Exports and foreign direct investments in an endogenous-entry model with real and nominal uncertainty *

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Abstract

Drawing on a tractable DSGE model with nominal rigidity, this paper studies the implications of firms' entry in domestic and foreign markets for the international business cycle. The paper shows that the decision to enter a new market as well as the choice whether to invest at home or abroad depend on global monetary and productivity conditions. I find that a domestic monetary expansion might favor or deter start-up investments, depending on whether the potential entrant is a national or a multinational firm. Moreover, a structural policy change, as an increase in the degree of monetary stabilization, has a positive impact on trend investments in all sectors. Firms' dynamics, in turn, amplifies consumption and employment spillovers in the world economy. I stress that this may have non-negligible consequences for welfare.

Keywords: multinational firms, endogenous entry, monetary policy, FDI

JEL codes: F41

1 Introduction

The tremendous growth in trade and FDI flows that has occurred in the past two decades has changed the structure of macroeconomic interdependence in the global economy, especially among similar, industrialized countries and between these and newly emerging economies (see UNCTAD, 2007). Consequently, a growing interest has been devoted to studies of the international business

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cycle where macroeconomic interdependence is endogenous.[1] Most contributions, however, focus on trade relations, overlooking international linkages through FDI flows. [2] This paper aims to fill the gap and investigate both dimensions of macroeconomic interdependence by focusing on the role of producers' entry in domestic and foreign markets for the transmission of monetary policy and productivity shocks around the world. For this purpose, it proposes a tractable DSGE model with nominal rigidity that incorporates the endogenous determination of the number of firms that decide to enter a new market at home or abroad. Firms are allowed to choose whether to serve foreign markets through exports or engage in direct investments overseas. [3]

The paper contributes to a recent strand of research analyzing the implications of firms' entry and product creation for monetary policy and the business cycle dynamics.[4] A general finding in this literature is that sticky prices can distort entry behavior in a number of ways, thereby creating a new role for monetary policy in welfare maximization. It is argued that well-designed monetary rules can eliminate the incentive on the part of firms to (excessively) contract extensive margins in cyclical downturns and help replicate the business cycle dynamics that would prevail with flexible prices. Moreover, entry and exit of firms can affect monetary transmission through a variety of channels. Bilbiie, Ghironi and Mélitz, 2007 stress the relevance of asset pricing in spreading the effects of monetary policy. The financing of start-up investments turns out to be negatively associated with a monetary expansion in their model. Others, as Bergin and Corsetti, 2005 and Lewis, 2006, focus on the real cost of new product creation, suggesting that monetary policy would rather boost entry (as it appears to be the case in the data). These contributions, as most models in this area, refer to closed economies.

Russ, 2007 and Cavallari, 2007 develop open economy models with endogenous entry that are closest to the one studied here. Russ focuses on foreign investments by multinational corporations in a setting with heterogeneous firms à la Mélitz, 2003. Cavallari considers a representative-firm model with endogenous trade and foreign investments. These contributions point to different mo-

[1] Open economy models with endogenous entry include, among others, Ghironi and Mélitz, 2005, Corsetti, Pesenti and Martin, 2007, Bergin, Glick and Taylor, 2006 and Bergin and Glick, 2003, 2005 and 2007.

[2] Russ, 2007 and Cavallari, 2007 provide notable exceptions. In a framework with a fixed number of firms, see also Cavallari, 2008.

[3] Helpman, Mélitz and Yeaple, 2004, have pioneered a fast-growing literature that investigates the general equilibrium consequences of alternative modes of foreign market access. Helpman, 2006, provides a comprehensive survey of contributions in this area.

[4] A non-exhaustive list of contributions in this area includes Bilbiie, Ghironi and Mélitz, 2007, Bergin and Corsetti, 2005, Lewis, 2006, Elkouri and Mancini Griffoli, 2006 and Barentsen and Waller, 2007. These studies refer to closed economies.

tives behind why monetary policy might in principle attract or deter foreign investments. The former stresses whether monetary uncertainty originates at home or abroad as a key determinant of the perception of exchange rate risk on the part of potential investors contemplating to engage in investments overseas. The latter focuses on the degree of monetary stabilization, showing that investments might be sub-optimally low when stabilization is not complete.

Differently from previous contributions, this paper nests within a unified framework both the decision of firms whether to enter a market at home or abroad (as in Russ, 2007) and whether to serve foreign customers through trade or by engaging in direct investments overseas (as in Cavallari, 2007). To this end, the model in Cavallari, 2007 is extended so as to encompass firms that operate on domestic markets only, endogenizing the size of the non-tradable sector. This in turn allows domestic demand to play a role (along with foreign demand) in the decision whether to serve foreign markets in the first place. In addition, the model can account for movements of firms between the traded and the non-traded sector as those stressed in the literature showing that a relevant fraction of the growth in trade volumes occurs at the extensive margin, with exports of new products and previously non-traded goods (see Kehoe and Ruhl, 2002). [5] The paper proposes a way of exploring the mechanisms behind such observations in a simple macro model where firms are identical in all respects except for the market demand they face. It provides an illustration of how the dynamics of firms across and within sectors can help improve our understanding of macroeconomic interdependence.

Remarkably, I find that firms' entry in domestic and foreign markets depends on current monetary and productivity conditions at home and abroad. The major role of external shocks is a novelty in the literature and a consequence of strictly interdependent investment decisions within and across sectors. A rise in home productivity, for instance, is shown to affect firms' investments well beyond the domestic borders, by discouraging overseas investments of home multinational firms in favor of domestic investments in the foreign country.

I further argue that a monetary expansion might have contrasting effects on domestic and foreign investments as a result of their different degree of exposure to exchange rate risk. In my setup with pre-determined prices and flexible entry costs, a monetary easing is associated with higher entry costs and a boosting demand, with clearly opposing effects on the attractiveness of new investments. An expansion at home is found to favor domestic investments at the expense of direct investments by foreign multinationals whenever exchange rate pass-through is not complete. The finding is a consequence of movements in the exchange rate that reduce the foreign-currency revenues of investments

[5] See also Bernard and Jensen, 2001. Based on a panel of US manufacturing firms between 1987 and 1997, they show that on average 13.9% of non-exporting firms begin to export in any given year in the sample and 12.6 % of exporters stop to trade.

below entry costs, thereby discouraging foreign investments. Exit of foreign multinationals from home markets, in turn, improves the prospective profits of home investors, crowding-in domestic investments.

Monetary policy can affect entry decisions also by changing the perception of macroeconomic risks on the part of potential investors. A more active monetary policy, as captured by a rise in monetary volatility or an increase in the covariance with productivity shocks, is found to have a permanent effect on the level of investments in all sectors of the economy. A counter-cyclical monetary policy, in fact, helps stabilize marginal costs and hence reduce the risks associated with pre-set prices.

Accounting for firms' dynamics allows to emphasize a new propagation mechanism in the international business cycle arising from cross-country differences in firms' integration strategies. When the number of producers is endogenous, high-productivity economies tend to attract domestic and foreign investments, supplying the widest range of product varieties. Firms in low-productivity economies, on the contrary, will find it convenient to invest abroad, serving foreign customers mainly through local affiliates of multinational corporations. As a consequence of massive entry in home markets, the relative price of home products will fall, i.e. the home country experiences a deterioration in its terms of trade. The finding is reminiscent of the well-known "immiserizing growth" by Bhagwati, 1958, showing that a sharp deterioration in the terms of trade of a growing economy might reduce welfare. Yet, in my model falling terms of trade are the result of asymmetries in firms' integration strategies over the business cycle. A caveat to my findings is that the tendency towards falling prices might be attenuated in sectors characterized by high dispersion of productivity across firms. The rise in the number of producers would then come with a drop in average productivity. The question provides an interesting ground for further research.

Finally, I compare consumption and employment spillovers with and without entry effects in a number of numerical exercises. The intuition that endogenous entry amplifies the propagation of monetary and productivity shocks is confirmed in all calibrations. Take, for instance, a global monetary expansion. The monetary easing, wherever it is originated, is associated with a rise in world-wide consumption and employment. International spillovers, however, are higher when extensive margins are allowed to move relative to the model with a fixed number of firms.

The paper is structured as follows. Section 2 models the world economy. Section 3 derives the sticky-price equilibrium of the log-linearized model. Section 4 provides numerical simulations that help address potential ambiguities in the analytical results. Section 5 concludes.

2 The model

2.1 Preferences

Expected lifetime utility of a typical home agent i is given by:

$$\Omega_{it} = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} U_{it}(C^i, \frac{M^i}{P}, L^i) \tag{1}$$

where flow utility U is a positive function of real consumption, C, and real money balances, M/P, a negative function of labor effort, L, and β is the discount factor. In order to keep algebraic complexity at a bare minimum, I adopt the additively-separable specification:

$$U_{it}(C^i, \frac{M^i}{P}, L^i) = \log C_{it} + \chi \log \frac{M_{it}}{P_t} - \kappa_t L_{it} \tag{2}$$

Foreign agents' preferences are expressed in an analogous way, but are defined over consumption of goods sold in the foreign country, C^*, foreign money balances, M^*/P^*, and foreign labor, L^*.

Each agent in the world economy consumes a basket that comprises tradable and non-tradable goods, C_T and C_N, respectively, as follows:

$$\begin{aligned} C &= \frac{C_T^{\gamma} C_N^{1-\gamma}}{\gamma^{\gamma} (1-\gamma)^{1-\gamma}} \\ C^* &= \frac{C_T^{*\gamma} C_N^{*1-\gamma}}{\gamma^{\gamma} (1-\gamma)^{1-\gamma}} \end{aligned} \tag{3}$$

with $\gamma \in (0, 1)$. Goods markets are characterized by monopoly distortions due to less than perfect substitutability among differentiated varieties. Traded goods consumed in the home country are defined over a continuum of varieties of mass N_X^*, where N_X^* is the number of foreign exporters, and are indexed by $f_X \in (0, N_X^*)$. Traded goods consumed abroad are defined over a mass N_X of varieties indexed by $h_X \in (0, N_X)$, where N_X is the number of home export firms. Consumption of tradables is therefore given by:

$$\begin{aligned} C_T &= \left[\int_0^{N_X^*} C(f_X)^{\frac{\phi-1}{\phi}} df_X \right]^{\frac{\phi}{(\phi-1)}} \\ C_T^* &= \left[\int_0^{N_X} C^*(h_X)^{\frac{\phi-1}{\phi}} dh_X \right]^{\frac{\phi}{(\phi-1)}} \end{aligned} \tag{4}$$

Consumers' preferences for non-traded goods are defined in a similar way:

$$C_N = \left[\int_0^{N_D} C(h_D)^{\frac{\phi-1}{\phi}} h_D + \int_{N_D}^{N_D+N^*_{MN}} C(f_{MN})^{\frac{\phi-1}{\phi}} f_{MN}\right]^{\frac{\phi}{(\phi-1)}} \tag{5}$$

$$C^*_N = \left[\int_0^{N^*_D} C(f_D)^{\frac{\phi-1}{\phi}} f_D + \int_{N^*_D}^{N^*_D+N_{MN}} C(h_{MN})^{\frac{\phi-1}{\phi}} h_{MN}\right]^{\frac{\phi}{(\phi-1)}}$$

where N_D and N^*_{MN} are, respectively, the number of home firms and foreign multinationals in the home non-traded sector and a similar interpretation holds for N^*_D and N_{MN}. The number of firms active in the world economy in each period will be determined endogenously in the model.

The assumption of a unitary elasticity of substitution in consumption between tradables and non-tradables in (4) is made for ease of simplicity in order to keep the model linear (in logs) as in Obstfeld and Rogoff, 2000b. A unitary elasticity might be a relatively high number compared to some estimates suggested in the literature. [6] This might imply too small fluctuations in the "theoretical" terms of trade relative to those observed in the data (a higher elasticity requires a lower price change in order to accommodate a given change in quantities). In my setup with endogenous investments, however, fluctuations in the terms of trade are intensified by movements of firms between the export and the non-traded sector. As it will be apparent below, asymmetric integration strategies on the part of firms active in world markets can lead to sharp movements in the terms of trade over time.

2.2 Technology

I associate each firm with an individual variety, so that a firm, say, h_D is the sole producer of the corresponding variety of the home non-traded good. There will therefore be three classes of firms consistent with preferences (4) and (5), namely export firms, domestic firms and affiliates of foreign multinational enterprises. Firms are identical in all other respects. The assumption of homogeneous firms has the major advantage of providing closed-form analytical solutions with no need to resort to a particular aggregation method. On the flip side, it leaves undetermined which firm belongs to which class. This, however, does not appear too limiting given the emphasis of the paper on the macro implications of entry.

Technology is linear and labor is the only input. The representative firm located in the home country faces the following production function:

$$Y(\omega) = AL(\omega)$$

[6] Lane and Milesi Ferretti, 2004 derive a value for the elasticity between tradables and non-tradables as low as 0.5. The estimated elasticity is even lower for relatively closed economies as the US, Europe and Japan. Others, as Ostry and Reinhart, 1992 provide estimates in the range between 0.6 and 1.3 for a sample of developing countries.

where $Y(\omega)$ is output of variety $\omega \in (0, h_D + h_X + f_{MN})$, L the labor input and A is a stochastic term capturing home labor productivity. Similarly, in the foreign country technology is given by:

$$Y^*(\omega^*) = A^* L^* (\omega^*)$$

where $\omega^* \in (0, f_D + f_X + h_{MN})$.

2.3 Entry

Entry in both the traded and the non-traded sector is costly. Entry costs comprise a one-period lag in investment, as firms must pay the fixed cost at the beginning of each period in order to start production in the subsequent period. Entry costs are denominated in the currency of the country where the investment is located, so that all firms establishing a new plant in the home country, comprising foreign multinationals, face entry costs equal to q in home currency. Similarly, new investments on the foreign soil entail the cost q^* in foreign currency. The entry cost for each class of firms is measured in units of labor as follows:

$$\begin{aligned} q_j &= \frac{W}{A} N_j^{\rho} \quad q_{MN} = \frac{W}{A} N_{MN}^{*\rho} \\ q_j^* &= \frac{W^*}{A^*} N_j^{*\rho} \quad q_{MNj}^* = \frac{W^*}{A^*} N_{MN}^{\rho} \end{aligned} \tag{6}$$

where $j = (D,\ X)$, W is the nominal wage in home currency, W^* the nominal wage in foreign currency and $\rho \geq 0$ is a measure of the concavity of the cost function. As stressed by Corsetti, Martin and Pesenti, 2008, a high value of ρ captures the growing difficulty of entering a market when the number of direct competitors increases.

In addition to entry costs, traded goods also entail iceberg-type transport costs, so that for one unit of the final good to arrive at a foreign destination $\tau > 1$ units must be sent. These shipping costs capture a variety of (variable) costs associated with international trade.[7]

2.4 Individual and government's budget constraints

In each period, the representative agent holds home currency, two international bonds, B^i and B^{*i}, respectively denominated in home and foreign currency, and shares in all types of domestic firms, s_j. He receives labor income from firms active on the home soil, a share in the profits of home

[7] Tariff barriers range on average between 4 and 5 per cent of the price of traded goods. Trade costs - including tariff and non-tariff barriers, shipping and distribution costs - vary greatly across classes of goods.

national and multinational firms, Π_j , and pays non-distortionary net taxes, T, to the government. The budget constraint of agent i is therefore:

$$B^i_{t+1} + \varepsilon_t B^{*i}_{t+1} + M^i_{t+1} + \sum_{j=D,X,MN} \int_0^{N_{jt}} s_j q_{jt} dh_j \leq B^i_t(1 + i_{t+1}) + \tag{7}$$

$$\varepsilon_t B^{*i}(1 + i^*_{t+1}) + M^i_t + W_t L^i_t + \sum_{j=D,X,MN} \int_0^{N_{jt-1}} s_j \Pi_{jt} dh_j - P^i_t C^i_t - T^i_t$$

where i and i^* are, respectively, home and foreign nominal interest rates and ε is the nominal exchange rate defined as units of home currency for one unit of foreign currency.

The government simply rebates all seignorage revenue in lump-sum transfers to households, so that its budget constraint is as follows:

$$\int_0^1 M^i_t - M^i_{t-1} di + \int_0^1 T^i_t di = 0 \tag{8}$$

2.5 The equilibrium allocation

The equilibrium in the world economy is characterized as follows. Given the stochastic processes driving monetary policies and productivity, and given the initial holdings of bonds, money and shares, the equilibrium is a set of processes for the nominal exchange rate ε, the number of firms active in the world economy (N_j and N^*_j), the home allocations and prices (L, C, P and W) and their foreign counterparts (L^*, C^*, P^* and W^*) such that **a)** consumers' optimality conditions are satisfied, **b)** firms' profits are maximized, **c)** the free entry conditions are met, **d)** markets for each asset, each good and for labor clear and **e)** the resource constraints are satisfied.

2.5.1 Consumers' first order conditions

Agents choose consumption, labor effort, money, bond and share holdings in each period so as to maximize their life-time utility (2) subject to the budget constraint (7). The first order conditions for home agents are:

$$C(h_D) = \frac{(1-\gamma) P_t C_t}{P_N} \left(\frac{p(h_D)}{P_N}\right)^{-\phi} \tag{9}$$

$$C(f_X) = \frac{\gamma P_t C_t}{P_T} \left(\frac{p(f_X)}{P_T}\right)^{-\phi} \tag{10}$$

$$C_t(f_{MN}) = \frac{(1-\gamma) P_t C_t}{P_N} \left(\frac{p(f_{MN})}{P_N}\right)^{-\phi} \tag{11}$$

$$W_t = \kappa P_t C_t \tag{12}$$

$$\frac{M_t}{P_t} = \chi C_t \frac{1 + i_{t+1}}{i_{t+1}} \tag{13}$$

$$q_{Dt} = E_t \left[\beta \frac{P_{t+1} C_{t+1}}{P_t C_t} \Pi_{Dt+1}(h_D) \right] \tag{14}$$

$$q_{Xt} = E_t \left[\beta \frac{P_{t+1} C_{t+1}}{P_t C_t} \Pi_{Xt+1}(h_X) \right] \tag{15}$$

$$\varepsilon_t q^*_{MNt} = E_t \left[\beta \frac{P_{t+1} C_{t+1}}{P_t C_t} \Pi_{MNt+1}(h_{MN}) \right] \tag{16}$$

$$P_t C_t = \beta E_t \left((1 + i_{t+1}) \right) \tag{17}$$

$$\varepsilon_t = \beta E_t \left(\frac{P_{t+1} C_{t+1}}{P_t C_t} \varepsilon_{t+1} \left(1 + i^*_{t+1}\right) \right) \tag{18}$$

where P_T, P_N and P are indices for, respectively, traded goods, non-traded goods and consumer prices defined as follows:

$$P = P_T^{\gamma} P_N^{1-\gamma} \tag{19}$$

$$\begin{aligned} P_T &= \left[\int_0^{N_X^*} p(f_X)^{1-\phi} df_X \right]^{\frac{1}{1-\phi}} \\ P_N &= \left[\int_0^{N_D} p(h_D)^{1-\phi} dh_D + \int_{N_D}^{N_D + N_{MN}^*} p(f_{MN})^{1-\phi} df_{MN} \right]^{\frac{1}{1-\phi}} \end{aligned} \tag{20}$$

where $p(f_X)$ and $p(f_{MN})$ are the prices for varieties f_X and f_{MN}, respectively, of the foreign good and $p(h_D)$ is the price of variety h_D of the home good.

Combining the Euler equations (17) and (18) and money demand (13), it is possible to define an index of the home monetary stance $\mu_t \equiv P_t C_t$ such that a monetary expansion, i.e. a rise in μ, is associated with a lower interest rate. Similarly, $\mu_t^* \equiv P_t^* C_t^*$ represents foreign monetary policy.

2.5.2 Profit maximization

I allow for nominal rigidities by assuming that firms set prices at the beginning of each period, before shocks and entry occur, and are committed to meet market demand at the given price for the whole period. [8] Firms act as monopolistic competitors and choose prices so as to maximize expected

[8]Firms' commitment applies as long as pre-set prices do not fall short of marginal costs. In what follows, the domain of real and nominal shocks is restricted so that the participation constraint is always satisfied.

profits given market demand, (9), (11) or (10). Firms active in foreign markets also take the degree of exchange rate pass-through as given, thereby letting the final price of their product vary with the exchange rate at a constant elasticity equal to η. [9] In this setting, a value of $\eta = 0$ corresponds to local currency pricing, namely a situation where prices are pre-determined in the consumers' currency and do not respond to movements in the exchange rate. The case $\eta = 1$ corresponds to producers' currency pricing. [10] Optimal pre-determined prices are given by:

$$\begin{aligned} p(h_D) &= \Phi \frac{\kappa E_{t-1}(\frac{\mu_t^2}{A_t})}{E_{t-1}(\mu_t)} \quad p(f_X) = \Phi \frac{\tau\kappa E_{t-1}(\frac{\mu_t^*\mu_t\varepsilon_t^{-\eta}}{A_t^*})}{\varepsilon_t^{-\eta} E_{t-1}(\mu_t \varepsilon_t^{-1})} \\ p(f_{MN}) &= \Phi \frac{\kappa E_{t-1}(\frac{\mu_t^2 \varepsilon_t^{-\eta}}{A_t})}{\varepsilon_t^{-\eta} E_{t-1}(\mu_t \varepsilon_t^{-1}))} \quad p^*(h_{MN}) = \Phi \frac{\kappa E_{t-1}(\frac{\mu_t^{*2}\varepsilon_t^{\eta}}{A_t^*})}{\varepsilon_t^{\eta} E_{t-1}(\mu_t^* \varepsilon_t)} \\ p^*(f_D) &= \Phi \frac{\kappa E_{t-1}(\frac{\mu_t^{*2}}{A_t^*})}{E_{t-1}(\mu_t^*)} \quad p^*(h_X) = \Phi \frac{\tau\kappa E_{t-1}(\frac{\mu_t^*\mu_t\varepsilon_t^{\eta}}{A_t^*})}{\varepsilon_t^{\eta} E_{t-1}(\mu_t^* \varepsilon_t)} \end{aligned} \tag{21}$$

where $\Phi \equiv \phi/(\phi - 1)$ is the usual mark-up. Note that preset prices incorporate a premium over expected marginal costs as a hedge against the risk of a future drop in profits. Expected profits, in fact, depend on the future realizations of marginal costs, $\kappa\mu/A$ at home and $\kappa\mu^*/A^*$ in the foreign country, as well as on the covariance between these variables and nominal spending, respectively, μ and μ^*. In foreign markets, the premium also depends on the expected movements in the exchange rate and their implications for final (consumers') prices. Consider, for instance, a home firm serving foreign customers either through exports or via foreign investments. Other things being equal, the premium in the foreign-currency price of her products will be higher as long as she expects the domestic currency to appreciate, a fall in ε, thereby reducing sales revenue in foreign currency. Depending on the degree of exchange rate pass-through, the appreciation may also affect expected profits through a change in foreign demand.

With sticky prices, mark-ups are time-varying ex-post. Any unexpected increase in marginal costs, as due for instance to a fall in productivity or a rise in nominal wages, will have no consequences for market demand as long as prices are fixed, thereby reducing profit margins. As usual with CES preferences, profits are proportional to overall spending in each sector. In the home country, the profits of domestic firms and foreign multinationals are given by:

[9] This is equivalent to saying that firms optimally choose the price for exports and multinational sales in their own currency, recognizing that the final price may vary with the exchange rate as in Corsetti and Pesenti, 2005.

[10] Empirical evidence on traded good prices, as documented by, among others, Goldberg and Knetter, 1997, Engel, 1999, Parsley and Wei, 2001 and Campa and Goldberg, 2005 points to a degree of exchange rate pass-through into import prices which is higher than zero on average although far below unity. Lipsey, 1999 documents that multinational firms also engage in substantial pricing-to-market through their affiliates abroad.

$$
\begin{aligned}
\Pi_t(h_D) &= \frac{(1-\gamma)\,\mu_t}{\Phi_t^D\left[N_{Dt-1}+\Upsilon_t^N N^*_{MNt-1}\right]} \\
\Pi_t(f_{MN}) &= \frac{(1-\gamma)\,\mu_t}{\Phi_t^{MN}\left[N_{Dt-1}+\Upsilon_t^N N^*_{MNt-1}\right]} \\
\Pi_t(h_X) &= \frac{\gamma\varepsilon_t\mu_t^*}{\Phi_t^X N_{Xt-1}}
\end{aligned}
\tag{22}
$$

where

$$
\begin{aligned}
\Phi_t^D &\equiv \frac{p(h_D)}{p(h_D)-\frac{\kappa\mu_t}{A_t}} \\
\Phi_t^X &\equiv \frac{\varepsilon_t^{-\eta}p(h_X)}{\varepsilon_t^{-\eta}p(h_X)-\frac{\tau\kappa\mu_t}{A_t}} \\
\Phi_t^{MN} &\equiv \frac{p(h_D)}{p(f_{MN})-\frac{\kappa\mu_t}{A_t}}\left(\frac{\varepsilon_t^{\eta}p^*(f_{MN})}{p(h_D)}\right)^{\phi} \\
\Upsilon_t^N &\equiv \left(\frac{\varepsilon_t^{\eta}p^*(f_{MN})}{p(h_D)}\right)^{1-\phi}
\end{aligned}
$$

and similar expressions hold in the foreign economy. As already noted, (the inverse of) profit margins Φ^j vary with nominal and productivity shocks as long as prices are fixed. With flexible prices, instead, profit margins would be constant at the level $1/\phi$.[11]

2.5.3 Free entry conditions

Each home firm will enter a domestic or a foreign market as long as the expected present value of operating profits in the subsequent period, on the right hand side, will cover entry costs, on the left hand side:

$$
\begin{aligned}
q_{Dt} &= E_t\left[\beta\frac{\mu_t}{\mu_{t+1}}\left(p_{t+1}(h_D)-\frac{\kappa\mu_{t+1}}{A_{t+1}}\right)C_{t+1}(h_D)\right] \\
q_{Xt} &= E_t\left[\beta\frac{\mu_t}{\mu_{t+1}}\left(\varepsilon_{t+1}p^*_{t+1}(h_X)-\tau\frac{\kappa\mu_{t+1}}{A_{t+1}}\right)C^*_{t+1}(h_X)\right] \\
\varepsilon_t q^*_{MNt} &= E_t\left[\beta\frac{\mu_t}{\varepsilon_{t+1}\mu_{t+1}}\left(\varepsilon_{t+1}p^*_{t+1}(h_{MN})-\frac{\kappa\mu^*_{t+1}}{A^*_{t+1}}\right)C^*_{t+1}(h_{MN})\right]
\end{aligned}
\tag{23}
$$

[11] Optimal flexible prices are simply given by:

$$
\begin{aligned}
p(h_D) &= p(f_{MN}) = \frac{\varepsilon p^*(h_X)}{\tau} = \frac{\phi}{\phi-1}\frac{\kappa\mu_t}{A_t} \\
p^*(f_D) &= p^*(h_{MN}) = \frac{p(f_X)}{\varepsilon\tau} = \frac{\phi}{\phi-1}\frac{\kappa\mu_t^*}{A_t^*}
\end{aligned}
$$

implying $\Phi^J = \phi$.

and similar relations hold for foreign firms. Substituting profits (22) and entry costs (6) into the equations above and re-arranging, yields:

$$
\begin{aligned}
N_{Dt}^{\rho+1} &= \frac{\beta\left(1-\gamma\right)A_t}{E\Phi_{t+1}^{D}\kappa\left(1+E\Upsilon_{t+1}^{N}\left[\frac{E\Phi_{t+1}^{MN}}{E\Phi_{t+1}^{D}}\frac{\mu_t}{\varepsilon_t\mu_t^*}\left(E_t(\frac{\mu_{t+1}}{\varepsilon_{t+1}\mu_{t+1}^*})\right)^{-1}\right]^{-\frac{1}{\rho}}\right)} \qquad (24)\\
N_{Xt}^{\rho+1} &= \frac{\beta\gamma A_t E_t\left(\frac{\varepsilon_{t+1}\mu_{t+1}^*}{\mu_{t+1}}\right)}{\kappa E\Phi_{t+1}^{X}}\\
N_{MNt}^{\rho+1} &= \frac{\beta\left(1-\gamma\right)A_t^* E_t\left(\frac{\varepsilon_{t+1}\mu_{t+1}^*}{\mu_{t+1}}\right)\frac{\mu_t}{\varepsilon_t\mu_t^*}}{\kappa E\Phi_{t+1}^{*MN}\left(E\Upsilon_{t+1}^{*N}+\left[\frac{E\Phi_{t+1}^{*MN}}{E\Phi_{t+1}^{*D}}\frac{\varepsilon_t\mu_t^*}{\mu_t}\left(E_t(\frac{\varepsilon_{t+1}\mu_{t+1}^*}{\mu_{t+1}})\right)^{-1}\right]^{\frac{1}{\rho}}\right)}
\end{aligned}
$$

2.5.4 Aggregate resource constraints

Asset markets' equilibrium requires that international bonds are in zero net supply:

$$\int_0^1 B_t^i di + \int_0^1 B_t^{i^*} di = 0 \quad \int_0^1 B_t^{*i} di + \int_0^1 B_t^{*i^*} di = 0 \qquad (25)$$

Goods market clearing in the world economy requires that world supply and demand for each type of good are equalized:

$$
\begin{aligned}
N_D Y(h_D) &\geq \int_0^1 C(h_D)di \quad N_D^* Y^*(f_D) \geq \int_0^1 C^*(f_D)di^* \qquad (26)\\
N_X Y(h_X) &\geq \int_0^1 C^*(h_X)di^* \quad N_X^* Y^*(f_X) \geq \int_0^1 C(f_X)di\\
N_{MN} Y^*(h_{MN}) &\geq \int_0^1 C^*(h_{MN})di^* \quad N_{MN}^* Y(f_{MN}) \geq \int_0^1 C(f_{MN})di
\end{aligned}
$$

Finally, equilibrium in the labor market yields:

$$
\begin{aligned}
L_t &\geq \frac{1}{A_t}\left[N_{Xt-1}Y(h_X)+N_{Dt-1}Y(h_D)+N_{MNt-1}^*Y(f_{MN})+N_{Dt}^{1+\rho}+N_{Xt}^{1+\rho}+N_{MNt}^{*1+\rho}\right] \qquad (27)\\
L_t^* &\geq \frac{1}{A_t^*}\left[N_{Xt-1}^*Y^*(f_X)+N_{Dt-1}^*Y^*(f_D)+N_{MNt-1}Y^*(h_{MN})+N_{Dt}^{1+\rho}+N_{Xt}^{1+\rho}+N_{MNt}^{1+\rho}\right]
\end{aligned}
$$

where $L = \int_0^1 L^i di$ and $L^* = \int_0^1 L^{*i^*} di^*$ are, respectively, the home and foreign labor force.

Aggregating the budget constraints (7) across agents and using the government (8) and resource constraints (26) and (27), yields the balance of payments in home currency:

$$\varepsilon P_T^* C_T^* - P_T C_T + N_{MNt-1}\varepsilon\Pi_{MNt}^* - N_{MNt-1}^*\Pi_{MNt} - N_{MNt}\varepsilon q_{MNt}^* + N_{MNt}^* q_{MNt} = 0 \qquad (28)$$

where initial bond holdings are assumed to be zero in each country, i.e. $B_0 = B_0^* = 0$. As usual in the class of models that use log utility, international asset trade is redundant, implying that bond holdings will be zero in any point in time provided initial non-monetary wealth is zero as well.[12] The first two addends in the expression above constitute the trade balance, i.e. home exports less home imports. The third term is the return on the investments of home multinational corporations abroad and the fourth term is the dividends of foreign multinationals at home, their difference is therefore net factor payments. The sum of the trade balance and net factor payments constitutes the current account. The last two terms are the financing of foreign direct investments towards and from the home economy and their difference is the capital account of the balance of payments.

Substituting demands (10), profits (22) and entry cost (6) into the aggregate accounting equation (28), gives a useful expression for the nominal exchange rate as a function of real and nominal shocks:

$$\varepsilon_t = \frac{\left\{\gamma + \frac{(1-\gamma)N_{t-1}^{MN}}{\Phi_t^{MN}\left(N_{t-1}^{MN}+\Upsilon_t^{*N}N_{t-1}^{*D}\right)} - \frac{\kappa\left(N_t^{*MN}\right)^{1+\rho}}{A_t}\right\}}{\left\{\gamma + \frac{(1-\gamma)N_{t-1}^{*MN}}{\Phi_t^{*MN}\left(\Upsilon_t^{N}N_{t-1}^{*MN}+N_{t-1}^{D}\right)} - \frac{\kappa\left(N_t^{MN}\right)^{1+\rho}}{A_t^*}\right\}}\frac{\mu_t}{\mu_t^*} \tag{29}$$

The expression above, together with the free entry conditions (24), capture macroeconomic dynamics in the home economy.

2.6 Solution strategy

In what follows, it is assumed that monetary policy and productivity shocks are lognormal distributed variables defines as:

$$\begin{aligned} \mu_t &= e^{m_t} \quad \mu_t^* = e^{m_t^*} \\ A_t &= e^{a_t} \quad A_t^* = e^{a_t^*} \end{aligned}$$

where m_t, m_t^*, a_t and a_t^* are random variables with a joint Normal distribution. Without loss of generality, the stochastic processes for monetary policy and productivity are hypothesized symmetric across countries with means, respectively, $-\frac{\sigma_m^2}{2}$ and $-\frac{\sigma_a^2}{2}$ and variances σ_m^2 and σ_a^2.[13]

A log-linearized version of the model will describe the macroeconomic dynamics of the world economy in the neighborhood of a symmetric steady state where all shocks are muted, i.e. where $m = m^* = a = a^* = 0$. For notational convenience, lower-case letters will denote the log deviation of

[12] As pointed by Corsetti and Pesenti, 2002, a balanced current account is the result of three hypothesis: i) a Cobb-Douglas consumption index ii) logarithmic utility in consumption and iii) zero initial net assets.

[13] Cross-country asymmetries in cyclical conditions can still be captured by the covariances σ_{am} and $\sigma_{a^*m^*}$.

the corresponding upper-case variables, so that, for instance, $c_t = \log C_t - \log C$, with the exception of the exchange rate for which $e_t = \log \varepsilon_t - \log \varepsilon$.

3 Macroeconomic dynamics

3.1 Entry and the nominal exchange rate

The percent change in the nominal exchange rate is given by (see Appendix A for analytical details):

$$e_t = a_0 (m_t - m_t^*) + a_1 (a_t - a_t^*) + a_2 (\sigma_{am} - \sigma_{a^*m^*}) \tag{30}$$

where the constants a_0, a_1 and a_2 are defined as follows:

$$\begin{aligned}
a_0 &= \frac{2\gamma\phi + (1-\gamma)\left[2 - \phi + \beta\left(1 + \frac{1}{\rho}\right)\right]}{2\gamma\phi + (1-\gamma)\left[1 - \eta(\phi - 1) + \beta\left(1 + \frac{1}{\rho}\right)\right]} \\
a_1 &= \frac{(1-\gamma)(\phi - 1)}{2\gamma\phi + (1-\gamma)\left[1 - \eta(\phi - 1) + \beta\left(1 + \frac{1}{\rho}\right)\right]} \\
a_2 &= a_0\eta\frac{(1-\gamma)(\phi - 1)(1 + \beta)}{2\left\{2\gamma\phi + (1-\gamma)\left[1 - \beta\left(2 + \phi + \frac{1}{\rho}\right) - (1-\eta)(\phi - 1)\right]\right\}}
\end{aligned}$$

In my setup with endogenous investments, the nominal exchange rate moves in response to a wide range of cyclical fluctuations comprising cross-country differences in monetary policy and productivity. A rise in, say, home productivity, i.e. an increase in a, affects both the current and the capital account of the balance of payments, with opposing effects on the exchange rate. With sticky prices, the main implication of the productivity rise will be an (unexpected) increase in the profits of all firms established on the home soil, including the local subsidiaries of foreign multinationals. As long as multinational profits are transferred abroad, the domestic currency will tend to depreciate. On the other side, however, higher productivity reduces entry costs in home markets, thereby attracting foreign direct investments and appreciating the domestic currency. In my specification, these two effects exactly cancel out with linear entry costs, i.e. when $\rho = 0$. I stress that the exchange rate moves one to one with cross-country differences in monetary policy in this case.

In general, for positive values of ρ, the net effect of the productivity rise is a priori ambiguous. [14] Moreover, the exchange rate might under-react to global monetary conditions and even turn negative, i.e. $a_0 \leq 1$. In order to see why, consider a one percent monetary expansion at home.

[14] The coefficient a_1 turns negative for a very low value of γ and a very high value of ϕ.

Absent multinational activities, the main external implication of the monetary easing would be a one percent increase in the value of home imports. In equilibrium, the value of exports must rise by the same amount, implying that the nominal exchange rate will need to depreciate by exactly one percent (recall that the trade balance is equal to $\gamma\mu_t - \gamma\varepsilon_t\mu_t^*$, so that $e_t = m_t - m_t^*$). [15] This is not necessarily the case when there are foreign investments. On the one side, in fact, the monetary expansion boosts demand in home markets, creating a more favorable environment for foreign firms established on the home soil and for those contemplating a start-up. On the other side, however, it inflates nominal costs, thereby reducing current and prospective profits. In my specification, these potentially offsetting effects happen to cancel out exactly when pass-through is complete, i.e. with $\eta = 1$, letting the exchange rate move one to one with relative monetary policy.[16]

I finally stress that the constant term in equation (30) can be interpreted as capturing trend movements. The nominal exchange rate fluctuates around its steady state value, displaying no trend, as long as cyclical conditions are completely symmetric across countries, i.e. when $\sigma_{am} = \sigma_{a^*m^*}$. Trend movements also disappear when exchange rate changes have no consequences for final prices, namely when $\eta = 0$.

The dynamics of start-up investments in the home country is as follows:

$$\begin{aligned}
n_{Dt} &= \frac{1}{(1+\rho)}\left[\left(1-\frac{a_1}{2\rho}\right)a_t + \frac{a_1}{2\rho}a_t^* + \frac{(1-a_0)}{2\rho}(m_t - m_t^*) + \chi^D\right] \\
n_{Xt} &= \frac{1}{1+\rho}\left(a_t + \chi^X\right) \\
n_{MNt}^* &= \frac{1}{(1+\rho)}\left[\left(1+\left(1+\frac{1}{2\rho}\right)a_1\right)a_t - \left(1+\frac{1}{2\rho}\right)\left[a_1 a_t^* + (1-a_0)(m_t - m_t^*)\right] + \chi^{MN}\right]
\end{aligned} \tag{31}$$

where χ^j are constants entirely determined by uncertainty:

$$\begin{aligned}
\chi^D &= \frac{\phi-1}{2}\left[\begin{array}{c}\sigma_m^2 - \sigma_a^2 + \left(1+\frac{1}{\rho(\phi-1)}\right)a_2\left(\sigma_{am} - \sigma_{a^*m^*}\right) + \frac{(\eta^2-1)}{2}\left(a_0^2\sigma_m^2 + a_1^2\sigma_a^2\right) \\ -(2\eta-1)\left(a_0\sigma_m^2 + a_1\sigma_a^2\right) + \eta\left(a_0\sigma_{am} + a_1\sigma_a^2\right)\end{array}\right] \\
\chi^{MN} &= \chi^D - \left(1+\frac{1}{\rho}\right)a_2\left(\sigma_{am} - \sigma_{a^*m^*}\right) \\
\chi^X &= \frac{\phi-1}{2}\left(\sigma_m^2 - \sigma_a^2\right) + a_2\left(\sigma_{am} - \sigma_{a^*m^*}\right)
\end{aligned}$$

Remarkably, equations (31) show that current monetary policy shocks can affect the attractiveness of investing in one's native market as compared with overseas. In order to see the point, focus on a home monetary expansion, i.e. an increase in m. The monetary easing, by raising nominal costs

[15] Note that the amount of currency depreciation does not depend on exchange rate pass-through. The adjustment will take place with unchanged trade flows in a very low pass-through scenario, i.e. when $\eta = 0$.

[16] It is immediate to verify that $a_0 = 1$ when $\eta = 1$.

in home currency, makes a start-up in the home economy more expensive. This will clearly deter investments. The rise in m, on the other side, boosts demand in home markets, thereby attracting domestic as well as foreign investors. As it will be apparent soon, which one of these two opposing effects will actually prevail crucially depends on whether potential investors are native or foreigners.

With a unitary demand elasticity as in the traded sector the two effects discussed above exactly cancel out. A one percent monetary policy shock will lead to a proportional increase in both entry costs and prospective profits, implying that export firms will have no incentive to engage in start-up activities.[17] This is not to say, however, that monetary policy has no bearing on investments in the traded sector. Various dimensions of monetary uncertainty, as volatility and the covariance with productivity shocks, are relevant for a firm contemplating to invest. Equation (31) shows that a symmetric world-wide increase in monetary volatility, i.e. a rise in σ_m^2, leads to an upward movement in trend investments by export firms, χ_X. The finding might appear odd at first sight. In a setup with nominal rigidity, however, investors might benefit from higher volatility on the ground that it facilitates changes in world spending and relative prices that would otherwise be difficult to achieve. The same reasoning applies to the investments of domestic and multinational firms. In addition, trend investments for all classes of firms are positively associated with a rise in the covariance σ_{am}, reflecting a higher degree of cyclical stabilization. A counter-cyclical policy in fact will help reduce the variability of marginal costs and therefore the risks associated with pre-determined prices.

In the non-traded sector, the home expansion might favor investments by domestic firms at the expense of direct investments by foreign multinationals. In my specification, this happens whenever exchange rate pass-through is not complete. In order to see why, consider a foreign multinational contemplating to open an affiliate in the home country before the monetary expansion takes place. The potential investor will balance as usual prospective profits and entry costs in its own currency. Since shocks are iid and future profits are calculated using the stochastic discount factor $\beta\mu_t^*/\mu_{t+1}^*$, the current monetary easing will affect her decisions only through the exchange rate. As the home currency, say, depreciates, the expected profits of the overseas affiliate will fall (precisely, by $1 - \eta a_0$ percent). The depreciation, on the other side, will help reduce entry costs in foreign currency, although not as much as necessary (entry cost will hike by $1 - a_0$ percent). The net effect is clearly lower or equal to zero depending on $\eta \leq 1$. Note that foreign investments are deterred even when the home currency appreciates. Exit of foreign multinationals, in turn, improves the prospective profits

[17] A unitary demand elasticity implies that the percent rise in foreign demand (equal to ηa_0) coincides with the percent drop in the export price, leaving revenues (and profits) in home currency unchanged. Expected profits, which are calculated using the stochastic discount factor $\frac{\beta\mu_t}{\mu_{t+1}}$, therefore raise as much as entry costs (precisely, by one percent).

of their competitors in the non-traded sector, crowding-in investments by domestic firms.

It is worth stressing that the opposed conclusions hold when the monetary easing originates abroad. In this case, on top of the effects already mentioned (with elasticities, respectively, equal to $\eta a_0 - 1$ for profits and a_0 for costs), foreign multinationals will benefit from discounting future profits at a lower interest rate (exactly, by one per cent). They will therefore anticipate an increase in the value of their overseas assets whenever $\eta < 1$, finding it convenient to engage in investments abroad. Entry of foreign investors, in turn, will crowd-out domestic investments. The argument that the "origin" of monetary policy matters for the attractiveness of investing in one's native country as compared with overseas is reminiscent of a similar finding in Russ, 2007. The results in the two papers, however, are quite distinct. In her framework, overseas investments respond to cross-country differences in monetary volatility. In my setup, all firms incorporate into their investment decisions the fact that monetary policy can affect nominal marginal costs. This in turn implies that current monetary shocks can play a role along with structural dimensions of monetary uncertainty in re-directing investments across countries and sectors as well inside the boundaries of the firm.

I finally stress that investments in the non-traded sector depend on productivity shocks all over the world. Clearly, a rise in home productivity, by reducing entry costs in home markets, will tend to encourage all types of investments at home. More surprisingly, investments also react to a change in productivity abroad. The finding is a consequence of strictly interdependent investment decisions both across and within sectors. A rise in a^* will induce foreign firms to opt in favor of exports rather than direct investments, implying that n^*_{MN} will fall. Exit of foreign multinationals, in turn, will weaken competition in the home non-traded sector, favoring native investors.

3.2 Consumption and employment

The dynamics of consumption and employment is given by:

$$l_t = m_t + m_t^* - a_t + (\rho + 1) \sum_{j=D,X,MN} n_t^j + \frac{1}{\phi - 1} \sum_{j=D,X,MN} n_{t-1}^j \tag{32}$$

$$c_t = m_t - p_t \simeq m_t - \eta e_t + \frac{1-\gamma}{\phi - 1} \left(n_{t-1}^D - n_{t-1}^{*MN} \right) + \frac{\gamma}{\phi - 1} n_{t-1}^{*X} \tag{33}$$

Global monetary conditions are the main determinant of movements in consumption and employment, as one would expect in a setting where monetary policy controls nominal spending and output accommodates any change in aggregate demand. Productivity shocks can affect consumption only indirectly, through entry and the nominal exchange rate.[18]

[18] The minor role of supply shocks in driving aggregate consumption and output is consistent with the so-called New Keynesian view of the business cycle, as synthesised by Clarida, Galì and Gertler, 1999.

Monetary policy is transmitted in the world economy through changes in world demand and the terms of trade. An easing of the global monetary stance, wherever it is originated, boosts world demand and output and re-directs expenditure across countries. Direct consumption spillovers, as captured by ηe in (33), depend on the pricing strategies of firms active in foreign markets and will be large in a high pass-through environment. [19] Over time, indirect spillovers will also materialize through a change in the number of firms serving domestic and foreign markets.

Worldwide employment needs to increase as well when a monetary expansion is in place so as to provide a larger amount of goods for consumption. In my setup with endogenous entry, the rise in world employment is the result of an increase in intensive margins, i.e. output per firm, as well as in extensive margins.

4 Numerical simulations

The purpose of this section is to provide a quantitative illustration of firms' dynamics and international spillovers in the wake of monetary policy and productivity shocks. I will consider the percent change of key endogenous variables around the steady state when a one percent shock to monetary policy and productivity occurs.

In the benchmark model, parameters are calibrated as follows. The discount factor β is set equal to .99, which corresponds to an interest rate of 1% at the conventional quarterly frequency (4% per year). The elasticity of substitution among varieties ϕ is set at 2, implying a mark-up rate of roughly 20%, as suggested by estimates based on aggregated data. I also experiment with a higher elasticity (and a lower mark-up) in the tradition of studies that use microeconomic data, letting ϕ be equal to 5 or 10. Notice that the elasticity of substitution between traded and non-traded goods, equal to unity in the model above, is lower than the elasticity across varieties, consistently with ample empirical evidence. Obstfeld and Rogoff , 2000a argue that a unit elasticity is a reasonable base case and the empirical literature would support even a lower estimate (and therefore a higher distance relative to ϕ). In my calibration, the difference between the elasticity across varieties and the elasticity between traded and non-traded goods can vary from two to ten times, as in Obstfeld and Rogoff , 2005. The share of tradable goods in consumption γ is set at .25, roughly corresponding to the dimension of the non-traded sector that we actually observe in OECD economies. The degree of exchange rate pass-through is $\eta = .6$, consistently with the findings in Engel and Rogers, 1996

[19] The depreciation of the home currency, by deteriorating the home terms of trade, switches world expenditure in favor of home goods. Since domestic prices are pre-determined, home consumer prices rise and foreign consumer prices fall with the depreciation of the exchange rate, thereby raising consumption in both countries.

and Campa and Goldberg, 2005. The concavity of the cost function is the most difficult parameter to calibrate. Corsetti, Pesenti and Martin, 2008 suggest a value of $\rho = .5$. I will also allow for higher (more conservative) values of ρ.

Table 1 contains the response of n_t^D, n_t^{*MN}, c_t, l_t, their foreign analogues and e_t to a one percent deviation of monetary policy from steady state. The values in parenthesis refer to the log change of the corresponding variable in the model with no entry (entries equal to zero are not reported). [20]

Table 1: effects of a 1% change in m

	n^D	n^{*MN}	n^{*D}	n^{MN}	e	c	l	c^*	l^*
benchmark	.06	-.11	-.06	.11	.91 (.77)	.45 (.54)	.92 (1)	.55 (.46)	1.08 (1)
$\phi = 5$	.22	-.44	-.22	.44	.67 (.17)	.60 (.90)	.67 (1)	.40 (.10)	1.33 (1)
$\phi = 10$	.46	-.91	-.46	.91	.32 (-.58)	.81 (1.35)	.32 (1)	.19 (-.35)	1.68 (1)
$\rho = 1$	.028	-.083	-.028	.083	.89 (.77)	.47 (.54)	.89 (1)	.53 (.46)	1.11 (1)
$\rho = 10$	.0003	-.007	-.0003	.007	.86 (.77)	.48 (.54)	.93 (1)	.52 (.46)	1.07 (1)

A home monetary expansion is generally associated with a less than proportional depreciation of the domestic currency. As already noted, the exchange rate might even respond in the "wrong" direction, as it is the case in the model with no entry when $\phi = 10$. The appreciation in this case is a consequence of a sharp decline in the profits of foreign multinationals established on the home soil, leading to a fall in net profit outflows. The effect materializes in highly competitive markets, where profit margins are small.

A depreciation of the home currency reduces the relative price of goods produced on the home soil, shifting global demand towards home products (with unit elasticity) and raising world consumption. Notice that changes in world consumption, $c + c^*$, coincide with changes in world monetary policy, $m + m^*$. Relative consumption, $c - c^*$, instead, can fluctuate over time as a result of cross-country movements in real money balances.

Monetary policy can affect prices in the world economy through the nominal exchange rate as well as by influencing entry behavior. A depreciating currency makes imported goods more expensive, thereby raising consumers' prices in home currency. Entry (exit) of new firms in domestic markets,

[20] In the model with no entry, the response of the nominal exchange rate to monetary and real shocks is as follows:

$$\frac{de_t}{dm_t} = -\frac{de_t}{dm_t^*} = \frac{2\gamma\phi + (1-\gamma)\left[2-\phi\right]}{2\gamma\phi + (1-\gamma)\left[1-\eta\left(\phi-1\right)\right]}$$

$$\frac{de_t}{da_t} = -\frac{de_t}{da_t^*} = \frac{(1-\gamma)\left(1-\phi\right)}{2\gamma\phi + (1-\gamma)\left[1-\eta\left(\phi-1\right)\right]}$$

by fostering (weakening) competition, will dampen (amplify) the inflationary consequences of the monetary expansion over time. In all simulations, firms' dynamics appears to play a remarkable role in spreading the effects of monetary policy, with higher consumption spillovers under endogenous entry as compared to the model with no entry.

The boost in global demand following a home expansion can be accommodated through a change in both intensive and extensive margins in the world economy. In the benchmark model, there will be a tiny 0.6% increase in the number of domestic firms and an 11% fall in the number of foreign multinationals active on the home soil, while the opposite occurs in the foreign country. New investments are more reactive to monetary policy in highly competitive markets, where even small profit opportunities induce large changes in firms' dynamics. With $\phi = 10$, for instance, the overall number of firms established at home reduces by 45%. Output per firm, on the contrary, will move from a low of 77% with $\phi = 10$ up to almost 100% when either entry costs are extremely high or competition is weak. Adjustment at the extensive margin becomes progressively less relevant as entry costs rise and it almost disappears with $\rho = 10$.

Now, consider Table 2, displaying the effects of a one percent change in home productivity.

Table 2: effects of a 1% change in a

	n^D	n^X	n^{*MN}	n^{*D}	n^{MN}	e	c	l	c^*	l^*
benchmark	.53	.67	.95	.14	-.28	.21 (.58)	-.13 (-.35)	1.03 (-1)	.13 (.07)	-.35
$\phi = 5$	.12	.67	1.76	.55	-1.09	.82 (2.07)	-.49 (-1.24)	1.33 (-1)	.49 (.27)	-1.23
$\phi = 10$	.29	.67	1.43	.38	-.76	.57 (3.97)	-.34 (-2.38)	2.58 (-1)	.34 (.59)	-.86
$\rho = 1$	.45	.50	.70	.07	-.20	.27 (.58)	-.16 (-.35)	2.30 (-1)	.16 (.09)	-.54
$\rho = 10$	.09	.09	.03	.002	-.003	.35 (.58)	-.21 (-.35)	1.31 (-1)	.21 (.12)	-3.85

The boost in home productivity attracts new investments on the home soil in both the traded and the non-traded sector. The overall increase in start-up activities at home remains substantial even when entry costs are very high. Notice that the share of home firms that decide to serve foreign markets through export rises at the expense of those engaging in foreign investments (the opposite holds in the foreign country). The effect is particularly strong in markets with higher degrees of competition.

I stress that attracting foreign investors, however, does not come without costs. In all simulations, the domestic currency depreciates in high-productivity economies as a result of massive outflows of multinational profits. In the model with no entry, where there are no compensating FDI inflows, this effect may become extremely strong and lead to a fall in real consumption as high as 200%. The combined effect of entry in home markets and a depreciating currency worsen the home terms of trade, reducing consumption in real terms. The apparently paradoxical finding that high productivity may deteriorate welfare is reminiscent of the "immiserizing growth" by Bhagwati, 1958. In my model, the deterioration of the terms of trade is exacerbated by the decision of firms to move investments towards high productivity economies. In a context where productivity is firm-specific, however, entry might rather *increase* prices. Over time, as more firms enter a market, the average productivity in that market declines, resulting in higher prices.[21] On this ground, one could expect "immiserizing growth" to be relevant in sectors where productivity dispersion is low.[22] The question deserves further investigation. In this respect, combining firms' heterogeneity and cyclical asymmetry within a macro model provides an interesting ground for future research.

5 Conclusions

This paper has provided a simple DSGE model with nominal rigidity and endogenous entry by national and multinational firms with the aim of exploring the implications of producers' entry for monetary policy and business cycle dynamics.

The main achievements of the paper can be summarized as follows. First, I show that both the decision whether to engage in start-up investments and the choice whether to invest at home or abroad depend on various dimensions of monetary policy. A domestic monetary expansion is found to attract the investments of firms that are not exposed to exchange rate risk, as those operating in markets located in their own country. Foreign direct investments, on the contrary, might be discouraged by exchange rate fluctuations that reduce the value of the overseas assets of multinational enterprises. Moreover, I find that a rise in world monetary volatility as well as the move towards cyclical stabilization may have a positive impact on trend investments in both the traded and the non-traded sector. The result is a consequence of reducing the macroeconomic risks associated with pre-determined prices when a counter-cyclical monetary policy is in place.

Second, I find that world-wide productivity conditions can influence not only foreign investments, as one might expect, but also domestic investments. The major role of external shocks in the non-traded sector is a consequence of strictly interdependent investment decisions within and across sectors.

Finally, international consumption and employment spillovers are magnified in a setup with en-

[21] The point is made in Mélitz, 2003.

[22] I thank the referee for suggesting this point. Helpman, Mélitz and Yeaple, 2004 document ample variability in the measures of productivity heterogeneity across sectors. In the US, for instance, dispersion is the highest in Tobacco, Electronics, Transport equipments and Other electronics and the lowest in Pulp and paper, Glass, Other industrial equipments and Industrial chemicals.

dogenous entry as compared with a static framework. I argue that this may have non-negligible consequences for world welfare. In particular, the massive entry of foreign investors in high productivity economies might turn counter-productive as long as it leads to a sharp deterioration in their terms of trade.

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6 Appendix A

This appendix illustrates how to derive equation (30) in the main text. Without loss of generality, I conveniently normalize previous period shocks so that the share of exporters and multinationals is symmetric across countries and re-write the equilibrium in the balance of payment as follows:

$$\varepsilon_t = \left\{ \frac{\gamma + (1-\gamma)\left[\Phi_t^{*MN}\left(1+\Upsilon_t^{*N}\right)\right]^{-1} - \frac{\kappa}{A_t^*}\left(N_t^{MN}\right)^{1+\rho}}{\gamma + (1-\gamma)\left[\Phi_t^{MN}\left(1+\Upsilon_t^{N}\right)\right]^{-1} - \frac{\kappa}{A_t}\left(N_t^{*MN}\right)^{1+\rho}} \right\} \frac{\mu_t}{\mu_t^*}$$

Using a first order Taylor approximation around the steady state, the above equation can be expressed in terms of percent changes of the original variables as follows:

$$e_t = m_t - m_t^* + \frac{1}{\Gamma}\left[\begin{array}{c} \frac{1-\gamma}{2}\left(\tau_t^{*N} - \tau_t^N\right) + (1-\gamma)\left(\phi_t^{*MN} - \phi_t^{MN}\right) - \\ \beta(1-\gamma)(1+\rho)\left(n_t^{MN} - n_t^{*MN}\right) + \beta(1-\gamma)\left(a_t^* - a_t\right) \end{array} \right] \quad (34)$$

where $\Gamma \equiv \gamma\phi + (1-\gamma)(1-\beta)$. Similarly, approximation of the free-entry conditions at home (24) and their analogues abroad gives:

$$\begin{aligned}
n_t^D &= \frac{1}{(1+\rho)}\left[\begin{array}{c} a_t - \left(1+\frac{1}{2\rho}\right)E_t\phi_{t+1}^D + \frac{1}{2\rho}E_t\phi_{t+1}^{MN} - \frac{1}{2}E_t\tau_{t+1}^N + \\ \frac{1}{2\rho}\left(m_t - e_t - m_t^* + E_t(e_{t+1})\right) \end{array} \right] \quad (35) \\
n_t^{*D} &= \frac{1}{(1+\rho)}\left[\begin{array}{c} a_t^* - \left(1+\frac{1}{2\rho}\right)E_t\phi_{t+1}^{*D} + \frac{1}{2\rho}E_t\phi_{t+1}^{*MN} - \frac{1}{2}E_t\tau_{t+1}^{*N} - \\ \frac{1}{2\rho}\left(m_t - e_t - m_t^* + E_t(e_{t+1})\right) \end{array} \right] \\
n_t^{*MN} &= \frac{1}{(1+\rho)}\left[\begin{array}{c} a_t - \left(1+\frac{1}{2\rho}\right)E_t\phi_{t+1}^{MN} + \frac{1}{2\rho}E_t\phi_{t+1}^{D} - \\ \frac{1}{2}E_t\tau_{t+1}^N - \left(1+\frac{1}{2\rho}\right)\left(m_t - e_t - m_t^* + E_t(e_{t+1})\right) \end{array} \right] \\
n_t^{MN} &= \frac{1}{(1+\rho)}\left[\begin{array}{c} a_t^* - \left(1+\frac{1}{2\rho}\right)E_t\phi_{t+1}^{*MN} + \frac{1}{2\rho}E_t\phi_{t+1}^{*D} - \\ \frac{1}{2}E_t\tau_{t+1}^{*N} + \left(1+\frac{1}{2\rho}\right)\left(m_t - e_t - m_t^* + E_t(e_{t+1})\right) \end{array} \right] \\
n_t^X &= \frac{1}{(1+\rho)}\left[a_t - E_t\phi_{t+1t}^X - E_t(e_{t+1})\right] \\
n_t^{*X} &= \frac{1}{(1+\rho)}\left[a_t^* - E_t\phi_{t+1t}^{*X} + E_t(e_{t+1})\right]
\end{aligned}$$

I then calculate optimal preset prices (21) using the properties of lognormal variables as follows:

$$
\begin{aligned}
P(h_D) &= \frac{\phi\kappa}{\phi-1}\exp\left\{\sigma_m^2+\sigma_a^2-2\sigma_{ma}\right\} \\
P^*(f_D) &= \frac{\phi\kappa}{\phi-1}\exp\left\{\sigma_m^2+\sigma_a^2-2\sigma_{m^*a^*}\right\} \\
P(f_{MN}) &= \frac{\phi\kappa}{\phi-1}\varepsilon^{\eta}\exp\left\{\sigma_m^2+\sigma_a^2+(1-\eta)Ee+\frac{(\eta^2-1)\sigma_e^2}{2}-2\sigma_{am}-(2\eta-1)\sigma_{em}+\eta\sigma_{ae}\right\} \\
P^*(h_{MN}) &= \frac{\phi\kappa}{\phi-1}\varepsilon^{-\eta}\exp\left\{\sigma_m^2+\sigma_a^2-(1-\eta)Ee+\frac{(\eta^2-1)\sigma_e^2}{2}-2\sigma_{m^*a^*}+(2\eta-1)\sigma_{em^*}-\eta\sigma_{a^*e}\right\} \\
P^*(h_X) &= \frac{\phi\kappa\tau}{\phi-1}\varepsilon^{-\eta}\exp\left\{\sigma_a^2-(1-\eta)Ee+\frac{(\eta^2-1)\sigma_e^2}{2}-\sigma_{am}-\eta(\sigma_{ea}-\sigma_{em})-(1-\eta)\sigma_{em^*}\right\} \\
P(f_X) &= \frac{\phi\kappa\tau}{\phi-1}\varepsilon^{\eta}\exp\left\{\sigma_a^2+(1-\eta)Ee+\frac{(\eta^2-1)\sigma_e^2}{2}-\sigma_{m^*a^*}+\eta(\sigma_{ea^*}-\sigma_{em^*})+(1-\eta)\sigma_{em}\right\}
\end{aligned}
$$

substitute the resulting expressions into Φ^{MN}, Φ^D, Φ^X, Υ^N and their foreign counterparts, take logs and finally obtain:

$$
\begin{aligned}
\tau_t^{*N}-\tau_t^N &= (\phi-1)\left(2E_te_{t+1}-(2\eta-1)(\sigma_{em}+\sigma_{em^*})+\eta(\sigma_{ea}+\sigma_{ea^*})\right) \\
\phi_t^{*MN}-\phi_t^{MN} &= (\phi-1)(m_t^*-m_t+a_t^*-a_t) \\
E\phi_{t+1}^{*j}-E_t\phi_{t+1}^j &= \frac{(\phi-1)}{2}\left(\sigma_a^2-\sigma_m^2\right) \qquad j=D,X,MN
\end{aligned}
$$

Substituting these expressions back into (A1) and (A2) leads to the semi-reduced form:

$$
e_t = a_0(m_t-m_t^*)-a_1(a_t-a_t^*)+a_2\left((1-2\eta)(\sigma_{em}+\sigma_{em^*})+\eta(\sigma_{ea}+\sigma_{ea^*})\right)
$$

At this point, it is straightforward to calculate the covariances in the above expression:

$$
\begin{aligned}
\sigma_{em} &= -\sigma_{em^*}=a_0\sigma_m^2+a_1\sigma_a^2 \\
\sigma_{ea} &= a_0\sigma_{am}+a_1\sigma_a^2 \\
\sigma_{ea^*} &= -a_0\sigma_{a^*m^*}-a_1\sigma_a^2
\end{aligned}
$$

and get equation (30) in the paper. The log deviations of entry variables are obtained in a similar way.