_{x,t}}{f_{x \min}}\right)^{-\varkappa}$. The firm will then decide to export whenever export profits are higher than trade costs. 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:

$$\bar{d}_{X,t}(h) = \left(\frac{\varepsilon p_t^*(h)}{P_t} - \frac{W_t(1 + \tau)}{P_t Z_t} \right) y_{X,t}^*(h) = f_{x,t}(h) \quad (20)$$

The share of exporters is thus given by:

$$\frac{N_{X,t}}{N_t} = \left[1 - \left(\frac{\bar{d}_{X,t}}{f_{x \min}} \right)^{-\varkappa} \right] \quad (21)$$

The share of exporters is an increasing function of the profit threshold: 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). The number of firms producing non-traded products is $N_{N,t} = N_t - N_{X,t}$.

3.3 Price setting

Firms are monopolistic competitors. In the domestic market, a firm h faces the following demand:

$$y_D(h) = (\rho_{D,t}(h))^{-\theta} \gamma \left(\frac{P_{D,t}}{P_{X,t}} \right)^{\gamma-1} (C_t + f_{e,t} N_{e,t} + f_{x,t} N_{X,t}) \quad (22)$$

where the first addend is demand for consumption purposes and the other addends capture demand for investment purposes. Export demand is given by a similar expression:

$$y_X(h) = (\rho_{X,t}^*(h))^{-\theta} (1 - \gamma) \left(\frac{P_{D,t}^*}{P_{X,t}^*} \right)^\gamma (C_t^* + f_{e,t}^* N_{e,t}^* + f_{x,t}^* N_{X,t}^*) \quad (23)$$

We assume staggered prices à la Calvo (1983). In each period a firm can set a new price with a fixed probability $1 - \alpha$ which is the same for all firms, both incumbents and new entrants, and is independent of the time elapsed since the last price change. In every period there is thus a share α of firms whose prices are pre-determined. In a symmetric equilibrium, pre-determined prices at a given point in time coincide with the average price chosen by firms active in the previous period.⁹ The assumption that new entrants behave like incumbent firms is without loss of generality: allowing entrants to make their first price-setting decision in an optimal way would have only second order effects. It might have major consequences in a setting where firms face costs of price adjustment as it would introduce heterogeneity in price levels across cohorts of firms entered at different points in time (see Bilbiie et al., 2007). Explaining endogenous changes in nominal rigidity is behind the scope of this paper.

Each firm sets the price for its own products so as to maximize the present discounted value of future profits, taking into account demand in domestic (22) and in foreign markets (23) as well as the probability that she might not be able to change the price in the future. Optimal pricing gives:

$$p_t(h) = \frac{\theta}{\theta - 1} \frac{E_t \sum_{k=0}^{\infty} (\alpha\beta(1 - \delta))^k \frac{W_{t+k} y_{t+k}(h)}{Z_{t+k} P_{t+k} C_{t+k}^{-\rho}}}{E_t \sum_{k=0}^{\infty} (\alpha\beta(1 - \delta))^k \frac{y_{t+k}(h)}{P_{t+k} C_{t+k}^{-\rho}}} \quad (24)$$

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

Clearly, when $\alpha = 0$ optimal pricing implies a constant markup $\frac{\theta}{\theta - 1}$ on marginal costs at all dates. Otherwise, markups are time-varying. The producer price index, PPI is given by:

$$(P_{D,t})^{1-\theta} = \alpha \frac{N_t}{N_{t-1}} (P_{D,t-1})^{1-\theta} + (1 - \alpha) N_t (p_t(h))^{1-\theta} \quad (25)$$

Note that an increase in the number of producers reduces the PPI. This is a consequence of love for variety: an increase in the range of available varieties implies an increase in the value of consumption

⁹The average price for, say, domestic goods P_D is given by:

$$(P_{D,t})^{1-\theta} = \frac{(P_{D,t-1})^{1-\theta}}{N_{t-1}}$$

and similarly for other price indexes. These properties are used in deriving the Calvo state equations below.

per unit of expenditure. Producer prices must therefore fall.

Similarly, the price index for imported goods is:

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

3.4 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 GDP as $Y_t \equiv \int_0^{N_t} \rho_{D,t}(h) y_t(h) dh$ in the Home economy and $Y_t^* \equiv \int_0^{N_t^*} \rho_{D,t}^*(f) y_t(f) df$ in the Foreign economy, 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:

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

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:

$$\begin{aligned} Y_t &= \gamma \left(\frac{P_{D,t}}{P_{X,t}} \right)^{\gamma-1} (C_t + N_{e,t} f_{e,t} + N_{x,t} f_{x,t}) + \left(\frac{P_{D,t}^*}{P_{X,t}^*} \right)^\gamma (1-\gamma) (C_t^* + f_{e,t}^* N_{e,t}^* + f_{x,t}^* N_{x,t}^*) \quad (26) \\ Y_t^* &= \gamma \left(\frac{P_{D,t}^*}{P_{X,t}^*} \right)^{\gamma-1} (C_t^* + N_{e,t}^* f_{e,t}^* + N_{x,t}^* f_{x,t}^*) + \left(\frac{P_{D,t}}{P_{X,t}} \right)^\gamma (1-\gamma) (C_t + N_{e,t} f_{e,t} + N_{x,t} f_{x,t}) \end{aligned}$$

the equilibrium of labor markets:

$$\begin{aligned} L_t &\geq \int_0^{N_t} \frac{y_t(h)}{Z_t} dh \\ L_t^* &\geq \int_0^{N_t^*} \frac{y_t(f)}{Z_t^*} df \end{aligned} \quad (27)$$

and the equilibrium of financial markets:

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

The net foreign asset position of the Home economy in Home currency is $B_t^{net} = B_t - \varepsilon_t B_t^*$. Normalizing initial financial wealth to zero in both economies, net foreign assets satisfy the aggregate accounting equations:

$$\begin{aligned} Y_t - C_t - N_{e,t} v_t &= \frac{B_t^{net}}{P_t} \\ Y_t^* - C_t^* - N_{e,t}^* v_t^* &= -\frac{B_t^{net}}{\varepsilon_t P_t^*} \end{aligned} \tag{28}$$

The equilibrium defined above is conditional on the monetary policy in place in the world economy, which in turn determines the dynamics of the nominal exchange rate. The monetary instrument is the one-period risk-free nominal interest rate, i_t and i_t^* in, respectively, the Home and the Foreign economy. Monetary policy in both countries belongs to the class of feedback rules.

We will consider fixed and floating regimes in turn while overlooking the transition from one regime to the other.¹⁰ Fixed regimes are modelled as hard pegs to the Home currency. In any fixed regime, monetary union or hard peg, UIP requires interest rate equalization at all dates. In unilateral pegs, the nominal interest rate is set by the leader country (the Home country in our simulations). In a monetary union, the interest rate is set by a supra-national authority on the basis of union-wide targets. We have checked that considering a monetary union instead of a hard peg has no major consequences for our analysis. In floating regimes, the central banks in the two economies set nominal interest rates in an uncoordinated way and let the nominal exchange rate reflect interest differentials across countries.

3.5 The log-linear model

The model is log-linearized around a symmetric steady where shocks are muted at all dates. This section discusses the main linearized equations while Appendix A contains the steady state and the full log-linearization.

¹⁰The analysis of the implications of exchange rate crises for business formation is left to future research.

3.5.1 Demand block

The aggregate demand block is derived from a log-linear approximation to Home and Foreign first order conditions with respect to consumption, bonds and shares. Inter-temporal optimization requires the marginal rate of substitution between current and one-period ahead consumption to equalize the real return on nominal assets, both bonds and shares. A first set of Euler equations, one for each country, will therefore describe the dynamic 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, will relate the inter-temporal profile of consumption to the real return on shares. The real value of the firm, 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:

$$E_t \widehat{C}_{t+1} = \widehat{C}_t + \frac{1}{\rho} \left(\widehat{i}_t - E_t \pi_{t+1}^C \right) \quad (29)$$

where a hat over a variable denotes the log-deviation from the steady state and $\pi_{t+1}^C = \ln \frac{P_{t+1}}{P_t} - 1$. An increase in the real interest rate raises the return on bonds, making it more attractive to postpone consumption in the future.

The Euler on shares is:

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

Risk-sharing implies:

$$\widehat{q}_t = \rho (\widehat{C}_t - \widehat{C}_t^*)$$

where the real exchange rate is given by:

$$\widehat{q}_t = \gamma (\Delta \widehat{\varepsilon}_t + \pi_t^{*D} - \pi_t^D) + (1 - \gamma) \widehat{T o T}_t \quad (30)$$

Finally, UIP links expected exchange rate changes to the interest rate differential:

$$E_t \Delta \widehat{\varepsilon}_{t+1} = \widehat{i}_t - \widehat{i}_t^* \quad (31)$$

3.5.2 Supply block

The supply block is derived from a log-linear approximation to the pricing and entry decisions of firms together with labor supply.

First, derive real prices from the Calvo state equation (25):

$$\begin{aligned}\widehat{\rho}_{D,t} &= \frac{\alpha}{1-\alpha}\pi_t^D + \frac{1}{(1-\alpha)(\theta-1)}\widehat{N}_t - \frac{\alpha}{(1-\alpha)(\theta-1)}\widehat{N}_{t-1} \\ \widehat{\rho}_{X,t} &= \frac{\alpha}{1-\alpha}\pi_t^X + \frac{1}{(1-\alpha)(\theta-1)}\widehat{N}_{X,t}^* - \frac{\alpha}{(1-\alpha)(\theta-1)}\widehat{N}_{X,t-1}^*\end{aligned}\quad (32)$$

where $\pi_t^D = \ln \frac{P_{D,t+1}}{P_{D,t}} - 1$ and $\pi_t^X = \ln \frac{P_{X,t+1}}{P_{X,t}} - 1$. With $\alpha = 0$, an increase in the range of available varieties reduces aggregate prices (the so-called variety effect) and the more so the lower the elasticity of substitution θ . This effect is dampened with $\alpha > 0$.

Using optimal pricing (24) in the expression for $\widehat{\rho}_{D,t}$ and re-arranging yields the Phillips curve:

$$\begin{aligned}\pi_t^D &= \frac{(1-\alpha\beta(1-\delta))(1-\alpha)}{\alpha} \left(\widehat{W}_t - Z_t \right) + \beta(1-\delta) E_t \pi_{t+1}^D + \frac{\beta(1-\delta)}{\theta-1} E_t \widehat{N}_{t+1} - \frac{1+\alpha\beta(1-\delta)}{\theta-1} \widehat{N}_t \\ &\quad + \frac{1}{\theta-1} \widehat{N}_{t-1}\end{aligned}\quad (33)$$

Imported inflation follows directly from the assumption on foreign currency pricing:

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

Second, a log-linear approximation to the number of entrants is obtained from the current account equation (28) as a function of output minus absorption and net foreign assets:

$$\widehat{N}_{e,t} = \frac{\theta(1-\beta(1-\delta))}{\beta\delta} \widehat{Y}_t + \left(1 - \frac{\theta(1-\beta(1-\delta))}{\beta\delta} \right) \widehat{C}_t - \widehat{v}_t - \frac{(1-\delta)}{\delta} \widehat{nfa}_t \quad (34)$$

where $\widehat{nfa}_t = \widehat{b}_t - \frac{1}{\beta} \widehat{b}_{t-1}$ and $b_t = \frac{B_t^{net}}{Y_t P_t}$. The aggregate constraint implies a trade-off between investments in new varieties and consumption (the coefficient on C is negative). The law of motion of firms is:

$$\widehat{N}_t = (1-\delta) \widehat{N}_{t-1} + \delta \widehat{N}_{e,t-1} \quad (35)$$

From (21) and (20), the share of exporting firms is given by:

$$\widehat{N}_{X,t} - \widehat{N}_t = \varkappa (\widehat{\mu}_{X,t} + \gamma(\pi_t^{D*} - \pi_t^{X*})) \quad (36)$$

where $\widehat{\mu}_{X,t}$ are export markups. An increase in export margins $\widehat{\mu}_{X,t}$ and/or in the internal terms of trade (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 the absence of nominal rigidity. With flexible prices, in fact, exporters are able to stabilize profits in their own currency and have therefore no incentive to relocate resources between home and foreign markets.

Finally, labor supply is:

$$\widehat{L}_t = -\rho\varphi\widehat{C}_t + \varphi (\widehat{W}_t - \pi_t^C) \quad (37)$$

3.5.3 Exchange rate regimes

We consider fixed and floating exchange rate regimes. The fixed regime is a unilateral (hard) peg to the Home currency with a fixed exchange rate at all dates. It is implemented by the interest rule $\widehat{i}_t^* = \widehat{i}_t - \varsigma\widehat{\varepsilon}_t$ with $\varsigma > 0$. The exchange rate target (normalized to zero) ensures determinacy.¹¹

In the floating regime, monetary policy in the two economies 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)).

4 Numerical simulations

This section provides stochastic simulations of our benchmark model using second-order approximation methods.¹² Given the scope of the analysis, which is focused on explaining the dynamics of extensive margins observed in the data, we consider productivity shocks.

4.1 Calibration

Annual calibration reflects the frequency of the data. Unless otherwise specified countries are symmetric and of equal size, $\gamma = 0.5$.

¹¹For robustness purposes, we have considered a monetary union in which the nominal interest rate is set according to a union-wide Taylor rule $\widehat{i}_t = \phi\widehat{i}_{t-1} + \phi_\pi\pi_t^C + \phi_y\widehat{y}_t$ where $\pi_t^C = (\pi_t^C)^\gamma (\pi_t^{*C})^{1-\gamma}$ and $\widehat{y}_t^C = (y_t)^\gamma (y_t^*)^{1-\gamma}$ are union-wide targets. This has no remarkable implications for the qualitative properties of the impulse responses.

¹²See Schmitt-Grohe and Uribe (2004). Simulations are made with Dynare. The algorithm used to compute a quadratic approximation of the decision rules is described in Collard and Juillard (2001).

For ease of comparison with early studies, the parametrization of consumers' preferences is based on Bilbiie et al. (2012): the inter-temporal 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 markups 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 impulse responses. The discount factor is $\beta = 0.96$, in line with an annual interest rate of 4%.

The rate of firm exit is $\delta = 0.10$ to match the 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 not consequential for the dynamics of the model and can be normalized to unity without loss of generality. The shape parameter is chosen to reproduce the average standard deviation of the extensive margin in our sample, implying $\varkappa = 2.8$.¹³ The iceberg cost does not affect any of the impulse responses, yet its value is tied to the export share through the zero profit condition (20). Given an export share equal to 0.27 in the average economy in our sample, this implies a value of $\tau = 0.49$. This is slightly higher than the value $\tau = 0.3$ considered in Ghironi and Mélitz (2005), yet well in the range of values (0.3, 0.75) considered in Corsetti et al. (2013).

Using quarterly data for major developed economies, Galí et al. (2001) document a degree of nominal rigidity in the range between 0.407 and 0.771 per year. We take the middle point from these estimates and set $\alpha = 0.59$, implying an average duration of nominal contracts of about 7 months. The degree of exchange rate pass-through varies widely across countries and sectors. Moreover, it has declined far below unity in recent times (Gust et al., 2010). We set $\eta = 0.6$ in line with the average degree of long-run pass-through documented by Campa and Goldberg, 2005 in a sample of developed economies.

The parameters of the Taylor rule draw on Bilbiie et al. (2008), $\phi_i = 0.8$, $\phi_y = 0$ and $\phi_\pi = 0.3$. They imply a long-run response to inflation equal to 1.5 and no role for output stabilization. We will consider positive values for the coefficient on output for sensitivity analysis.

The parameters of the exogenous productivity process, $Z_t = \rho_Z Z_{t-1} + \epsilon_{Z,t}$, are an annualized version of those in King and Rebelo (1999), i.e. $\rho_z = 0.815$ and $\sigma_z = 0.013$.

¹³The shape parameter is such that $\sqrt{\frac{\varkappa(f_{x \min})^2}{(\varkappa-1)^2(\varkappa-2)}} = 6.5$.

4.2 Impulse responses

For the purpose of illustrating the transmission mechanism, we consider a one percent productivity rise in the home economy and simulate the model in the benchmark calibration with symmetric Taylor rules and flexible exchange rates. Figure 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 and 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 internal terms of trade drop, shifting 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, 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, 2009). 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 entry, where exchange rate variability can affect the extent to which firms re-locate production across sectors. As a matter of fact, the productivity rise induces a larger share of domestic

firms to export their products abroad. Relocations away from the non-tradable sector imply lower prices for new products and previously non-traded goods. Hence, high-productivity countries (the home economy in our simulations) have a comparative advantage in these sectors. The opposite is true in low-productivity countries (the foreign economy in the simulation), where firms re-locate toward mature products in the non-tradable sector. We will soon argue that fixed exchange rates can strengthen a country's comparative advantage in sectors that produce new products.

In order to illustrate the implications of exchange rate policy for the pattern of trade, Figure 7 reports the impulse response functions of export margins and markups, contrasting the transmission in fixed and flexible regimes. We consider adjustments at the extensive margin (number of new products and previously non-traded goods) as well as adjustments at the intensive margin (export volume per previously traded good). Solid lines now represent responses in floating regimes while dashed lines refer to fixed exchange rates.

[Figure 7 about here.]

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. These dynamics reflect the incentive for high-productivity countries (the home country in the simulation) to specialize in the production of new products and trade previously non-traded goods. High productivity, in fact, stimulates entry and increases the production of new goods. This in turn, implies lower international prices for these products (see Figure 5) and hence a comparative advantage in these sectors. Clearly, low-productivity countries (the foreign country in the simulation) specialize in the production of mature products and trade previously traded goods.

The exchange rate regime can strengthen a country's comparative advantage by having asymmetric effects on trade margins. Figure 7 shows that extensive margins are smoother with flexible than with fixed rates, independently of the country of origin of the shock. Intensive margins, on the contrary, are smoother in fixed regimes. Moreover, intensive and extensive margins appear to be negatively correlated with each other as in the data (Naknoi, 2015). Last but not least, fixed regimes are associated with smoother export markups. These responses suggest a strong incentive to adjust trade over the extensive margin in fixed regimes. So long as fixed exchange rates favour relocations toward trade of new products, they can strengthen a country's international competitiveness in these sectors. By contrast, flexible regimes imply a strong incentive to adjust trade at the intensive margin. They can therefore strengthen a country's international competitiveness in sectors that produce mature products and previously traded goods.

Our findings 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 for a number of reasons. To begin with, 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. In a setup with both homogeneous and differentiated goods, Bergin and Corsetti, 2015 show that monetary stabilization, by reducing markup uncertainty, can foster the competitiveness of firms operating in monopolistic competitive markets and induce relocations toward sectors that produce differentiated goods. Monetary stabilization helps strengthen a country's comparative advantage in these sectors. On the contrary, constraining policy with an exchange rate peg shifts production and exports away from differentiated goods (toward homogeneous goods) and weakens a country's comparative advantage in these sectors. We suggest a complement argument. In our setup, all firms produce differentiated products in monopolistic competitive markets. While all firms sell their products in the domestic market, only a subset of these firms export their products abroad. Fixed exchange rates, by stabilising export markups, provide a strong incentive for domestic producers to trade previously non-traded products and re-locate production away from non-traded sectors. Fixed exchange rates can therefore strengthen a country's comparative advantage in trade of new products.

4.3 Unconditional moments

Table 1 reports unconditional means of key variables obtained from a stochastic simulation of a second order approximation of the model, and Table 2 reports standard deviations. 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. The third column reports the percentage difference between fixed and flexible regimes.

Consistently with the transmission mechanism outlined above, production shifts toward the creation of new products in the high-productivity country. This is reflected in a permanent rise in the range of goods produced in the home economy and a permanent fall in the foreign country. On average, N raises by 2.8 percent above trend and N^* falls by 3.3 percent below trend when both countries follow uncoordinated Taylor rules. These values reduce to, respectively, 1.4 and 1.8 percent when the foreign country adopts a unilateral peg. This specialization pattern implies a shift of trade toward previously non-traded goods in the home country and away from traded goods in

the foreign country. This is reflected in the opposite movement of the export share in these two economies. Notice that the trade shift is stronger in fixed regimes: the cross-country differential in export shares is 1.7 percent higher with fixed compared to flexible regimes. Moreover, export markups are higher on average in fixed regimes, reflecting a strong incentive to re-locate production toward export sectors in these regimes.

Table 2 shows that the model is in line with the volatility of key variables in the United States (in ratio to the volatility of output), such as consumption, employment and entry. Data are annual and cover the period from 1977 to 2011. Macroeconomic data are from the Bureau of Economic Analysis (BEA). Business formation data are from the Business Dynamics Statistics (BDS) of the US Census Bureau.¹⁴

[Table 2 about here.]

[Table 3 about here.]

5 Conclusions

This paper has addressed the role of the exchange rate regime for the pattern of trade from both a theoretical and an empirical perspective.

In the empirical part, we consider bilateral exports at the intensive and the extensive margin among 23 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. These dynamics imply a relocation of trade toward new products and previously non-traded goods in high-productivity countries and a relocation toward mature products and previously traded goods in

¹⁴The BDS dataset is publicly available at <http://www.census.gov/ces/dataproducts/bds/>. It is part of the confidential Longitudinal Business Database (LBD). It covers most of the country's economic activity. The only major exclusions are self-employed individuals, employees of private households, railroad employees, agricultural production employees, and most government employees.

low-productivity countries. Trade relocations are particularly strong in fixed regimes. The reason is a high incentive for exporters to adjust trade at the extensive margin whenever export profits are stabilized as 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 comparative advantage well beyond the short run. In our simulations, *fixed exchange rates* foster the competitiveness of firms that trade new products and previously non-traded goods.

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Appendix A

A.1 Steady state

The model is solved in log-deviation from a symmetric steady state equilibrium in which 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 ψ . It is immediate to verify that symmetry implies $q = \varepsilon = ToT = 1$. The steady state number of firms is obtained from the following expression:

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

Other variables are given by:

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

A.2 Loglinear model

Loglinearized conditions for households are:

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

Loglinearized conditions for firms are:

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

Other log-linear equilibrium conditions are:

$$\begin{aligned}
\widehat{\rho}_{D,t} &= \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}_{D,t}^* &= \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}_{X,t} &= \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}_{X,t}^* &= \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}_{X,t}^* - \widehat{N}_{X,t-1}^* \right) + \pi_t^{*D} \\
\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 \\
\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(1-\varrho) \widehat{C}_t + \varrho \sigma \widehat{N}_{e,t} + (1-\gamma)(1-\varrho) \left(\widehat{C}_t + \widehat{q}_t \right) + (1-\sigma) \varrho \left(\widehat{N}_{e,t}^* + \widehat{q}_t \right) \\
&\quad + (1-\sigma) \varrho f_x \left(\widehat{N}_{X,t}^* + \widehat{q}_t \right) \\
\widehat{Y}_t^* &= \gamma(1-\varrho) \widehat{C}_t^* + \varrho \sigma \widehat{N}_{e,t}^* + (1-\gamma)(1-\varrho) \left(\widehat{C}_t^* - \widehat{q}_t \right) + (1-\sigma) \varrho \left(\widehat{N}_{e,t} - \widehat{q}_t \right) \\
&\quad + (1-\sigma) \varrho f_x \left(\widehat{N}_{X,t} - \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 &= (\sigma - \gamma) (\pi_t^D - \pi_t^X) \\
\widehat{v}_t^* &= (\sigma - \gamma) (\pi_t^{*D} - \pi_t^{*X}) \\
\widehat{q}_t &= \rho \left(\widehat{C}_t - \widehat{C}_t^* \right) \\
\widehat{q}_t &= \widehat{q}_{t-1} + \Delta \widehat{\varepsilon}_t + (1-\gamma) (T_t + (\pi_t^{*X} - \pi_t^X))
\end{aligned}$$

where $\varrho = \frac{\delta\beta}{\theta(1-\beta(1-\delta))}$.

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

Appendix B

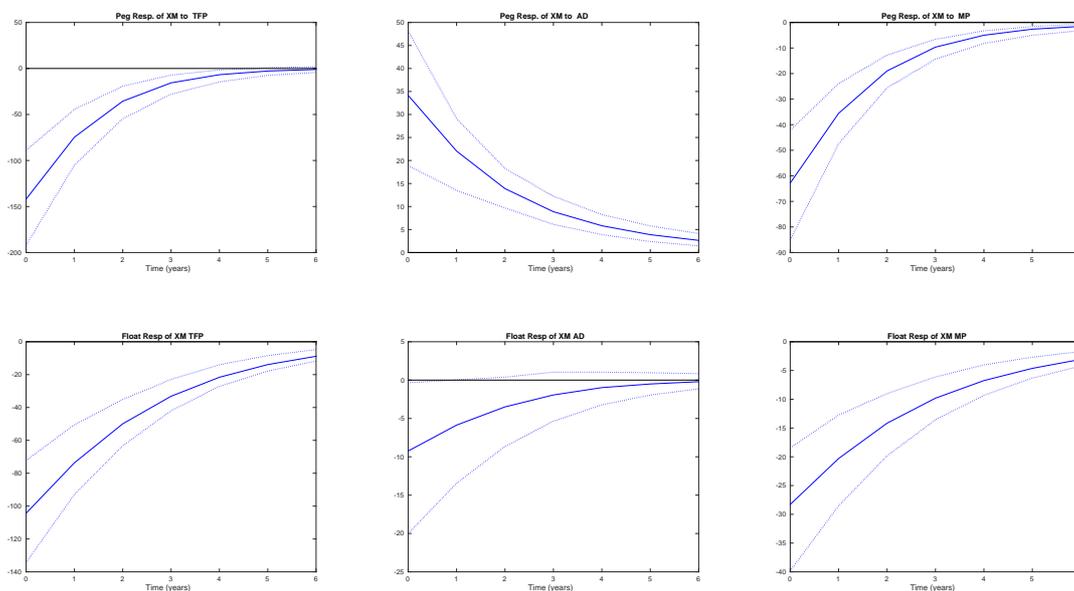
B.1 Data

[Table 4 about here.]

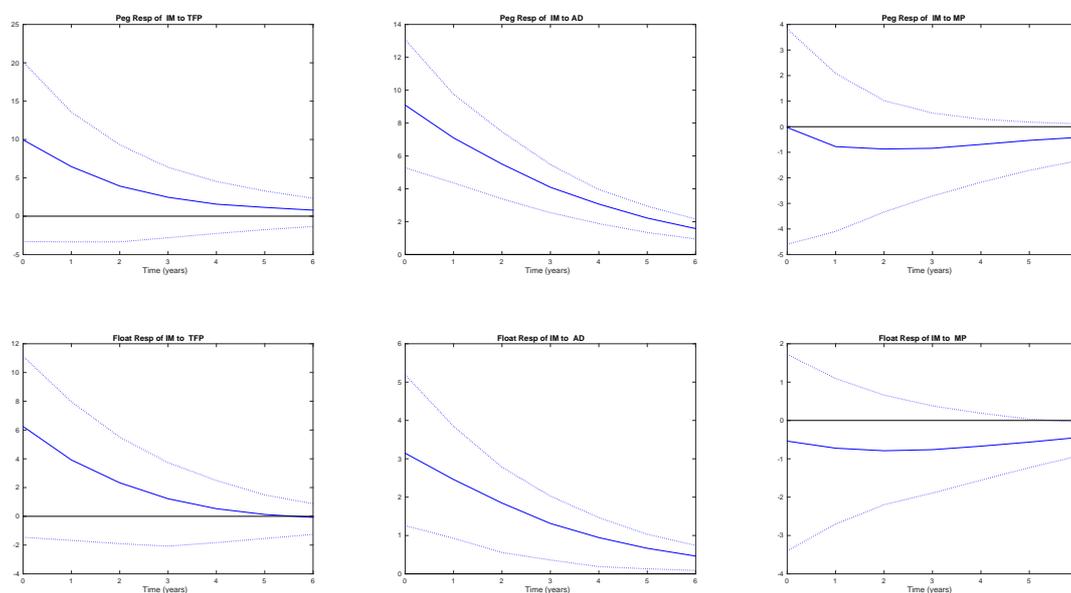
B.2 Peggers and floaters

[Table 5 about here.]

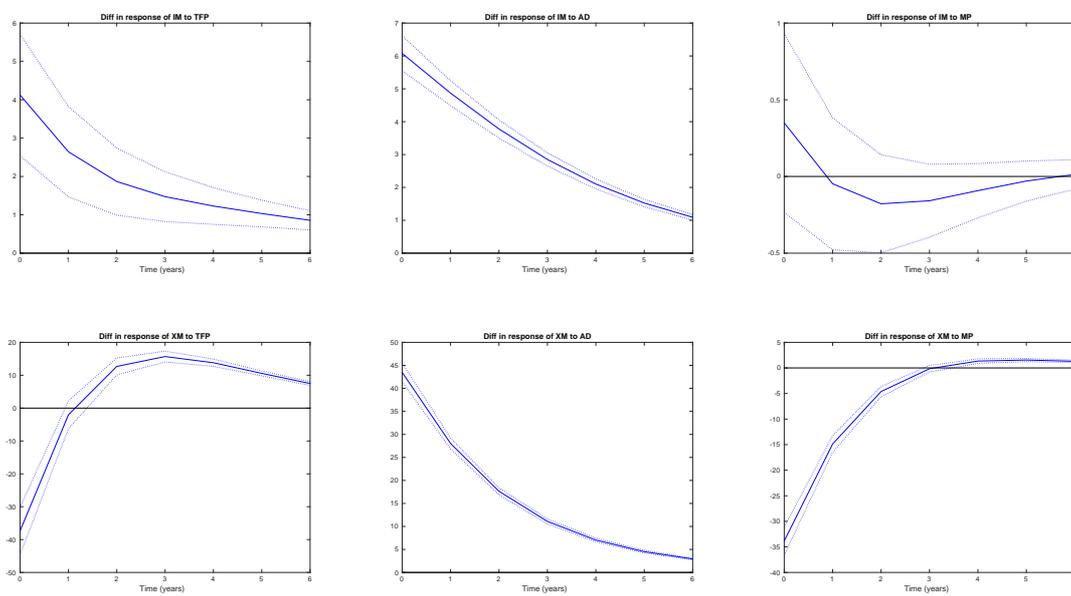
Mean responses of extensive margins to external shocks in fixed regimes (top row) and in flexible regimes (bottom row).



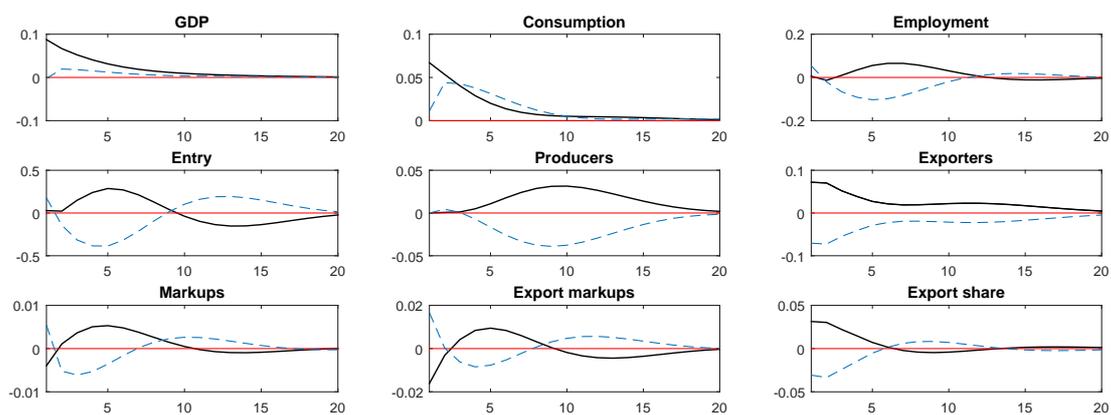
Mean responses of intensive margins to external shocks in fixed regimes (top row) and in flexible regimes (bottom row).



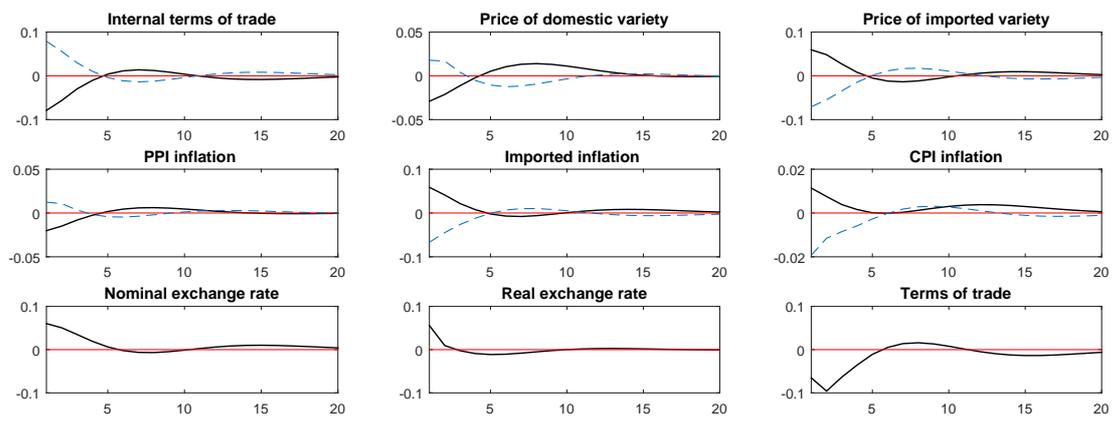
Differences of responses in the sample of peggers and in the sample of floaters.



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



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



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

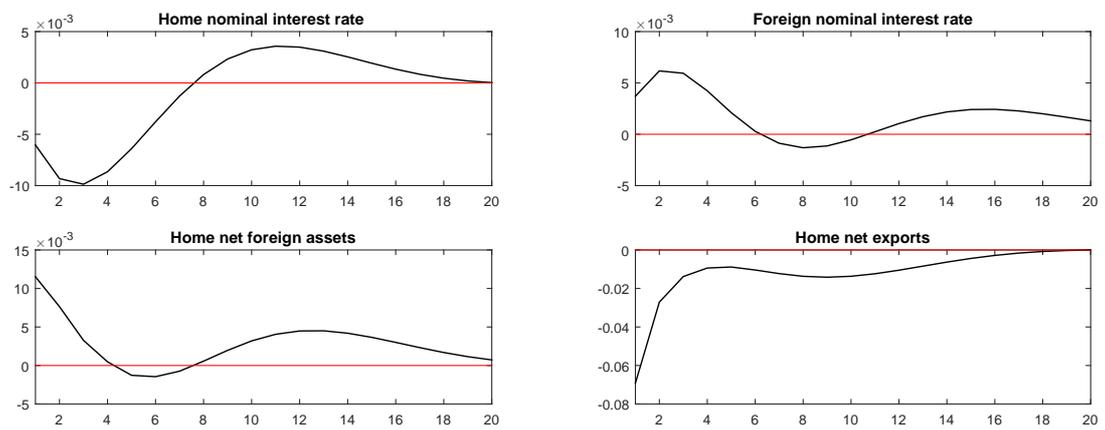


Figure 1:

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

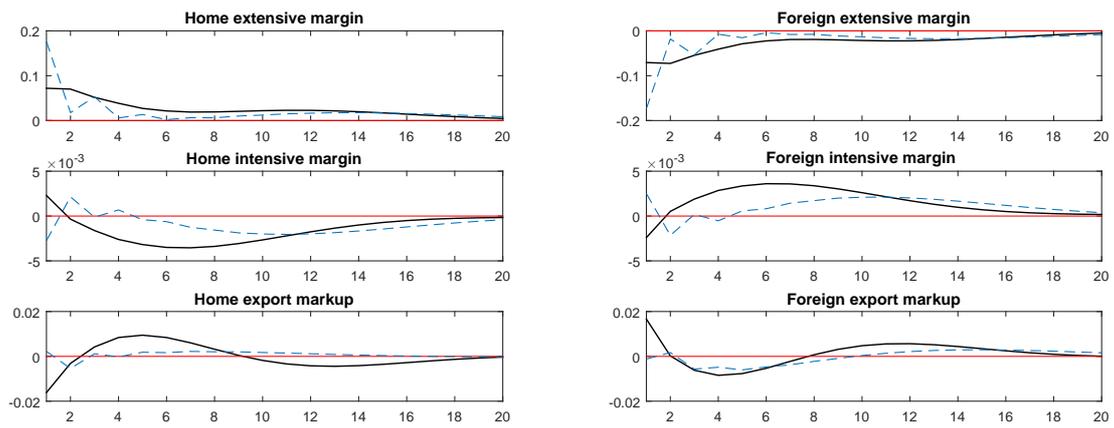


Table 1: Unconditional means

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: Unconditional means

	flexible ER	fixed ER	fixed-flex (%)
Y	0,03378	0,0395	0,575
Y^*	0,0104	0,0090	-0,135
C	0,0240	0,0309	0,691
C^*	0,02264	0,0208	-0,185
N	0,0286	0,0141	-1,45
N^*	-0,0330	-0,0177	1,534
N_X/N	0,0180	0,0260	0,794
N_X^*/N^*	-0,01409	-0,02301	-0,892
μ_X	-0,00078	0,0012	0,197
μ_X^*	0,0025	0,000007	-0,239

Table 3: Standard deviations

Note: entry is measured by the number of establishments created in the last 12 months (data source: BDS). GDP, Consumption and Employment (hours worked) are measured at constant prices with base year 2009 and are not seasonally adjusted (data source: BEA). Data are annual and cover the period 1977-2011. All variables are logged and HP-filtered with a smoothing parameter of 6.25.

Ratios of standard deviation of GDP			
	US Data	Flexible ER	FixedER
Consumption	0.75	0.7848	0.7898
Employment	1.10	1.0573	1.1544
Entrants	3.85	5.3417	6.3730

Table 4: Data

Original series	Source	Data transformation
Pegggers and Floaters Nominal GDP	OECD.StatExtracts	log difference after deflating with GDP Deflator
Pegggers and Floaters GDP Deflator	OECD.StatExtracts	None
Pegggers and Floaters Export Price index	IFS-IMF database	Used to calculate Terms of Trade
Pegggers and Floaters Import Price index	IFS-IMF database	Used to calculate Terms of Trade
Pegggers 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
