Two Essays on Globalization and Inflation

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Abstract

This dissertation consists of two essays studying the impact of globalization on the inflation dynamics.

Inflation has considerably decreased and its volatility has sharply fallen since the 1980s in industrial countries. The first essay aims at assessing to which extent globalization, defined as a fall in iceberg trade costs, may account for the moderation of inflation over the last three decades. I develop a 2-country new-Keynesian stochastic general equilibrium model with oligopolistic competition -that generates strategic interactions- and endogenous firm entry. In the long run, globalization triggers endogenous changes in the market structure and in the degree of openness, which in turn affects the short run dynamics of inflation. Simulating the model with productivity, government spending and monetary policy shocks, I find that globalization slightly dampens the volatility of inflation. The decline in the volatility of inflation is not due to a flattening of the Phillips curve, but to foreign factors: a decrease in relative import prices or an increase in the number of foreign firms (extensive margin of trade) both weigh down on the desired markup of domestic firms and reduce inflation in the short run.

The second essay considers the decline in the sensitivity of inflation to domestic slack observed in developed countries over the last 30 years. This flattening of the Phillips curve has been often attributed to globalization. However, this intuition has so far not been formalized. I develop a general equilibrium setup that can rationalize the flattening of the Phillips curve in response to a fall in trade costs. In order to do so, I add three ingredients to an otherwise standard two-country new-Keynesian model: *strategic interactions* generate time varying desired markup; *endogenous firm entry* makes the market structure change with globalization; *heterogeneous productivity* allows for self-selection among firms. Because of productivity heterogeneity, only high-productivity firms (that are also the bigger ones) enter the export market. They tend to transmit less marginal cost fluctuations into inflation because they absorb them into their desired markup in order to protect their market share. At the aggregate level, the increase in the proportion of large firms reduces the pass-through of marginal cost into inflation.

Index words: Inflation, Phillips curve, Macroeconomic Impacts of Globalization

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Chapter 1

Impact of Globalization on Inflation: Dissecting the Transmission Channels

1.1 Introduction

Inflation has considerably decreased and its volatility has sharply fallen since the 1980s in industrial countries. Recently, inflation has remained remarkably stable despite the dramatic contraction in activity after 2008. Besides, the fall in the responsiveness of inflation to the output gap, also referred to as the flattening of the Phillips curve, has been largely documented in the literature[1] but its causes are far from being clearly identified. It is worth understanding the reasons behind this moderation of inflation because the implications for the conduct of monetary policy may be quite different depending on the driving forces.

Three plausible explanations are usually put forward for the moderation of inflation. The first one refers to a change in the nature of shocks affecting the economy, whose volatility has declined (the "good luck" story). The second explanation is about the success of monetary policy that did a great job at stabilizing inflation and anchoring expectations. The stronger credibility of the monetary policy regime is responsible for the low level of inflation that, in turn, may explain the flattening

[1] See for instance International Monetary Fund [29],Peach et al. [37] or Kohn [32].

of the Phillips curve -insofar as prices become stickier under low inflation-.[2] Under the “good luck” or “good policy” theory, the weakening of the sensitivity of inflation to economic slack is fragile and reversible. Therefore, the policymaker’s scope for fine-tuning is not as large as the apparent loosening of the inflation-output tradeoff suggests, since *(i)* the relationship precisely depends on the credibility of its action (good policy hypothesis) or *(ii)* the chance might reverse (good luck hypothesis).
A third explanation emphasizes the strengthening in competition generated by deregulation and the fall in trade costs. Globalization -measured as the openness to international trade- has dramatically accelerated since the 80’s, and this structural change could have engendered a durably low and stable inflation environment. If the flattening of the Phillips curve has been driven by structural forces, then the policymaker would have more margin to sustain economic activity without experiencing too much of inflationary pressures.

This paper aims at assessing theoretically to which extent globalization may have contributed to the lowering and the stabilization of inflation over the last three decades. I build on a two-country new-Keynesian framework twisted with two additional ingredients. The first assumption states that the competition at the sector level is oligopolistic : firms are competing in prices *à* la Bertrand. Because of oligopolistic competition, the price-elasticity of demand depends on firms’ market share and thus the desired markup fluctuates over time. This assumption renders inflation responsive to short run fluctuations in firms’ market share, as in Guerrieri et al. [27], or Benigno and Faia [5]. The second assumption is that the number of operating firms is endogenous. In the spirit of Ghironi and Melitz [25], the number of firms serving

[2] See Ball et al. [3]: if firms face menu costs when adjusting their nominal prices, they take advantage of a low inflation environment to change their prices less frequently

the domestic market and/or exporting to the foreign market is an outcome of the model driven by trade costs. Intuitively, in an oligopolistic economy, producers are concerned about loosing market share and they adjust their markup in response to marginal cost fluctuations. By contracting their markup, they alter the response of their prices to fluctuations in marginal costs.

I define globalization as a permanent decrease in the per-unit transportation cost (the melting-iceberg trade cost). When iceberg costs fall, foreign competitors export more (the *intensive* margin) and the set of firms that are able to export augments (the *extensive* margin). The increase in the number of foreign competitors on the domestic market affects endogenously the number of domestic firms since the least profitable ones are forced to exit. Ultimately the fall in trade costs modifies the market structure. The economy shifts from one steady state with very few foreign competitors and high import prices to a new one with more foreign goods, less domestic firms and lower import prices.

As far as the short run dynamics of inflation is concerned, the assumptions of oligopolistic competition and endogenous firm entry give rise to an augmented Phillips curve that exhibits new terms on the right-hand side. In addition to the marginal cost and inflation expectations, domestic inflation is also influenced in the short run by two foreign factors : the *relative import prices* effect and the *extensive margin* effect, i.e. the number of competitors on the domestic market. In the pre-globalization environment (when iceberg trade costs are high) those foreign factors vanish. They strengthen as soon as foreign competitors start entering the domestic market, supporting the global slack hypothesis: domestic inflation becomes more dependent on foreign determinants, which alleviates the role of domestic factors.

Simulating the model with productivity, government spending and monetary policy shocks, I find that globalization dampens the volatility of inflation. The decline in the volatility of inflation is not due to a flattening of the Phillips curve[3], but to foreign factors: a decrease in relative import prices or an increase in the number of foreign firms (extensive margin of trade) both squeeze the desired markup of domestic firms and thus dampen the response of inflation to marginal cost fluctuations.

The rest of the paper proceeds as follows. Section 1 places my contribution with regards to the literature. Section 2 details the model. Section 3 solves for the steady state and Section 4 compares the dynamics of inflation around the pre-globalization steady state versus the post-globalization steady state.

1.2 Related Literature

This paper relates to the literature that investigates the pro-competitive impact of globalization and its consequences on inflation.

The intuition behind the pro-competitive effect of globalization is the existence of strategic interactions: in response to a decline in the price of imported goods, domestic firms are concerned about losing market share and consequently adjust by reducing their desired markups, thus maintaining their prices relatively low. Eventually, changes in the desired markup modify the responsiveness of aggregate inflation

[3]On the contrary, the sensitivity of inflation to domestic marginal cost increases since real rigidities wane with globalization.

to real marginal costs (the slope of the Phillips curve). Standard NKPC models with Dixit-Stiglitz monopolistic competition fail to capture the impact of globalization on the pricing behavior of domestic firms because there are no strategic interactions. There is an infinite number of very small firms whose share on the market is negligible. Each firm considers that its decision has no impact on the market and therefore does not behave strategically. It turns out that the price-elasticity of demand faced by each firm is fixed and their desired markup is also constant.[4] This is why globalization does not have any pro-competitive effect on the economy in monopolistic competition setups.

My work follows a stream of the literature that incorporates strategic complementarities into otherwise standard new-Keynesian setups. Sbordone [38] and Guerrieri et al. [27] typically introduce *demand*-side complementarities by modifying the standard CES utility function. The authors rely on preferences *à* la Kimball (1995) that pose a relationship between the elasticity of substitution and the number of goods available on the market. Sbordone [38] builds a closed economy model to focus especially on these pro-competitive pressures. Globalization is identified as an increase in the total number of varieties/firms competing in the domestic market and she finds that for plausible parameter values, this engenders a steepening of the Phillips Curve. Guerrieri et al. [27] develop an open economy model and show that foreign prices do account for the moderation of inflation in the US. One fragility of the demand-side complementarity approach though is the lack of micro-foundations behind the Kimball aggregator.

[4]The actual markup varies in response to marginal cost fluctuation due to a sluggish adjustment in prices but the desired markup is fixed.

Instead my model relies on *supply*-side complementarities that arise from a change in the market structure : oligopolistic competition replaces monopolistic competition.[5] Following Dornbusch [21] and Benigno and Faia [5] I consider that firms are “big" enough at the sector level to affect sectoral price. Thus they internalize this effect when setting their optimal price.

Whatever the motivation behind strategic complementarities, they engender a time varying desired markup that changes with the firm's market share. If their market share falls, firms loose pricing power and their markup contracts. Therefore firms do not fully pass through fluctuations in their marginal costs to the prices (a fraction is absorbed in the markup adjustment). Fluctuations in the desired markup eventually affect the inflation dynamics.

My paper differs from the aforementioned literature in that the market structure is endogenous. In the previous models the number of firms/varieties is exogenous and globalization is modeled as an *ad-hoc* increase in the number of varieties in steady state. Introducing endogenous firm entry generates two new features.

First, the market structure is an outcome of the model, not an assumption. The steady state number of competitors is endogenous and depends on the per-unit iceberg trade cost, the distribution of market penetration fixed costs and the elasticity of substitution between varieties. The steady state market share of domestic firms determines the sensitivity of inflation to domestic marginal costs.

[5]The standard monopolistic case is nested in this framework if the intra-sectoral elasticity of substitution, θ, equals the inter-sectoral elasticity, σ.

Second, I find that inflation is influenced in the short run by marginal costs and inflation expectations and also by the cyclical fluctuations in the average market share of firms as in Benigno and Faia [5] or Guerrieri et al. [27]. However, by contrast to the previous papers, this “market share" channel does not uniquely consists in *relative import prices* but also depends on the *extensive margin of trade*. Following a positive productivity shock in the foreign country, relative import prices fall and the number of foreign varieties consumed domestically increase. Everything else being equal, those two effects shift the Phillips curve downwards.

Cecioni [17] and Etro and Colciago [22] also rely on oligopolistic competition and endogenous firm entry assumptions but in a *closed* economy framework. They find that short run markups vary countercyclically because, after a positive shock, the entry of new firms reduces their market share. Cecioni [17] concludes that a cyclical increase in the number of operating firms lowers CPI inflation in the short run[6]. A closely related series of papers deals with optimal monetary policy under endogenous entry : Bilbiie et al. [13], Bilbiie et al. [12], Faia [23], and Bergin and Corsetti [6] all study models with endogenous firm entry and sluggish price adjustment to derive the optimal monetary policy. Those papers are connected to mine but they restrict to a *closed* economy and they focus on optimal policy while I am assessing the effects of globalization.

My work is also connected to a more empirical literature that considers the world-wide level of resource utilization as a potential determinant of domestic inflation. Borio and Filardo [14] provide empirical evidence that inflation has become more sensitive to the global output gap (measured as a weighted average of trade partner

[6]Etro and Colciago [22] develop a flexible price environment.

output gaps) to the detriment of domestic conditions. But Ihrig et al. [28] criticize the robustness of their estimates. From a theoretical perspective, this paper corroborates the global slack hypothesis.

Finally, this work is linked to two important papers in open economy that combines extensive margin of trade and general dynamic equilibrium (but in a *flexible* price environment).

First, my model borrows many ingredients from Ghironi and Melitz [25], in particular *(i)* the simultaneous entry mechanism[7] and *(ii)* firms' heterogeneity that determines an endogenous cutoff level pinning down the average productivity of exporting firms as well as the number of exporting firms. However I depart from their setup in many aspects.
Firstly I contemplate a new-Keynesian economy with price adjustment costs. Coupled with the assumption of trade costs -that segment the market-, this triggers Pricing-to-Market[8] while the Law-of-One-Price holds in Ghironi and Melitz [25]. In addition I assume oligopolistic competition and I relax the heterogeneity in firms' productivity. Instead I suppose that firms are symmetric in terms of labor productivity but face different market penetration costs. This is a way to keep the model tractable with

[7] At each period of time, new firms enter "simultaneously", up to the point where the entry cost equals the average firm expected value. The average profit depends on the number of operating firms. At equilibrium the free entry condition binds, which means that the entry of one additional firm would reduce the market share of operating firms in such a way that their net profit would become negative. The simultaneous entry mechanism differs from the sequential entry procedure in Atkeson and Burstein [2] where potential entrants wait in line for penetrating the market.

[8] A producer facing a shock on its relative marginal cost adjusts its relative price on the domestic and on the foreign market differently because the markup is different on each market.

oligopolistic competition.[9]

Second, my work also share crucial elements with Atkeson and Burstein [2]. They rely on a two-country economy with oligopolistic competition and endogenous firm entry. They consider the flexible price case and focus on explaining deviations from the Purchasing Power Parity. An important difference with Ghironi and Melitz [25] is the timing for firm entry. Atkeson and Burstein [2] rely on a sequential entry mechanism : in each sector firms wait in line (sorted by decreasing productivity) and enter one by one, knowing all the characteristics of the competitors already operating in that sector. Instead, I keep the simultaneous entry mechanism, as in Ghironi and Melitz [25], that makes the model analytically tractable.

Similarly to Atkeson and Burstein [2], my model endogenously triggers Pricing-To-market, however this result comes from the conjunction of different assumptions. Pricing-to-Market behavior means that, for a same variation in marginal cost, firms adjust differently their prices on domestic and foreign market. PTM typically arises from the combination of two assumptions *(1)* market segmentation and *(2)* time variable markups. The idea is that, if markups were fixed, then the firms would adjust similarly their prices on the foreign and the domestic market despite the segmentation due to trade costs. In my model, the assumption of price stickiness is sufficient to create a time varying markup.[10] On the contrary, Atkeson and Burstein [2] rely on a flexible price framework and the assumption of oligopolistic competition is a necessary condition for departing from the Law-of-One-Price.

[9]See sections 1.3.2 and 2.3.1 for a detailed comparison of Ghironi and Melitz [25] model with respect to my setup.

[10]As in Betts and Devereux [11].

1.3 Model

The economy is composed of two countries, domestic (d) and foreign (f). In each country there exists a continuum of sectors on $[0, 1]$, indexed by k, producing differentiated goods $Y_t(k)$. Within each sector, there is only a finite and relatively small number of firms that compete in prices *à* la Bertrand.

1.3.1 Households

The problem of the representative household in country D is

$$\max_{\left\{C_t, L_t, B_t^d, B_t^f, u_t\right\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t)$$

$$\text{s.t.} : P_t C_t + B_t^d + P_t \frac{\phi_b}{2} \left(\frac{B_t^d}{P_t} \right)^2 + e_t B_t^f + e_t P_t \frac{\phi_b}{2} \left(\frac{B_t^f}{P_t^*} \right)^2 + u_t(\tilde{N}_t + \tilde{N}_{e,t}) \tilde{v}_t P_t$$

$$\leq R_{t-1} B_{t-1}^d + e_t R_{t-1}^* B_{t-1}^f + W_t L_t + u_{t-1} \left[\tilde{N}_t (\tilde{d}_t + \tilde{v}_t) P_t \right] + T_t^B - T_t^G$$

where C_t is the consumption of final good at time t, β is a subjective discount factor, L_t is the supply of hours of work and the utility function is $U(C_t, L_t) = \left[\frac{C_t^{1-\gamma}}{1-\gamma} - \frac{L_t^{1+\nu}}{1+\nu} \right]$. W_t is the nominal wage determined competitively on the labor market and P_t is the consumption price. Households can invest in three types of assets: domestic risk free bonds, foreign risk free bonds and shares in a mutual fund of domestic firms. B_t^d is the quantity of domestic risk-free bonds purchased at $t-1$. $R_t = 1 + r_t^n$ and $R_t^* = 1 + r_t^{*n}$ are respectively the nominal return on domestic and foreign risk-free bonds from $t-1$ to t. Domestic bonds are issued by domestic households and denominated in domestic currency. Foreign bonds are issued by foreign households and denominated in foreign currency. To solve the indeterminacy problem for bonds holdings at steady state, I assume quadratic costs of adjusting bonds. Those costs are collected by financial intermediaries that rebate them to households (T_t^B). e_t is the nominal exchange rate and should be read as "1 unit of F currency = e_t units of D currency".

All the variables for the country F are denoted symmetrically with a '*'.
u_t is the number of share holdings in a mutual fund of domestic firms. The household enters period t with share holding u_{t-1} and receives income from dividend $(\tilde{d}_t P_t)$ on its share holdings plus the value of selling its share position $(\tilde{v}_t P_t)$. $\tilde{v}_t$ is the average firms' share value in real terms (in domestic units of consumption), and $\tilde{d}_t$ is the average firms' dividends.

At time t, resources are used to consume and to buy u_t shares in the mutual fund composed of $\tilde{N}_t + \tilde{N}_{e,t}$ domestic firms and $-T_t^G$ are nominal fiscal transfers. $\tilde{N}_t$ is the total number of domestic firms already active at time t and $\tilde{N}_{e,t}$ is the number of new firms entering the economy D at time t and who start producing at $t+1$. They face the same exogenous rate of exit δ as old firms already present on the market. So $(1-\delta)$ of the firms will survive and pay dividends at time $t+1$: $\tilde{N}_{t+1} = (1-\delta)(\tilde{N}_t + \tilde{N}_t^e)$. The exogenous destruction rate is required for the number of firms to be finite and going back to equilibrium after a shock.
Among the $\tilde{N}_t$ domestic firms on the market at time t, N_t^d firms are selling goods on the domestic market and N_t^{d*} are exporting to the country F. The two sets may overlap since some domestic firms might be both a domestic market supplier and an exporter.
Optimality conditions for the representative household are detailed in Appendix A.1.

1.3.2 Firms and Production

Final goods producer

A non-tradable final good Y_t is composed of differentiated goods from a continuum of sectors

$$Y_t = \left[\int_0^1 Y_t(k)^{\frac{\sigma-1}{\sigma}} dk\right]^{\frac{\sigma}{\sigma-1}}$$

where σ is the elasticity of substitution between goods from different sectors. In each sector k, a retailer firm combines foreign and domestic goods to produce $Y_t(k)$. The final goods producer chooses its optimal production plans to maximize its profit:

$$\max_{x_t(i|k)} P_t(k)Y_t(k) - \sum_{i=1}^{N_t^k} P_t(i|k)x_t(i|k)$$

$$\text{s.t.} Y_t(k) = \left[\sum_{i=1}^{N_t^k} x_t(i|k)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} = \left[\sum_{i=1}^{N_t^{d|k}} x_t(i|k)^{\frac{\theta-1}{\theta}} + \sum_{j=1}^{N_t^{f|k}} x_t(j|k)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$$

where $N_t^{d|k}$ and $N_t^{f|k}$ are respectively the number of domestic and foreign varieties consumed in sector k on domestic market at time t.

A *variety* i is equivalent to a good or a firm since each firm produces one differentiated good. For the sake of simplicity the number of varieties N is continuous rather than discrete. This assumption means that N should be interpreted as a variety index -a proxy for the market structure-, rather than strictly the number of firms. Hereafter N is continuous and "small enough" for strategic interactions to hold.[11]

[11]This shortcut borrows from Barro and i Martin [4], chapter 6 "Technological Change: Models with an Expanding Variety of Products" : *We shall find it convenient to think of the number of varieties, N, as continuous rather than discrete. This assumption is unrealistic if we view N as literally the number of kinds of intermediate goods employed, although the error would be small if N is large.* A similar setup where N is continuous but small at the sector level also appears in Rotemberg and Woodford (JPE, 1992) and is used by Jaimovich and Floetotto [31] : *It is assumed that the economy contains a large number of sectors. Each sector is comprised of a finite number of differentiated, monopolistically competitive intermediate firms. Within a given sector, each firm takes into account the effect that the*

Optimality Conditions:

$$x_t(i|k) = \left(\frac{P_t(i|k)}{P_t(k)}\right)^{-\theta} Y_t(k) = \left(\frac{P_t(i|k)}{P_t(k)}\right)^{-\theta} \left(\frac{P_t(k)}{P_t}\right)^{-\sigma} Y_t$$

where $P_t(k) = \left[\sum_{i=1}^{N_t^k} P_t(i|k)^{1-\theta}\right]^{\frac{1}{1-\theta}} = \left[\sum_{i=1}^{N_t^{d|k}} P_t(i|k)^{1-\theta} + \sum_{j=1}^{N_t^{f|k}} P_t(j|k)^{1-\theta}\right]^{\frac{1}{1-\theta}}$
and $P_t = \left[\int_0^1 P_t(k)^{1-\sigma} dk\right]^{\frac{1}{1-\sigma}}$.

Alternatively I could define $Y_t(k) = N_t^{k\,\frac{-1}{\theta-1}} \left[\sum_{i=1}^{N_t^k} x_t(i|k)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$ and then the demand would write as $x_t(i|k) = \left(\frac{P_t(i|k)}{P_t(k)}\right)^{-\theta} \frac{Y_t(k)}{N_t^k}$ where $P_t(k) = N_t^{k\,\frac{1}{\theta-1}} \left[\sum_{i=1}^{N_t^k} P_t(i|k)^{1-\theta}\right]^{\frac{1}{1-\theta}}$. This specification eliminates the "love for variety" channel by which consumers can increase their utility just by spreading their consumption across more varieties.

INTERMEDIATE GOODS PRODUCERS

1. **Market structure: oligopolistic competition generates a time varying price-elasticity of demand.**

   A firm is not small with respect to the sector and competes in prices *à* la Bertrand. Producers internalize the impact on the sectoral price when choosing their optimal price ($\frac{\partial P_t(k)}{\partial P_t(i|k)} \neq 0$ in the firm's optimization programm). Consequently the elasticity of demand to its own price is not constant (although the elasticity of substitution between goods in sector k is constant: θ).

$$-\frac{\partial x_t(i|k)}{\partial P_t(i|k)} \frac{P_t(i|k)}{x_t(i|k)} = \theta - (\theta - \sigma)\left(\frac{\partial P_t(k)}{\partial P_t(i|k)} \frac{P_t(i|k)}{P_t(k)}\right)$$

pricing and production decisions of other firms have on the demand for its goods. The price elasticity of demand faced by the typical firm is thus positively related to the number of firms in the sector. Finally, Faia [23] similarly has a continuous index of variety N with oligopolistic competition.

where $\frac{\partial P_t(k)}{\partial P_t(i|k)} \frac{P_t(i|k)}{P_t(k)} = \frac{P_t(i|k) x_t(i|k)}{P_t(k) Y_t(k)} = \left[\frac{P_t(i|k)}{P_t(k)}\right]^{1-\theta} = \xi_t(i|k)$, the market share of firm i in sector k.

2. **Price Adjustment Cost**

   Prices are sticky following Rotemberg price setting. ϕ_p is a parameter measuring the cost of adjusting prices.

   $PAC_t(i|k) = \frac{\phi_p}{2}\left[\frac{P_t(i|k)}{P_{t-1}(i|k)} - 1\right]^2 \frac{P_t(i|k)}{P_t} x_t(i|k)$ is the cost for firm i in sector k of adjusting its price at time t, expressed in units of final consumption. This cost can be interpreted as the amount of material that a firm must purchase in order to implement a price change.

3. **Technology, domestic and foreign market penetration costs**

   Each firm produces a different variety of goods but they all have the same linear technology : $\forall$ good $i, \forall$ sector $k, x_t(i|k) = A_t h_t(i|k)$. The production function has constant returns to scale and labor is the only input. The real marginal cost of production in country D is $\frac{W_t}{P_t A_t} = \frac{w_t}{A_t} = s_t$ and $\frac{w_t^*}{A_t^*} = s_t^*$ in country F.

   A domestic firm i can produce for the domestic market and/or the foreign market and faces a specific penetration cost on each market (D and F) that is drawn for a probability distribution. The domestic market penetration fixed cost drawn by i is $f_H(i)$ and the foreign market penetration fixed cost is $f_X(i)$. Fixed costs are firm specific and do not vary over time. Following Ghironi and Melitz [25], I assume that those costs are paid in terms of effective labor units. In addition to the fixed market penetration cost $f_X(i)$, an exporter also faces a melting-iceberg cost ($\tau \geq 1$, the same for all firms). To sell one unit of good to the foreign country, the exporter must produce and ship τ units because $\tau - 1$ units melt on the way.

4. **Profit Maximization**:

For simplicity, I suppose that all sectors are identical[12] and from now on I drop the index k. N_t differentiated goods are sold in each sector k: N_t^d goods are produced by domestic firms and N_t^f by foreign firms, such that $N_t = N_t^d + N_t^f$. Symmetrically in a representative sector of country F, N_t^* differentiated goods are consumed: $N_t^* = N_t^{d*} + N_t^{f*}$ where N_t^{d*} is the number of varieties produced by firms located in country D and consumed in country F and N_t^{f*} is the number of varieties produced by firms located in country F and consumed in country F. Because of trade costs markets are segmented and a domestic firm i can set a different price on domestic and foreign markets in order to maximize its total profit.

Maximization of the domestic component of profits

$$\max_{P_{t+j}^d(i)} \sum_{j=0}^{\infty} \mathbb{E}_t \Bigg[(1-\delta)^j Q_{t,t+j} \Bigg(P_{t+j}^d(i) x_{t+j}(i) - \frac{W_{t+j}}{A_{t+j}} x_{t+j}(i) \\ - \frac{\phi_p}{2} \Big(\frac{P_{t+j}^d(i)}{P_{t+j-1}^d(i)} - 1 \Big)^2 P_{t+j}^d(i) x_{t+j}^d(i) - f_{H,t+j}(i) \frac{W_{t+j}}{A_{t+j}} \Bigg) \Bigg]$$

s.t.

$$x_t^d(i) = \left(\frac{P_t^d(i)}{P_t} \right)^{-\theta} Y_t$$

$Q_{t,t+j}$ is a stochastic discount factor: $Q_{t,t+j} = \beta^j \dfrac{U'(C_{t+j})}{U'(C_t)} \dfrac{P_t}{P_{t+j}}$

Optimality conditions :

$$\frac{P_t^d(i)}{P_t} = p_t^d(i) = \tilde{\mu}_t^d(i) \frac{w_t}{A_t}$$

[12]In section 2.2.5 I demonstrate why this is true.

where:

$$
\begin{aligned}
\tilde{\mu}_t^d(i) &= \frac{\tilde{\theta}_{i,t}^d}{(\tilde{\theta}_{i,t}^d - 1)\left[1 - \frac{\phi_p}{2}(\Pi_{i,t}^d - 1)^2\right] + \phi_p \Pi_{i,t}^d(\Pi_{i,t}^d - 1) - \Gamma_{i,t}} \\
\tilde{\theta}_{i,t}^d &= \left| \frac{\partial x_t^d(i)}{\partial P_t^d(i)} \frac{P_t^d(i)}{x_t^d(i)} \right| = \theta - (\theta - \sigma)\left(\frac{\partial P_t}{\partial P_t^d(i)} \frac{P_t^d(i)}{P_t}\right) = \theta - (\theta - \sigma) {p_{i,t}^d}^{1-\theta} \\
\Gamma_{i,t}^d &= \phi_p \mathbb{E}\left[Q_{t,t+1}(1-\delta){\Pi_{i,t+1}^d}^2(\Pi_{i,t+1}^d - 1)\frac{x_{t+1}^d(i)}{x_t^d(i)}\right] \\
\Pi_{i,t}^d &= \frac{P_t^d(i)}{P_{t-1}^d(i)}
\end{aligned}
$$

Note that under flexible prices the markup becomes $\mu_t^{d,desired} = \frac{\tilde{\theta}_{i,t}^d}{\tilde{\theta}_{i,t}^d - 1}$. Unlike monopolistic competition, the desired market is not constant over time but depends on the firm's market share: $\tilde{\theta}_{i,t}^d = \theta - (\theta - \sigma)\xi_t^d(i)$. If $\theta = \sigma$ the model collapses to the monopolistic case and $\mu_t^{d,desired} = \frac{\theta}{\theta - 1}$. It means that the elasticity of substitution within a sector is equal to the elasticity of substitution between sectors. Since there is an infinity of sectors, this yields back to the standard monopolistic case and the strategic interactions, that were taking place within a sector, vanish. If the market share $\xi_t^d(i)$ tends to zero (either N_t^d or N_t^f is very high), the market structure also becomes monopolistic.

Maximization of the exports component of profits

$$
\max_{P_{t+j}^{d*}(i)} \sum_{j=0}^{\infty} \mathbb{E}_t \Bigg[(1-\delta)^j Q_{t,t+j}\Bigg(P_{t+j}^{d*}(i)x_{t+j}^{d*}(i) - \tau_t \frac{W_{t+j}/e_t}{A_{t+j}} x_{t+j}^{d*}(i)
- \frac{\phi_p}{2}\Big(\frac{P_{t+j}^{d*}(i)}{P_{t+j-1}^{d*}(i)} - 1\Big)^2 P_{t+j}^{d*}(i)x_{t+j}^{d*}(i) - \frac{f_{X,t+j}(i)w_{t+j}P_{t+j}^*}{rer_{t+j}A_{t+j}}\Bigg)\Bigg]
$$

s.t.

$$
\begin{aligned}
x_t^{d*}(i) &= \left(\frac{P_t^{d*}(i)}{P_t^*}\right)^{-\theta} Y_t^* \\
Q_{t,t+j} &= \beta^j \frac{U'(C_{t+j})}{U'(C_t)} \frac{P_t}{P_{t+j}}
\end{aligned}
$$

rer_t is the real exchange rate and e_t the nominal exchange rate: $rer_t = \frac{P_t^* e_t}{P_t}$

Optimality conditions :

$$\frac{P_t^{d*}(i)}{P_t^*} = p_t^{d*}(i) = rer_t^{-1}\tilde{\mu}_t^{d*}(i)\tau_t \frac{w_t}{A_t}$$

Firms' dividends

For a firm i in country D, the dividend (expressed in units of domestic consumption) is the sum of the profit from sales on the domestic market and the profit from sales on the foreign market $d_t(i) = d_t^d(i) + d^{d*}(i)$ where:

$$d_t^d(i) = \begin{cases} 0 & \text{if the firm does not sell in D.} \\ \left[1 - \frac{1}{\tilde{\mu}_t^d(i)} - \frac{\phi_p}{2}[\Pi_t^d(i) - 1]^2\right] x_t^d(i) \frac{P_t^d(i)}{P_t} - \frac{w_t}{A_t} f_H(i) & \text{otherwise.} \end{cases}$$

$$d_t^{d*}(i) = \begin{cases} 0 & \text{if the firm does not export.} \\ rer_t \left[1 - \frac{1}{\tilde{\mu}_t^{d*}(i)} - \frac{\phi_p}{2}[\Pi_t^{d*}(i) - 1]^2\right] x_t^{d*}(i) \frac{P_t^{d*}(i)}{P_t} - \frac{w_t}{A_t} f_X(i) & \text{otherwise.} \end{cases}$$

where $f_H(i)$ and $f_X(i)$ are random variables. $\Pi_t^d(i) = \frac{P_t^d(i)}{P_{t-1}^d(i)}$, $\Pi_t^{d*}(i) = \frac{P_t^{d*}(i)}{P_{t-1}^{d*}(i)}$.

Cutoff values and firms average

Firms have the same labor productivity but they differ in their fixed costs, $f_H(i)$ and $f_X(i)$, that are drawn independently by each firm i from the following uniform distributions:

$$f_H \sim U\left[a_H, b_H\right]$$

$$f_X \sim U\left[a_X, b_X\right]$$

- **Average profit from home sales**

It is profitable for a firm i in country D to produce for the domestic market if its fixed cost draw $f_H(i)$ is below the cutoff value $\overline{f_{H,t}} = \sup\left\{f_{H,t},\ \text{st. } d_t^d(f_{H,t}) \geq 0\right\}$. For a firm from country F, the cutoff writes $\overline{f_{H,t}^*} = \sup\left\{f_{H,t}^*,\ \text{st. } d_t^{f*}(f_{H,t}^*) \geq 0\right\}$. Since profit is a decreasing function with respect to fixed cost, the cutoff value is:

$$\overline{f_{H,t}}\frac{w_t}{A_t} = \left[1 - \frac{1}{\tilde{\mu}_t^d} - \frac{\phi_p}{2}[\Pi_t^d(i) - 1]^2\right] p_t^{d(1-\theta)} Y_t$$
$$\overline{f_{H,t}^*}\frac{w_t^*}{A_t^*} = \left[1 - \frac{1}{\tilde{\mu}_t^{f*}} - \frac{\phi_p}{2}[\Pi_t^{f*}(i) - 1]^2\right] p_t^{f*(1-\theta)} Y_t^*$$

Consequently, the probability for a domestic firm of supplying the domestic market is $G_H(\overline{f_{H,t}}) = \mathbb{P}(f \leq \overline{f_{H,t}}) = \frac{\overline{f_{H,t}} - a_H}{b_H - a_H}$. And the average fixed cost of domestic firms that are active on the domestic market is : $\widetilde{f_{H,t}} = \frac{a_H + \overline{f_{H,t}}}{2}$. Symmetrically in country F: $G_H(\overline{f_{H,t}^*}) = \mathbb{P}(f \leq \overline{f_{H,t}^*}) = \frac{\overline{f_{H,t}^*} - a_H}{b_H - a_H}$. And the average fixed cost of foreign firms active in the foreign market is : $\widetilde{f_{H,t}^*} = \frac{a_H + \overline{f_{H,t}^*}}{2}$.

Since all firms are symmetric in terms of productivity and only differ in their fixed cost draw, the average profit from domestic sales is

$$\begin{aligned}\tilde{d}_t^d &= \left[1 - \frac{1}{\tilde{\mu}_t^d} - \frac{\phi_p}{2}[\Pi_t^d - 1]^2\right] p_t^{d(1-\theta)} Y_t - \widetilde{f_{H,t}}\frac{w_t}{A_t} \\ &= \left[1 - \frac{1}{\tilde{\mu}_t^d} - \frac{\phi_p}{2}[\Pi_t^d - 1]^2\right] p_t^{d(1-\theta)} Y_t - \frac{a_H + \overline{f_{H,t}}}{2}\frac{w_t}{A_t}\end{aligned}$$

- **Average profit from exports**

It is profitable for a firm to export if its fixed cost draw $f_X(i)$ is below the cutoff value $\overline{f_{X,t}} = \sup\left\{f_{X,t},\ \text{st. } d_t^{d*}(f_{X,t}) \geq 0\right\}$ in country D and $\overline{f_{X,t}^*} = \sup\left\{f_{X,t}^*,\ \text{st. } d_t^f(f_{X,t}^*) \geq 0\right\}$ in country F. Hence:

$$\overline{f_{X,t}}\frac{w_t}{A_t} = rer_t\left[1 - \frac{1}{\tilde{\mu}_t^{d*}} - \frac{\phi_p}{2}[\Pi_t^{d*} - 1]^2\right] p_t^{d*(1-\theta)} Y_t^*$$

$$\overline{f_{X,t}^*}\frac{w_t^*}{A_t^*} = rer_t^{-1}\left[1 - \frac{1}{\tilde{\mu}_t^f} - \frac{\phi_p}{2}[\Pi_t^f - 1]^2\right] p_t^{f(1-\theta)} Y_t$$

Consequently, the probability for a firm from country D of being an exporter is $G_X(\overline{f_{X,t}}) = \mathbb{P}(f \leq \overline{f_{X,t}}) = \frac{\overline{f_{X,t}}-a_X}{b_X-a_X}$. And the average fixed cost of domestic exporters is: $\widetilde{f_{X,t}} = \frac{a_X+\overline{f_{X,t}}}{2}$.

Symmetrically for a firm from country F : $G_X(\overline{f_X^*}) = \mathbb{P}(f \leq \overline{(f_{X,t}^*)}) = \frac{\overline{f_{X,t}^*}-a_X}{b_X-a_X}$.

And the average fixed cost of foreign exporters is $\widetilde{f_{X,t}^*} = \frac{a_X+\overline{f_{X,t}^*}}{2}$.

Eventually the average profit from exports is

$$\begin{aligned}\tilde{d}_t^{d*} &= rer_t\left[1-\frac{1}{\tilde{\mu}_t^{d*}}-\frac{\phi_p}{2}[\Pi_t^{d*}-1]^2\right]p_t^{d*(1-\theta)}Y_t^*-\widetilde{f_{X,t}}\frac{w_t}{A_t}\\ &= rer_t\left[1-\frac{1}{\tilde{\mu}_t^{d*}}-\frac{\phi_p}{2}[\Pi_t^{d*}-1]^2\right]p_t^{d*(1-\theta)}Y_t^*-\frac{a_X+\overline{f_{X,t}}}{2}\frac{w_t}{A_t}\end{aligned}$$

Endogenous Firm entry

The equity mutual fund -that collects households' savings - invests in setting up $\tilde{N}_{e,t}$ new firms. A large mass of prospective entrepreneurs is waiting to enter and new firms are created up to the point where the expected discounted stream of future profits (the net present value of an average firm in the mutual fund) equals the entry cost $f_{E,t}$. At equilibrium there is no more incentive for additional firms to enter:

$$\tilde{v}_t = f_{E,t}\frac{W_t}{A_tP_t}$$

where

$$\tilde{v}_t = \beta(1-\delta)\mathbb{E}_t\left[\tilde{v}_{t+1}+\tilde{d}_{t+1}\right]$$

$$\tilde{d}_t = G(f_{H,t})\tilde{d}_t^d + G(f_{X,t})\tilde{d}_t^{d*}$$

Note that $\tilde{d}_t$ is the average dividend distributed to shareholders by firms in the mutual funds. The decision to create new firms is taken prior to knowing firms' specific fixed costs draws $f_H(i)$ and $f_X(i)$ and prior to knowing their specific sector, based on the distribution of fixed costs $(G(.))$[13]. The timing schedule is described in figure 1.1. Equilibrium conditions hold symmetrically for the foreign country.

1. Firms pay entry cost to become active on the market.

2. Only $(1-\delta)$ of all active firms survive. A proportion δ of them are hit by the exit shock and never produce.

3. The surviving firms draw their fixed costs, which determines their type : type d if $f_H(i) \leq \overline{f_H}$, type d^* if $f_X(i) \leq \overline{f_X}$, and not operating if both fixed costs are above the cutoff values. The very same firm might be both type d and d^*. Since there is an infinity of sectors, the number of firms in the mutual fund is infinitely large and the realized distribution of costs (*post*-entry) is the same as the true probability distribution (*pre*-entry) : $\underbrace{\frac{N^d}{\tilde{N}}}_{realized} = \underbrace{\mathbb{P}(f \leq \overline{f_H})}_{theoretical}$ and $\underbrace{\frac{N^{d*}}{\tilde{N}}}_{realized} = \underbrace{\mathbb{P}(f \leq \overline{f_X})}_{theoretical}$.

4. Firms are allocated across sectors following the same proportions : N^d firms of type d and N^{d*} firms of type d^* in each sector. At the sector level, the number of firms is not infinity but small enough for strategic interactions to take place. Sectors are symmetric in the sense that the number of domestic market suppliers N^d and the number of exporters N^{d*} are identical in each sector. Consequently the average prices $P_t(k)$ and quantities $Y_t(k)$ are the same across sectors because they only depend on the number of competitors, relative

[13]Since entry is simultaneous and not sequential as in Atkeson and Burstein [2], it makes sense to suppose that firms take their decision before knowing the realized distribution of fixed costs of their competitors within the sector.

prices, iceberg costs and productivity but not on fixed costs.

Despite the symmetry in firms' optimal choice, the actual realized profit may be different among firms. To understand this point, suppose that firms i and i' are both the same type d^* because $f_{X,t}(i) < f_{X,t}(i') < \overline{f_{X,t}}$. Firms i and i' set the same optimal price p_t^{d*} but i gets a higher profit than i'. Therefore, the average profit may differ across sectors depending on the specific costs draw of firms within the sector. However households care only about the average dividend *across* sectors that equals the expected dividend *ex ante* because there is an infinite continuum of sectors; the law of large number holds in the aggregate, not at the sector level:

$$\tilde{d}_t = G(f_{H,t})\tilde{d}_t^d + G(f_{X,t})\tilde{d}_t^{d*} = \int_0^1 \left(\frac{1}{\tilde{N}_t^k} \sum_{i=1}^{N_t^{d|k}} d_t^d(i|k) + \frac{1}{\tilde{N}_t^k} \sum_{j=1}^{N_t^{d*|k}} d_t^{d*}(j|k) \right) dk$$

The assumption on the timing for firms' entry ensures that the actual average dividend redistributed to households *post*-entry is the same as the expected dividend *pre*-entry. The fact that prospective entrants correctly anticipate the average firm value makes the model tractable while allowing for heterogeneity between firms and strategic interactions. The timing enables to reconcile two opposite forces at work in the model: on the one hand, the number of firms is “small" at the sector level for strategic interactions to make sense; on the other hand the number of firms must be large for the actual realization of average dividend to coincide with its theoretical expected value.[14]

The model is now equivalent to one with N_t^d identical domestic firms in each sector supplying the domestic market and facing the fixed cost $\widetilde{f_{H,t}}$, N_t^{d*} identical domestic firms exporting to the foreign market and facing the fixed cost $\widetilde{f_{X,t}}$, N_t^{f*} identical foreign firms supplying the foreign market and facing the fixed cost $\widetilde{f_{H,t}^*}$, and N_t^f identical foreign firms exporting to the domestic market and facing the fixed cost $\widetilde{f_{X,t}^*}$.

The reason why I choose to rely on heterogenous fixed costs instead of heterogenous productivity is because it allows to simplify the model to an "average version". I would not be able to use the same trick if firms were heterogenous in productivity instead of heterogenous in costs. Ghironi and Melitz [25] do reduce the heterogenous productivity model to an *average firm* model because their market structure is monopolistic. Thus the markup is fixed and it turns out that the price set by the *average firm*[15] is equal to the average price set by the continuum of firms above the cutoff productivity value. But this equality does not hold anymore with oligopolistic competition since the markup is not a linear function with respect to the productivity. Thus, the average price is not equal to the price set by the average firm.

[14] If the timing were different and firms knew their specific penetration cost and those of their competitors within the sector prior to taking production decisions, things would be quite different. Sectors would be heterogenous *ex post*, depending on the realized cost draws of firms at the sector level, and the cutoff values would differ across sectors. This very rich setup would be closer to Atkeson and Burstein [2]. Their framework is more realistic and is very powerful to account for deviations from relative purchasing power parity in a flexible prices environment but it is also much less tractable and doesn't permit any approximation around the steady state.

[15] In their setup the average firm is characterized as a firm with the weighted average productivity of all firms above a productivity cutoff value.

1.3.3 Monetary Policy

The monetary authority in each country follows a Taylor rule to set the nominal interest rate R_t:

$$log(R_t) = log(R) + \gamma_\pi(log(\Pi_t) - log(\Pi))) + \gamma_y(log(GDP_t)) - log(GDP))$$

1.3.4 Government

$$\forall t : T_t^G = G_t$$

1.3.5 Aggregate Equilibrium Conditions

Aggregate accounting equation for households Budget Constraint:

Total expenditures (aggregate consumption and investment in new firms) is equal to the aggregate total income from labor and dividends.

$$C_t + G_t + b_t^d + rer_t b_t^f + \sum_{i=1}^{\tilde{N}_{e,t}} \tilde{v}_t(i) = \frac{W_t}{P_t} L_t + \frac{R_{t-1}}{\Pi_t} b_{t-1}^d + rer_t \frac{R_{t-1}^*}{\Pi_t^*} b_{t-1}^f + \sum_{i=1}^{N_t^d} d_t^d(i) + \sum_{i=1}^{N_t^{d*}} d_t^{d*}(i)$$

because $T_t^B = P_t \frac{\phi_b}{2} \left(\frac{B_t^d}{P_t}\right)^2 + e_t P_t \frac{\phi_b}{2} \left(\frac{B_t^f}{P_t^*}\right)^2$

Market clearing:

- Bonds market

  Bonds are in zero net supply worldwide: $B_t^d + B_t^{d*} = 0$

- Shares Market

  $u_t = 1$

- Labor Market

  $$\int_0^1 \left(\sum_{i=1}^{N_t^d} h_t^d(i|k) + \sum_{i=1}^{N_t^d} h_{H,t}(i|k) + \sum_{i=1}^{N_t^{d*}} \tau_t h_t^{d*}(i|k) + \sum_{i=1}^{N_t^{d*}} h_{X,t}(i|k) + \sum_{i=1}^{\tilde{N}_t^e} h_{E,t}(i|k) \right) dk = L_t$$

where by definition:

$h_{H,t}(i|k) = \frac{f_{H,t}(i|k)}{A_t}$, since $f_{H,t}(i|k)$ is the fixed cost in units of effective labor faced by firm i in sector k for penetrating the domestic market.

$h_{X,t}(i|k) = \frac{f_{X,t}(i|k)}{A_t}$, since $f_{X,t}(i|k)$ is the firm specific fixed export cost in units of effective labor.

$h_{E,t}(i|k) = \frac{f_{E,t}}{A_t}$, since $f_{E,t}$ is the entry cost in units of effective labor for entering the market.

- Final consumption good Market

  The total amount of final good consumed (households consumption plus government consumption plus cost of adjusting prices) is equal to the total amount of final good produced.

$$Y_t^{absorbtion} = C_t + G_t + PAC_t$$

and

$$Y_t^{supply} = \left[\sum_{i=1}^{N_t^d} x_t^d(i)^{\frac{\theta-1}{\theta}} + \sum_{j=1}^{N_t^f} x_t^f(j)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} = \sum_{i=1}^{N_t^d} \frac{P_t^d(i)}{P_t} x_t^d(i) + \sum_{j=1}^{N_t^f} \frac{P_t^f(j)}{P_t} x_t^f(j)$$

In equilibrium : $Y_t^{absorbtion} = Y_t^{supply}$

All those equilibrium conditions hold symmetrically for the foreign country.

Net Foreign Assets and Trade Balance

$$\underbrace{b_t^d + rer_t b_t^f}_{NFA_t} = \frac{R_{t-1}}{\Pi_t} b_{t-1}^d + \frac{R_(^* t-1}{\Pi_t^*} rer_t b_{t-1}^f + \underbrace{rer_t N^{d*} p^{d*^{(1-\theta)}} Y_t^* - N^f p^{f^{(1-\theta)}} Y_t}_{\text{Trade Balance}}$$

1.4 Steady State

An equilibrium is defined as a set of

quantities $\left\{\tilde{N}_t^d, \tilde{N}_t^f, \tilde{f}_{X,t}, b_t^d, b_t^f, \tilde{f}_{H,t}, C_t, G_t, L_t\right\}$ for the domestic and symmetrically for the foreign country;

and prices $R_t, w_t, p_t^d, p_t^f, \pi_t, \pi_t^d, \pi_t^f, rer_t$ for the domestic and symmetrically for the foreign country

such that

- given the sequences of prices, the optimality conditions are satisfied for all the agents in the domestic and in the foreign country;
- labor market, bonds market, shares market and final consumption good market clear;
- Net Foreign Asset position is :

$$b_t^d + rer_t b_t^f = \frac{R_{t-1}}{\Pi_t} b_{t-1}^d + \frac{R_{t-1}^*}{\Pi_t^*} rer_t b_{t-1}^f + rer_t N^{d*} p^{d*(1-\theta)} Y_t^* - N^f p^{f(1-\theta)} Y_t$$

Appendix D presents in details the steps to get the Net Foreign Asset Position condition.

1.4.1 Optimality and Equilibrium Conditions in Steady State

I suppose that the two countries are symmetric and therefore the real exchange rate is 1. Inflation is zero in steady state. I summarize all the equilibrium conditions in steady state in Table 2.1. The superscript indicates the origin of the firm (d or f) and the destination market that the firm is serving (‘ ’ for country D or ‘*’ for country F). The notations read as detailed in Table 1.1.

1.4.2 Calibration

I consider quarterly frequency and set the parameters as follows: $\beta = 0.99$ which yields a 4% real interest rate. Following Bilbiie et al. [13], the risk aversion coefficient γ is 1 to have a log utility from consumption, the inverse of the Frisch elasticity of labor, ν, is 4 and the exit shock is 0.025. I normalize steady state productivity to 1.

I introduce a productivity shock, a government spending shock and a monetary policy shock that I calibrate following Smets and Wouters [39]. The parameters for TFP, governement spending and monetary policy shocks persistence are respectively $\rho_A = 0.95, \rho_g = 0.97, \rho_R = 0.12$ and the associated standard deviations are $\sigma_A = 0.0045, \sigma_A = 0.0052, \sigma_R = 0.0024$. This calibration ensures that productivity shocks are small enough so that there is a positive number of new entrants in each period.[16]

As far as the elasticity of substitution is concerned, I set $\theta = 6$ and $\sigma = 1.5$ as in Benigno and Faia [5], which implies that the intra-sectoral elasticity of substitution is higher than the inter-sectoral, consistently with Broda and Weinstein [15] findings.[17] It results approximately in a 20% markup.

The entry cost parameter (relatively to productivity) pins down the mass of firms paying the entry cost. I choose f_E to match a number of firms per sector close to 20 as in Atkeson and Burstein [2] and set $f_E = 0.1$ in the benchmark case. If f_E

[16] If a large negative productivity shock were allowed to occur, the expected value of a firm would become negative and the number of firms willing to stop production would be higher than the number of firms shut down by the exogenous exit shock. In that case the number of new entrants would be negative. I do not allow for this extreme case and make sure that the free entry condition holds in each period of time.

[17] Anderson and van Wincoop [1] find that the inter-sectoral elasticity of substitution lies between 5 and 10.

increases (relatively to productivity) then the number of entering firms decreases. For $f_E = 1$ the number of active firms becomes 3.

The distribution of fixed export costs does not change with globalization. The fixed costs should be interpreted as reflecting firms' ability to prospect and penetrate new markets (that may depend on the specific skills of their workers, or on their network, etc.). It is a way to differentiate firms' profitability while keeping the simplifying assumption of homogeneous labor productivity. Since there is no empirical evidence regarding the shape of the fixed costs distribution, I choose a uniform distribution. The main advantage is to provide an easy intuition on what is going on with the cutoff values and the corresponding average fixed cost of active firms. I suppose that the lower bound of the distribution is $a_H = a_X = 0$.

Since the per-unit trade cost may reflect different type of barriers to trade, I take an agnostic stand and choose the upper bounds b_H and b_X in order to match a share of exporters (number of exporters to domestic producer) approximately equal to 21% post-globalization. $b_X = 0.0079$ and $b_H = 0.0049$, which means that the variance of fixed costs for exporting is higher that the variance of fixed penetration costs for serving the domestic market.

I model globalization as a structural shock captured through a fall in iceberg costs τ. To be consistent with US data from 1960 to 2015, I set $\tau = 1.4$ for the pre-globalization steady state, which implies a home bias of 0.986 and $\tau = 1.1$ post-globalization, meaning a home bias equal to 0.865. This value is in the range of standard unit iceberg costs commonly used in the literature : 1.34 or 1.58 in Atkeson and Burstein [2]; 1.1 or 1.3 in Ghironi and Melitz [25]; 1.25 in Obstfeld and Rogoff [36].

Regarding nominal rigidities, standard results in the literature estimate a duration of prices equal to three quarters, corresponding to $\alpha = 0.66$. I choose the price adjustment cost in order for the Phillips curve slope in the Rotemberg setup (with price adjustment cost ϕ_p) to match the Phillips curve slope arising in models *à* la Calvo.[18] Consequently I choose $\phi_p = 28$.

The Taylor rule coefficients are standard: $\gamma_\pi = 1.5$, $\gamma_y = 0.125$, and inertia $\rho = 0.8$.

1.4.3 Comparison with the Data

Tables 1.3 and 1.4 report my results. The model does reasonably well at replicating qualitative patterns of the empirical moments but it fails on some key quantitative dimensions due to its simplicity.

On the good side, the order of magnitude for the recent period are in line with the observed moments. Consumption is less volatile than output while investment is much more volatile. I am able to reproduce a small decline in the volatility of inflation, but the order of magnitude is much smaller in the model. I also capture the negative correlation of net export with output even though the model under-predicts the magnitude of the correlation.

On the bad side, one important caveat arises. The model does not reproduce the fall in the volatility of output observed in the data. With globalization, domestic output is affected by domestic shocks *and* also by foreign shocks through net exports. As a

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$$\underbrace{\frac{\theta - 1}{\phi_p}}_{\text{Rotemberg PC slope}} = \underbrace{\frac{(1-\alpha)(1-\alpha\beta)}{\alpha}}_{\text{Calvo PC slope}}$$

where α is the probability of being unable to re-optimize a price in the Calvo setup.

result, the volatility of output slightly increases after globalization. This is consistent with a stream of the literature[19] advocating that the decline in the output volatility after the mid eighties (the so-called Great Moderation) was largely due to a change in the nature of shocks, i.e. to the "Good Luck" hypothesis, rather than globalization. The model can reproduce the decline in the variance of consumption. This is driven by net exports that allow households to better smooth consumption in the open economy post-globalization.

The results of the simulation are to be read as an illustration of the channels through which globalization might affect inflation. The purpose of the paper is not to quantitatively fit the observed moments, but rather to understand through which mechanisms the dynamics of inflation is modified with globalization.

1.4.4 Comparing two steady states (before and after globalization)

As iceberg trade costs fall, two mechanisms are at work: *(i)* the decline in relative export prices (p^f) leads incumbent exporters to increase their volume of sales x^f (the intensive margin) and *(ii)* new firms enter the export market (the extensive margin) because the revenue from export-sales increases when τ falls. Thus the cutoff value of fixed cost for exports to be profitable is relaxed causing a jump in N^f .
As expected, the welfare increases with globalization since the share of production lost in iceberg costs is reduced.

1.5 Dynamics Around the New Steady State

I compare the dynamics of inflation around the post-globalization steady state and the pre-globalization state.

[19]E.g. Stock and Watson [40].

1.5.1 The augmented NKPC

Loglinearizing the actual markup $\tilde{\mu}^d_{i,t}$ around the steady state gives the augmented Phillips curve:

$$\pi^d_t = \frac{\tilde{\theta}^d - 1}{\phi_p}\hat{mc}^d_t - \frac{1}{\phi_p}\hat{\tilde{\theta}}^d_t + \beta(1-\delta)\mathbb{E}_t\pi^d_{t+1} \tag{1.1}$$

where $\hat{mc}^d_t = \hat{W}_t - \hat{P}^d_t - \hat{A}_t$ and $\hat{P}^d_t$ and $\hat{A}_t$ are log-deviation from the steady state of the domestic producer price and productivity.

Inflation is influenced by its "usual" determinants (changes in the marginal cost of domestic firms and inflation expectations) but also negatively affected by the cyclical fluctuations in the price-elasticity of demand, $\hat{\tilde{\theta}}^d_t$, that can be interpreted as a measure of firms' pricing power, negatively related to their market share.

$$\hat{\tilde{\theta}}^d_t = -\frac{(\theta - \sigma)\xi^d}{\tilde{\theta}^d}\hat{\xi}^d_t$$

Thus:

$$\pi^d_t = \frac{\tilde{\theta}^d - 1}{\phi_p}\hat{mc}^d_t + \frac{1}{\phi_p}\frac{(\theta - \sigma)\xi^d}{\tilde{\theta}^d}\hat{\xi}^d_t + \beta(1-\delta)\mathbb{E}_t\pi^d_{t+1}$$

Inflation fluctuates in response to variations in the market share of domestic firms. This market share effect consists of two channels : the changes in relative prices and the changes in firms' entry (extensive margin):

$$\hat{\xi}^d_t = (1-\theta)[\hat{P}^d_t(1 - N^d\xi^d) - \hat{P}^f_t(1 - N^f\xi^f)] - (N^d\xi^d\hat{N}^d_t + N^f\xi^f\hat{N}^f_t)$$

I denote the home bias $\omega = \left[\frac{N^d x^d P^d}{N^d x^d P^d + N^f x^f P^f}\right]$, i.e. :

$$\omega = N^d\frac{{P^d}^{1-\theta}}{P^{1-\theta}} = N^d\left(\frac{P^d}{P}\right)^{1-\theta} = N^d{p^d}^{1-\theta} = N^d\xi^d$$

$$(1-\omega) = N^f\xi^f$$

Hence:

$$\hat{\xi}^d_t = (\theta - 1)(1-\omega)[\hat{P}^f_t - \hat{P}^d_t] - (\omega\hat{N}^d_t + (1-\omega)\hat{N}^f_t)$$

And eventually:

$$\pi_t^d = \overbrace{\frac{\tilde{\theta}^d - 1}{\phi_p} \hat{mc^d}_t}^{\text{PC slope}} + \overbrace{\frac{(\theta-1)(1-\omega)}{\phi_p} \frac{(\theta-\sigma)\xi^d}{\tilde{\theta}^d} [\hat{P}_t^f - \hat{P}_t^d]}^{\text{Relative import prices}} - \overbrace{\frac{1}{\phi_p} \frac{(\theta-\sigma)\xi^d}{\tilde{\theta}^d} (\omega \hat{N}_t^d + (1-\omega)\hat{N}_t^f)}^{\text{Extensive margin}}$$
$$+ \overbrace{\beta(1-\delta)\mathbb{E}_t \pi_{t+1}^d}^{\text{Inflation exp.}}$$

In addition to inflation expectations, the three other terms on the right-hand side are either new or slightly modified with respect to the closed economy Phillips curve.

1. The marginal cost channel : $\frac{\tilde{\theta}^d - 1}{\phi_p} \hat{mc}_t^d = \frac{\tilde{\theta}^d - 1}{\phi_p}(\hat{mc}_t - \hat{p}_t^d)$

   The short-run sensitivity of inflation to marginal cost depends on the steady state price-elasticity of demand ($\tilde{\theta}^d$) that is decreasing with respect to firms' market share (ξ^d) since $\tilde{\theta}^d = \theta - (\theta - \sigma)\xi^d$. By construction, in my model globalization necessarily induces a decline in the average market share of domestic firms. Hence, the demand curve that domestic non-exporters (type d firms) face becomes more elastic. Domestic firms lose pricing power and inflation get more responsive to marginal costs.

   To understand how globalization affects the market share of domestic producers in this model, recall that the market share is $\xi_t^d = p_t^{d(1-\theta)}$ and that the price is set by domestic non-exporter producers as $p_t^d = \tilde{\mu}_t^d s_t = \frac{\theta - (\theta-\sigma) p_t^{d(1-\theta)}}{\theta - (\theta-\sigma) p_t^{d(1-\theta)} - 1} s_t$. This nonlinear equation implies that p_t^d is a strictly increasing convex function in s_t on the interval $(0, +\infty)$. Symmetrically for the exporters (type $d*$ firms): p_t^{d*} is a strictly increasing convex function in $\tau_t s_t$. Globalization, defined as a fall in τ, renders labor relatively more productive and thus increases the marginal cost. Hence, $s = \frac{w}{A}$ increases while τs goes down. Consequently, the relative price set by type d firms increases and their market share $\xi_t^d = p_t^{d(1-\theta)}$ shrinks.

2. The open economy Phillips curve is also augmented with global factors through the cyclical fluctuations in domestic firms' market share that are driven by *(a)* import prices relative to domestic producer prices and *(b)* the cyclical entries/exits of competitors.

   (a) The "relative price channel" : $\frac{(\theta-1)(1-\omega)}{\phi_p}\frac{(\theta-\sigma)\xi^d}{\tilde{\theta}^d}[\hat{P}_t^f - \hat{P}_t^d] = \frac{(\theta-1)(1-\omega)}{\phi_p}\frac{(\theta-\sigma)\xi^d}{\tilde{\theta}^d}[\hat{p}_t^f - \hat{p}_t^d]$

   When import prices fall (relatively to domestic production prices), this channel exerts downward pressures on domestic inflation. This channel is all the more important as openness to trade $(1-\omega)$ is high. This relative import price mechanism disappears when the economy is closed $(\omega = 1)$ or when competition becomes monopolistic and shuts down the strategic interactions. This occurs either when the intra-sectoral elasticity of substitution equals the inter-sectoral elasticity of substitution $(\theta = \sigma)$ or when the market share becomes infinitely small $\xi^d \to 0$.

   (b) The "extensive margin channel": $\frac{1}{\phi_p}\frac{(\theta-\sigma)\xi^d}{\tilde{\theta}^d}(\omega\hat{N}_t^d + (1-\omega)\hat{N}_t^f)$

   Fluctuation in the aggregate (weighted) number of firms $(\omega\hat{N}_t^d + (1-\omega)\hat{N}_t^f)$ put downwards pressures on inflation when there is a net entry of firms (equivalent to a net creation of goods). The more open the economy, the more sensitive inflation to the extensive margin of imports. The impact of the extensive margin channel on inflation vanishes when competition becomes monopolistic.

These last two channels supports the global slack hypothesis: domestic inflation has become more dependent on foreign factors, alleviating the role of domestic slack.

1.5.2 Impulse Response Functions

Figures 1.2 and 1.3 show the deviation from steady state (in level) of endogenous variables in response to a one standard deviation shock in home productivity. The **solid line** is the response around the **pre-globalization steady state** and the **dashed line** is the response to a shock in the neighborhood of the **post-globalization** steady state.

1. In the pre-globalization state (when trade-costs are high), the foreign country is not affected by a shock in country D. As soon as the country opens to international trade, country F responds to shocks in D. A positive TFP shock in D induces net exports to country F, an increase in output and a decline in inflation in country F due to a decline in the desired markup of foreign firms as imported varieties flow the market.

2. The response of domestic variables to domestic shocks also changes with globalization. In the pre- or post-globalization states, a positive productivity shock triggers an increase in output and a decrease in prices (CPI inflation in country D declines). The marginal cost increases because the real wage increases with labor productivity. The Producer Price Index inflation decreases because both the relative marginal cost ($\hat{mc}_t^d = \hat{s}_t - \hat{p}_t^d = -\hat{\hat{\mu}}_t^d$) and the desired markup decline when productivity goes up. The fall in the desired markup is due to an increase in the number of domestic and foreign competitors and a decline in the relative price of imports ($P_t^f - P_t^d$). In the end, the response of domestic inflation to a productivity shock is dampened in the globalized environment compared to a more closed economy. The decline in the volatility of inflation is not due to a

flattening of the Phillips curve[20], but to foreign factors: a decrease in relative import prices or an increase in the number of foreign firms (extensive margin of trade) both squeeze the desired markup of domestic firms and thus dampen inflation .

1.6 Conclusion

I have developed a 2-country new-Keynesian stochastic general equilibrium model with oligopolistic competition -that generates strategic interactions- and endogenous firm entry. Globalization triggers endogenous changes in the market structure and in the degree of openness, which in turn affects the short run dynamics of inflation. I find that globalization dampens the volatility of inflation. The decline in the volatility of inflation is due to foreign factors. Typically, a decrease in relative import prices or an increase in the number of foreign firms (extensive margin of trade) both weigh down on the desired markup of domestic firms and reduce inflation in the short run.

By contrast to standard open economy new-Keynesian models in which foreign inflation only affects the Consumption Price inflation (proportionally to the share of foreign goods in the CPI basket), my setup shows how foreign factors transmit to the domestic *Producer Price* inflation. The analysis corroborates the global slack hypothesis (Borio and Filardo, 2006) to the extent that domestic PPI inflation becomes more responsive to foreign factors.

One limitation is that the model does not permit understanding the flattening of the Phillips curve observed in industrialized countries since the mid-eighties. By

[20] On the contrary, the sensitivity of inflation to domestic marginal cost increases since real rigidities wane with globalization

construction, in my setup, the decline in iceberg trade costs (that characterizes globalization) always gives rise to a decline in foreign prices relatively to domestic prices. As a result, the market power of domestic firms, measured as the inverse of their perceived price elasticity of demand, declines with globalization. In the end, the sensitivity of inflation to marginal cost necessarily increases, which means a steepening of the Phillips curve. Given the calibration, the steepening is relatively small, but still, the direction is at odds with the empirical literature.

The next chapter of my dissertation precisely tackles this puzzle regarding the slope of the Phillips curve.

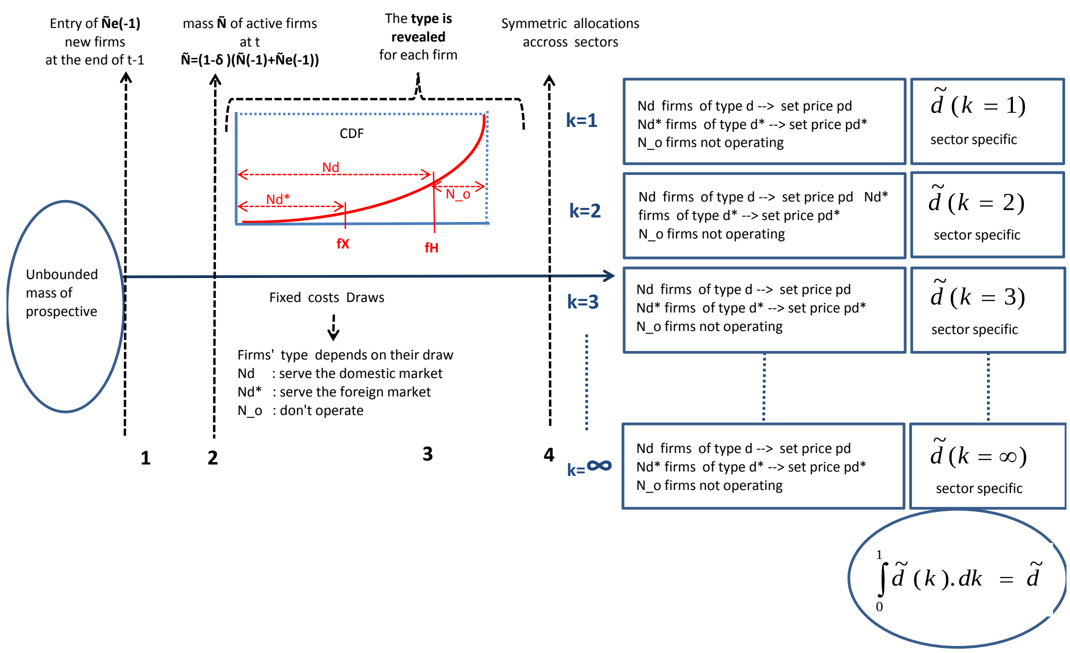


Figure 1.1: Timing

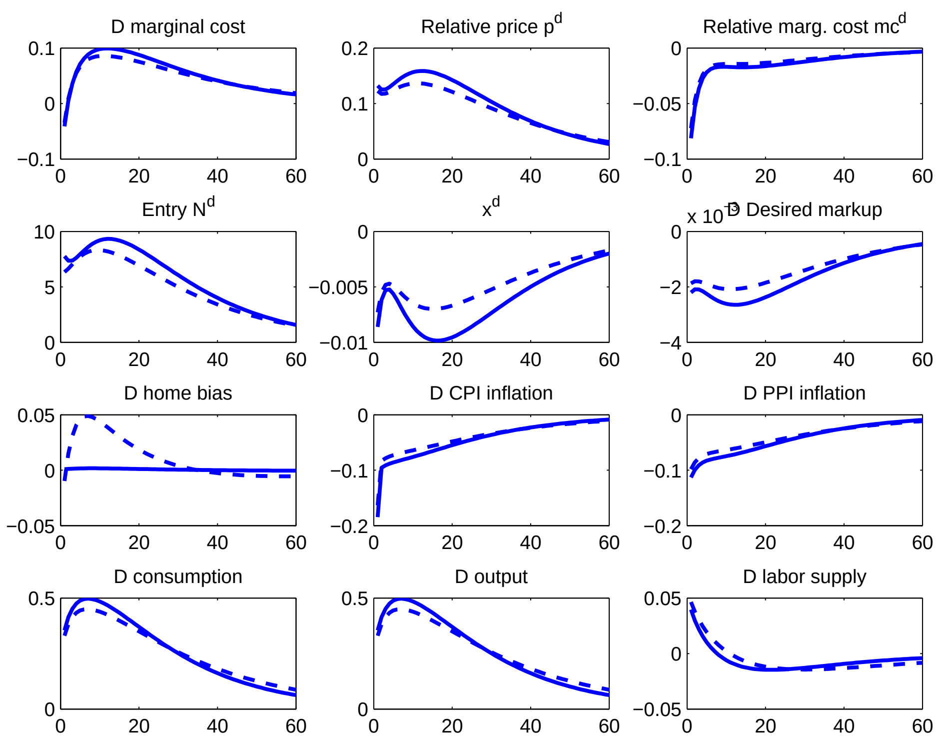


Figure 1.2: Responses in Country D to a TFP Shock in Country D - Deviation From Steady State in Level

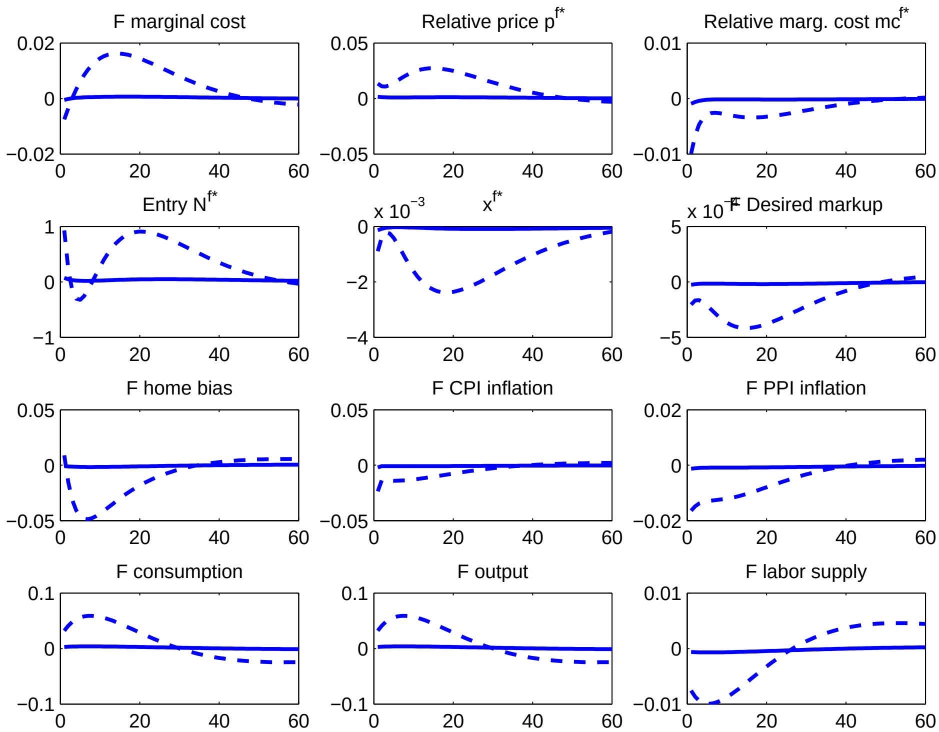


Figure 1.3: Responses in Country F to a TFP Shock in Country D - Deviation From Steady State in Level

Table 1.1: Notations Summary

Notation	**refers to**
d	a firm from country D serving market D
$d*$	a firm from country D serving market F
$f*$	a firm from country F serving market F
f	a firm from country F serving market D
$\tilde{N}$	the mass of domestic active firms, i.e. firms having paid the entry cost on D
$\frac{N^d}{\tilde{N}}$; $\frac{N^{d*}}{\tilde{N}}$	the share of domestic active firms serving respectively the market D and F
$\tilde{N}^*$	the mass of foreign active firms
$\frac{N^{f*}}{\tilde{N}^*}$; $\frac{N^f}{\tilde{N}^*}$	the share of foreign active firms serving respectively the market F and D
$N = N^d + N^f$	the number of varieties consumed in each sector of country D
$N^* = N^{d*} + N^{f*}$	the number of varieties consumed in each sector of country F

Table 1.3: Moments for Data

Variable :	GDP	C	I	$\frac{X-M}{GDP}$	π^{GDPdef}
BEFORE					
St. Dev. σ_{var}	1.87%	1.49%	4.16%	0.37%	0.35%
$\frac{\sigma_{var}}{\sigma_{GDP}}$	1.00	0.80	2.22	0.20	0.18
Corr(var,GDP)	1.00	0.87	0.94	−0.43	0.13
AFTER					
St. Dev.	1.10%	0.95%	3.56%	0.31%	0.18%
$\frac{\sigma_{var}}{\sigma_{GDP}}$	1.00	0.86	3.23	0.51	0.16
Corr(var,GDP)	1.00	0.90	0.92	−0.49	0.41

Note: Variables are are average over twenty simulations of length 100. Variables are real output (GDP), real consumption (C), investment in new businesses ($N_e\tilde{v}$), the ratio of net exports to output and GDP deflator inflation. Except for these last two ratio, statistics refer to logarithms of variables.Data are quarterly from the OECD's quarterly national accounts. The sample period pre- globalization is 1960:1985; post-globalization : 1985-2015

Table 1.2: Steady State Equilibrium

	Country D	Country F
Intra-temporal tradeoff	$L^{\nu} = \frac{w}{C^{\gamma}}$	$L^{*\nu} = \frac{w^*}{C^{*\gamma}}$
Pricing for domestic sales	$\frac{p^d}{\tilde{\mu}^d} = \frac{w}{A} = s$	$\frac{w*}{A*} = s^* = \frac{p^{f*}}{\tilde{\mu}^{f*}}$
Pricing for exports	$\frac{p^{d*}}{\tilde{\mu}^{d*}} = \tau s$	$\frac{p^f}{\tilde{\mu}^f} = \tau s^*$
Price-elasticity of demand	$\tilde{\theta}^d = \theta - (\theta - \sigma){p^d}^{1-\theta}$	$\tilde{\theta}^{f*} = \theta - (\theta - \sigma){p^{f*}}^{1-\theta}$
	$\tilde{\theta}^{d*} = \theta - (\theta - \sigma){p^{d*}}^{1-\theta}$	$\tilde{\theta}^f = \theta - (\theta - \sigma){p^f}^{1-\theta}$
Variable markup	$\tilde{\mu}^d = \frac{\tilde{\theta}^d}{\tilde{\theta}^d - 1}$	$\tilde{\mu}^{f*} = \frac{\tilde{\theta}^{f*}}{\tilde{\theta}^{f*} - 1}$
	$\tilde{\mu}^{d*} = \frac{\tilde{\theta}^{d*}}{\tilde{\theta}^{d*} - 1}$	$\tilde{\mu}^f = \frac{\tilde{\theta}^f}{\tilde{\theta}^f - 1}$
Cutoff cost for dom. sales	$\overline{f_H} = \frac{A_t}{w_t} Y {p^d}^{1-\theta} \frac{1}{\tilde{\theta}^d}$	$\overline{f_H^*} = \frac{A_t^*}{w_t^*} Y^* {p^{f*}}^{1-\theta} \frac{1}{\tilde{\theta}^{f*}}$
Cutoff cost for exports	$\overline{f_X} = \frac{A_t}{w_t} Y^* {p^{d*}}^{1-\theta} \frac{1}{\tilde{\theta}^{d*}}$	$\bar{f_X^*} = \frac{A_t^*}{w_t^*} Y {p^f}^{1-\theta} \frac{1}{\tilde{\theta}^f}$
Domestic comp. of Profit	$\tilde{d}^d = Y {p^d}^{1-\theta} \left[\frac{1}{\tilde{\theta}^d}\right] - \frac{a_H + \overline{f_H}}{2} \frac{w}{A}$	$\tilde{d}^{f*} = Y^* {p^{f*}}^{1-\theta} \left[\frac{1}{\tilde{\theta}^{f*}}\right] - \frac{a_H + \overline{f_H^*}}{2} \frac{w^*}{A^*}$
Export comp. of Profit	$\tilde{d}^{d*} = Y^* {p^{d*}}^{1-\theta} \left[\frac{1}{\tilde{\theta}^{d*}}\right] - \frac{a_X + \overline{f_X}}{2} \frac{w}{A}$	$\tilde{d}^f = Y {p^f}^{1-\theta} \left[\frac{1}{\tilde{\theta}^f}\right] - \frac{a_X + \overline{f_X^*}}{2} \frac{w^*}{A^*}$
Dividend	$\tilde{d} = \frac{\overline{f_H} - a_H}{b_H - a_H} \tilde{d}^d + \frac{\overline{f_X} - a_X}{b_X - a_X} \tilde{d}^{d*}$	$\tilde{d}^* = \frac{\overline{f_H} - a_H}{b_H - a_H} \tilde{d}^{f*} + \frac{\overline{f_X} - a_X}{b_X - a_X} \tilde{d}^f$
Free Entry Condition	$\tilde{v} = \frac{\beta(1-\delta)}{1-\beta(1-\delta)} \tilde{d} = \frac{w}{A} f_E$	$\tilde{v}^* = \frac{\beta(1-\delta)}{1-\beta(1-\delta)} \tilde{d}^* = \frac{w^*}{A^*} f_E^*$
Firms' Law of Motion	$N_e = \frac{\delta}{1-\delta} N$	$N_e^* = \frac{\delta}{1-\delta} N^*$
Aggregate output	$Y = C + G$	$Y^* = C^* + G^*$
Aggregate expenditures	$Y + \tilde{N}_e \tilde{v} = wL + \tilde{N} \tilde{d}$	$Y^* + \tilde{N}_e^* \tilde{v}^* = w^* L^* + \tilde{N}^* \tilde{d}^*$
Demand in country D	$x^d = {p^d}^{-\theta} Y$	$x^f = {p^f}^{-\theta} Y$
Demand in country F	$x^{d*} = {p^{d*}}^{-\theta} Y^*$	$x^{f*} = {p^{f*}}^{-\theta} Y^*$
Consumer Price Index	$1 = \left[N^d {p^d}^{1-\theta} + N^f {p^f}^{1-\theta}\right]^{\frac{1}{1-\theta}}$	$1 = \left[N^{f*} {p^{f*}}^{1-\theta} + N^{d*} {p^{d*}}^{1-\theta}\right]^{\frac{1}{1-\theta}}$
Labor Market Clearing	$L = N^d \frac{x^d}{A} + \tau_t N^{d*} \frac{x^{d*}}{A} + N^d \frac{f_H}{A} + N^{d*} \frac{f_X}{A} + N_e \frac{f_E}{A}$	$L^* = N^{f*} \frac{x^{f*}}{A^*} + \tau_t N^f \frac{x^f}{A^*} + N^{f*} \frac{f_H}{A^*} + N^f \frac{f_X}{A^*} + \tilde{N}^* \frac{f_E^*}{A^*}$
Bonds	$b_t^d + b_t^{d*} = 0$	$b_t^f + b_t^{f*} = 0$
Balance of Payments	$0 = rer_t N^{d*} {p^{d*}}^{(1-\theta)} Y_t^* - N^f {p^f}^{(1-\theta)} Y_t$	

Table 1.4: Moments for Model Generated Data

Variable :	GDP	C	$N_e\tilde{v}$	$\frac{X-M}{GDP}$	π^{PPI}
BEFORE					
St. Dev.	1.20%	1.14%	14.74%	0.00%	0.99%
$\frac{\sigma_{var}}{\sigma_{GDP}}$	1.00	0.94	12.25		0.82
Corr(var,GDP)	1.00	0.87	0.66		0.08
AFTER					
St. Dev.	1.24%	1.04%	19.14%	0.54%	0.96%
$\frac{\sigma_{var}}{\sigma_{GDP}}$	1.00	0.84	15.70	0.43	0.78
Corr(var,GDP)	1.00	0.87	0.28	0.25	0.09

Note: Statistics are based on Hodrick-Prescott-filtered data. Variables are average over twenty simulations of length 150. Variables are real output (GDP), real consumption (C), investment in new businesses ($N_e\tilde{v}$), the ratio of net exports to output and the Production Price Index inflation. Except for these last two ratio, statistics refer to logarithms of variables.

Table 1.5: Steady State Values

	Before Globalization	After Globalization
τ	1.4	1.1
Marginal cost	1.5196	1.5395
N^d	20.6351	19.2683
N^f	1.5359	4.7877
Consumption	1.5505	1.5707
Production price index p^d	1.8372	1.8603
Import price index p^f	2.5565	2.0409
Domestic comp. of profit	0.0064	0.0061
Export comp. of profit	0.0012	0.0038
Price elast. of demand θ^d	5.7850	5.7980
Price elast. of demand θ^f	5.9588	5.8729
x^d	0.0403	0.0379
x^f	0.0056	0.0217
Output	1.5505	1.5707
Home bias ω	0.9859	0.8648
Welfare	0.2436	0.2565

Chapter 2

Globalization, Market Structure and the Flattening of the Phillips Curve

2.1 Introduction

In spite of the dramatic economic contraction following the Lehman collapse and the ensuing subdued growth dynamics, inflation has displayed a remarkable stability. This "missing disinflation" puzzle has renewed attention in academic and policy circles on the fundamental forces behind the loosening of the inflation-output tradeoff observed in advanced countries since the mid 1980's.[1] Among the possible explanations, globalization has stood as one of the prime suspects, ever since Chairman Bernanke's speech "Globalization and Monetary Policy" in 2007. Intuitively, as openness to international trade increases, producers adjust their pricing behavior for fear of losing their market share. This should in principle feedback on the slope of the Phillips curve.[2] Yet, in spite of its appeal, it has proven extremely difficult to formalize this simple story in the workhorse new-Keynesian paradigm.

[1] A non exhaustive selection among the numerous publications since the mid 2000's includes Peach et al. [37], Kohn [32], Bernanke [9], International Monetary Fund [29], International Monetary Fund [30]. The *missing disinflation puzzle* terminology is introduced by Gordon [26], or Coibion and Gorodnichenko [20] among others.

[2] The Phillips curve slope is defined, in a broad way, as the responsiveness of inflation to any measure of the slack/tightness on the domestic production factors such as output gap, unemployment gap, marginal cost or capacity utilization.

In this paper, I provide a novel analytical framework that can replicate the flattening of the Phillips curve in response to globalization, in the context of a two-country new-Keynesian model. Key is the inclusion of three ingredients: *Strategic interactions* due to oligopolistic competition; *Endogenous entry* on the export market due to fixed penetration costs; and *Heterogeneity in firms' productivity.*

Globalization is defined as a fall in international per-unit trade costs. The set of competitors endogenously changes as it becomes profitable for new firms to export (*Endogenous Entry assumption*). By the *Productivity Heterogeneity assumption*, only the more productive firms choose to export and, they are also the largest firms.[3] Largest firms are the most prone to act strategically by absorbing marginal cost movements into their markup in order to protect their market share. Because of the *Strategic Interactions assumption*, large firms are less prone to transmit marginal cost fluctuations into price adjustments compared to smaller firms. At the aggregate level, the increase in the relative proportion of more productive/larger firms, due to globalization, engenders a flattening of the aggregate Phillips curve.

As soon as one of the three key assumptions is relaxed, the model predicts opposite results, i.e. either no change or a steepening of the Phillips curve. I demonstrate why each assumption is necessary to reproduce the flattening of the Phillips curve, but not sufficient by itself. To establish that point, the causality from globalization to the slope of the Phillips curve can be decomposed into two parts: (i) How does the elasticity of inflation to marginal cost vary with the market structure? (ii) How does

[3] This result is in line with standard heterogenous-firm trade models à la Melitz [35] or Chaney [18] where the more productive price set a lower relative price and hence capture a larger market share. The empirical literature [10] indeed finds that exporters are larger and more productive than non exporters.

the market structure change with globalization?

How does the slope of the Phillips curve vary with the market structure? The view that the degree of competition might affect the slope of the Phillips curve presumes that firms act strategically. In order to capture the strategic interactions channel, I relax the standard fixed price elasticity of demand assumption. To that end, I introduce the *oligopolistic competition* assumption, stating that firms compete in prices, *à* la Bertrand, within sectors[4]. They internalize their influence on the sectoral price when setting their optimal price. This leads to a perceived price-elasticity of demand that co-moves with firm's relative price. In the end, the desired markup[5] also fluctuates over time, as in Atkeson and Burstein [2] or Benigno and Faia [5].[6]

Coupled with nominal rigidities, the *oligopolistic competition* assumption gives rise to an augmented new-Keynesian Phillips curve, whose slope is not fixed anymore. The responsiveness of inflation to marginal cost is decreasing in firm's market share, ξ.[7] As firms respond to a marginal cost shock by absorbing part of that shock into their desired markup, the pass-through of marginal cost into inflation is mechanically reduced.[8] The strategic "desired markup adjustment" is all the larger as the economy is composed of large players (with more market power). In the limit, if firms' market

[4]In the vein of Dornbusch [21].

[5]The one prevailing under flexible prices.

[6]Instead of supply side complementarities, Chen et al. [19], Sbordone [38] or Guerrieri et al. [27] rely on demand side complementarities, introducing a *Kimball* demand function that directly relates the elasticity of substitution between goods to the number of available goods. Another option for generating time varying price elasticity of demand relies on distribution costs as in Berman et al. [8].

[7]The inverse of the market share, $1/\xi$, can be interpreted as a measure of the competition toughness in steady state.

[8]Those results are in line with Sbordone [38], Benigno and Faia [5] and Guerrieri et al. [27] .

share becomes infinitely small, strategic interactions vanish and the model yields back to the standard fixed elasticity of demand case.
As in Woodford [41], for a given degree of nominal rigidities, the higher the degree of strategic interactions (also sometimes referred to as real rigidities), the flatter the Phillips curve. The remaining question regards the impact of globalization on firms' market share/market power.

How does the market structure change with globalization?
The answer depends on the way globalization is defined.
Sbordone [38] and Benigno and Faia [5] consider symmetric firms and model globalization as an increase in the overall number of goods (N), which, as a corollary, entails a decline in domestic firms market share ($\xi = 1/N$). Such a definition of globalization necessarily leads to a decline in firms' market power and a steepening of the Phillips curve as strategic interactions weaken.

Instead, I borrow from the new trade literature and I argue that globalization might favor the emergence of “big players". In the vein of Melitz [35] or Chaney [18], I introduce two assumptions: the *set of exporters is endogenous*, due to fixed penetration costs on the export market; and firms are *heterogeneous in productivity.*

When the iceberg trade cost falls, only the high-productivity firms choose to export and high-productivity firms are also large ones as in Atkeson and Burstein [2] or Berman et al. [8]. Therefore new firms who enter the market have more market power than the average. They are consequently relatively more prone to act strategically, by adjusting their desired markup, and exhibit a flatter Phillips curve. At the aggregate level, as globalization favors an environment with relatively more “large market share" firms, the aggregate Phillips curve flattens.

Related literature. My contribution connects three streams of the literature.

First, this paper is related to the new-Keynesian open economy literature. From standard new-Keynesian open-economy models as Gali and Monacelli [24], there is a broad agreement on how import prices have a direct effect on consumer price inflation proportionally to their share in the consumption basket. Besides, domestic producer price inflation is related to the terms of trade insofar as the latter influences the domestic real marginal cost.

I consider another channel that works through firm strategic behavior and directly affects the slope of the Phillips curve. In that sense, my work is very close to Sbordone [38][9], Benigno and Faia [5] and Guerrieri et al. [27] who embed strategic interactions into otherwise standard DSGE models in order to assess the impact of globalization on inflation dynamics. However, it differs in a crucial aspect: instead of defining globalization only as an increase in the number of goods, I define globalization as a fall in trade costs that allows for both *(i)* an increase in the number of available varieties and *(ii)* for the selection of the most productive firms (a mechanism for which the international trade literature provides solid evidence).

Sbordone [38], Guerrieri et al. [27] or Benigno and Faia [5] relax the fixed elasticity of demand hypothesis by relying respectively on demand side strategic complementarities (with preferences *à* la Kimball) or on oligopolistic competition. In their setups, there is no endogenous entry/exit of firms, and globalization is modeled as an

[9] Sbordone studies a closed economy, but the impact of the rest of the world is captured through the number of varieties available to domestic customers.

increase in the number of varieties. The firms are homogeneous in productivity and globalization unambiguously lowers the share of each firm in the market, therefore alleviating strategic interactions. Firms' concerns about losing market share diminish, which promotes greater price flexibility and steepens the slope of the Phillips curve. In my framework, it is not necessarily the case that firms' market share falls with globalization. The effect depends on each firm relative productivity. The more productive ones might gain market shares by penetrating the export market. In the end, the aggregate Phillips curve slope depends on the relative share of big versus small firms in the economy.

Second, this work is related to the recent literature that embeds endogenous varieties in a new-Keynesian DSGE setup.

A closely related series of papers deals with optimal monetary policy under endogenous entry: Bilbiie et al. [12], Bilbiie et al. [13], and Bergin and Corsetti [7] study models with endogenous firm entry and sluggish price adjustment to derive the optimal monetary policy.

Part of this literature also introduces strategic complementarities. In particular, Cecioni [17], Etro and Colciago [22], Faia (2012), Lewis and Poilly [33], or Etro and Rossi (2014) rely on oligopolistic competition and endogenous firm entry assumptions in a closed economy framework. They find that short run markups vary countercyclically because, after a positive shock, the entry of new firms reduces their market share. Cecioni [17] concludes that a cyclical increase in the number of operating firms lowers CPI-inflation in the short run.

My work differs from those papers along two dimensions : first, I study an open economy[10]; second, I suppose that firms are heterogeneous in productivity. As a

[10]In order to assess the effects of globalization.

result, I am able to account for a flattening of the Phillips curve while the aforementioned papers predict no change or a steepening.

Third, the paper also shares ingredients with the international trade literature on Pricing-To-Market and imperfect exchange rate pass-through.
This literature demonstrates that strategic interactions are sufficient to generate pricing-to-market and imperfect pass-through even in the absence of nominal rigidities (see. [16]). This result still holds in my model. In the long run, when prices are flexible, the model boils down to Atkeson and Burstein [2] framework. My results are consistent with other models where the perceived price elasticity of demand declines with firm productivity. It is in line with Berman et al. [8] who point out an heterogeneity in pricing to market driven by firm specific productivity.
However, my approach differs from international trade literature on imperfect pass-through as I consider a *sticky price environment*. I am focusing on how the combination of strategic interactions and nominal rigidities affects the inflation/real marginal cost nexus. As opposed to Atkeson and Burstein [2]or Berman et al. [8], I do not focus on the link between prices and nominal marginal costs, but I am looking at the relationship between inflation and real marginal cost (the Phillips curve slope).

In terms of modeling, this work is closely related to Ghironi and Melitz [25] and Atkeson and Burstein [2] insofar as I consider a dynamic two-country economy with an endogenous set of exporters driven by trade costs.[11]

I simplify Atkeson and Burstein [2] framework by imposing symmetry across sectors. As sectors are identical, I can solve the model analytically in the vein of Ghi-

[11]The key difference is that I am focusing on a sticky prices environment while they both deal with flexible prices.

roni and Melitz [25]: in steady state, there exists an endogenous cutoff productivity value that determines the set of exporters, their prices and the quantities sold, and eventually pins down the slope of the aggregate Phillips curve. Compared to Atkeson and Burstein [2], I do not have the insights related to the heterogeneity across sectors but I gain the possibility to derive an analytical solution.

The rest of the paper proceeds as follows. Section 1 describes the model. Section 2 solves for the steady state and Section 3 derives the new-Keynesian Phillips curve (aggregating heterogeneous firms' behavior). Section 4 provides theoretical results and Section 5 is a Numerical example.

2.2 Model

Assume that the economy is composed of two countries, domestic (d) and foreign (f). In each country there exists a continuum of sectors on $[0, 1]$, indexed by k, producing differentiated goods. Within each sector, firms compete strategically in prices (*à* la Bertrand).[12]

The model is a general equilibrium that involves four types of agents in each country: households, intermediate goods producers, final good producers and a monetary authority. The representative household maximizes its intertemporal utility by choosing consumption, and assets holdings (risk free nominal bonds) and receives income from labor and dividends from firms. The monetary authority follows a standard Taylor rule. Since the behavior of the representative household and the monetary authority is pretty standard, I delay the full description to Appendix B.1. The firm behavior is the key novel ingredient in my model and it departs from the standard

[12] I derive in Appendix B.7 a version with quantity competition *à* la Cournot and I show that the results are qualitatively similar.

new-Keynesian framework through the existence of strategic interactions entailed by oligopolistic competition.

2.2.1 Final goods producer

A non-tradable final consumption good Y_t^c is composed of differentiated goods from a continuum of sectors k on $[0,1]$: $Y_t^c = \left[\int_0^1 Y_t^c(k)^{\frac{\sigma-1}{\sigma}} dk\right]^{\frac{\sigma}{\sigma-1}}$, where σ is the elasticity of substitution between goods from different sectors. The demand for sectoral good is $Y_t^c(k) = \left(\frac{P_t(k)}{P_t}\right)^{-\sigma} Y_t^c$, where P_t is the Dixit-Stiglitz price index defined as $P_t = \left[\int_0^1 P_t(k)^{1-\sigma} dk\right]^{\frac{1}{1-\sigma}}$ and $P_t(k)$ is the sectoral price.

In each sector k, a retailer firm combines foreign and domestic goods to produce $Y_t^c(k) = \left[\sum_{i\in\Omega_t^k} x_t(i)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} = \left[\sum_{i\in\Omega_t^{k,d}} x_t^d(i)^{\frac{\theta-1}{\theta}} + \sum_{i\in\Omega_t^{k,f}} x_t^f(i)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$. $\Omega_t^{k,d}$ and $\Omega_t^{k,f}$ are respectively the sets of domestic and foreign varieties consumed in sector k on domestic market at time t and satisfy $\Omega_t^{k,d} \bigcup \Omega_t^{k,f} = \Omega_t^k$ and $\Omega_t^{k,d} \bigcap \Omega_t^{k,f} = \emptyset$.

A *variety* i is equivalent to a *good* or a *firm* or a *production line* since each firm produces one differentiated good. N_t^k is the measure of Ω_t^k and represents the number of differentiated goods sold in each sector k. Similarly, $N_t^{k,d}$ is number of goods produced by domestic firms while $N_t^{k,f}$ is number goods produced by foreign firms (and consumed in sector k). By definition $N_t^k = N_t^{k,d} + N_t^{k,f}$.
The final goods producer in sector k chooses its optimal production plans to maximize its profit:

$$\max_{\{x_t(i)\}_{i\in\Omega_t^k}} P_t(k)Y_t^c(k) - \sum_{i\in\Omega_t^k} P_t^x(i)x_t(i)$$

$$\text{s.t. } Y_t^c(k) = \left[\sum_{i\in\Omega_t^k} x_t(i)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$$

Optimality Conditions:

$$x_t(i) = \left(\frac{P_t^x(i)}{P_t(k)}\right)^{-\theta} Y_t^c(k) = \left(\frac{P_t^x(i)}{P_t(k)}\right)^{-\theta} \left(\frac{P_t(k)}{P_t}\right)^{-\sigma} Y_t^c$$

where $P_t(k) = \left[\sum_{i\in\Omega_t^k} P_t^x(i)^{1-\theta}\right]^{\frac{1}{1-\theta}} = \left[\sum_{i\in\Omega_t^{k,d}} P_t^d(i)^{1-\theta} + \sum_{j\in\Omega_t^{k,f}} P_t^f(j)^{1-\theta}\right]^{\frac{1}{1-\theta}}$ and $P_t^x(i)$ is the nominal price of good i, $P_t^x(i) \in \{P_t^d(i), P_t^f(i)\}$ depending on the country where the good has been produced.

2.2.2 Intermediate goods producers

1. **Heterogeneous productivity**

   Each firm produces a different variety. Firms are heterogenous in productivity and are indexed by their productivity type, z, that does not vary over time. The production function has constant returns to scale and labor h_t is the only input: for all firms with productivity z, for all sectors k, $x_t(z) = A_t z h_t(z)$. A_t is the aggregate labor productivity (respectively A_t^* in country F), z is the specific firm relative productivity factor. The real marginal cost of production for a firm with productivity z in country D is $\frac{W_t}{P_t A_t z} = \frac{w_t}{A_t z} = s_t(z)$ and $\frac{w_t^*}{A_t^* z^*} = s_t^*(z^*)$ in country F.

2. **Market structure: oligopolistic competition generates a time varying price-elasticity of demand.**

   Firms compete in prices à la Bertrand, internalizing their impact on the sectoral price when choosing their optimal price ($\frac{\partial P_t(k)}{\partial P_t^x(z)} \neq 0$ in the firm's optimization program). Consequently the perceived elasticity of demand to its own price, $\Theta(z)$, is not constant, although the elasticity of substitution between goods in sector k is constant (θ).

$$\Theta(z) = -\frac{\partial x_t(z)}{\partial P_t^x(z)} \frac{P_t^x(z)}{x_t(z)} = \theta - (\theta - \sigma)\left(\frac{\partial P_t(k)}{\partial P_t^x(z)} \frac{P_t^x(z)}{P_t(k)}\right)$$

where $\frac{\partial P_t(k)}{\partial P_t^x(z)} \frac{P_t^x(z)}{P_t(k)} = \frac{P_t^x(z) x_t(z)}{P_t(k) Y_t^c(k)} = \left[\frac{P_t^x(z)}{P_t(k)}\right]^{1-\theta} = \xi_t(z)$, the market share of firm z in sector k.

3. **Price Adjustment Cost**

   Prices are sticky *à* la Rotemberg. $PAC_t(z) = \frac{\phi_p}{2}\left[\frac{P_t^x(z)}{P_{t-1}^x(z)} - 1\right]^2 \frac{P_t^x(z)}{P_t} x_t(z)$ is the cost incurred by a firm z in any sector for adjusting its price at time t, expressed in units of final consumption. This cost can be interpreted as the amount of material that a firm must purchase in order to change a price. $\phi_p = 0$ yields to flexible prices.

4. **Market Penetration Cost**

   A domestic firm z can serve the domestic market as well as the foreign market if it is profitable to do so. Firms face a fixed penetration cost on the export market ($f_X u_f$), where u_f is the unit in which the cost f_X is paid. As a benchmark, I assume that this cost is paid in units of consumption (i.e. $u_f = 1$).[13] In addition to the fixed market penetration cost f_X, an exporter also faces a melting-iceberg cost ($\tau \geq 1$). To sell one unit of good to the foreign country, an exporter must produce and ship τ units because $\tau - 1$ units melt on the way.

[13] As a robustness check I allow for those costs to be paid in terms of effective labor units (i.e. $u_f = \frac{w}{A}$ units of consumption) as in Ghironi and Melitz [25]. As long as those costs are low enough, the two specifications predict the same impact of globalization on the Phillips curve. I choose the "consumption unit" as a benchmark in order to keep the model as simple as possible and to isolate the mechanisms trough which globalization affects the pricing behavior of firms. For clarity, I don't want the impact of globalization to be driven by a change in fixed costs induced by a move in $\frac{w}{A}$ because this effect is of second order compared to the direct channels : the extensive margin (change in the set of exporters) and the intensive margin (changes in their price).

5. **Profit Maximization**

Because of trade costs, markets are segmented and a domestic firm z can set different prices on domestic and foreign markets in order to maximize its total profit.

Maximization of the domestic component of profits by domestic firms

$$\max_{P^d_{t+j}(z)} \sum_{j=0}^{\infty} \mathbb{E}_t \left[Q_{t,t+j} \left(P^d_{t+j}(z) x_{t+j}(z) - \frac{W_{t+j}}{A_{t+j} z} x_{t+j}(z) - \frac{\phi_p}{2} \left(\frac{P^d_{t+j}(z)}{P^d_{t+j-1}(z)} - 1 \right)^2 P^d_{t+j}(z) x^d_{t+j}(z) \right) \right]$$

s.t. $x^d_t(z) = \left(\frac{P^d_t(z)}{P_t(k)} \right)^{-\theta} Y^c_t(k)$

where $Q_{t,t+j}$ is a stochastic discount factor, $Q_{t,t+j} = \beta^j \frac{U'(C_{t+j})}{U'(C_t)} \frac{P_t}{P_{t+j}}$.

Optimality conditions : The optimal relative price is a markup over the real marginal cost.

$$\frac{P^d_t(z)}{P_t} = p^d_t(z) = \mu^d_t(z) \frac{w_t}{A_t z} = \mu^d_t(z) s_t(z) \tag{2.1}$$

where:

$$\mu^d_t(z) = \frac{\Theta^d_t(z)}{(\Theta^d_t(z) - 1)\left[1 - \frac{\phi_p}{2}(\Pi^d_t(z) - 1)^2\right] + \phi_p \Pi^d_t(z)(\Pi^d_t(z) - 1) - \Gamma_t(z)}$$

$$\Theta^d_t(z) = \left| \frac{\partial x^d_t(z)}{\partial P^d_t(z)} \frac{P^d_t(z)}{x^d_t(z)} \right| = \theta - (\theta - \sigma) p^d_t(z)^{1-\theta} = \theta - (\theta - \sigma)\xi^d_t(z)$$

$$\Gamma^d_t(z) = \phi_p \mathbb{E}\left[Q_{t,t+1} \Pi^d_{t+1}(z)^2 (\Pi^d_{t+1}(z) - 1) \frac{x^d_{t+1}(z)}{x^d_t(z)} \right]$$

$$\Pi^d_t(z) = \frac{P^d_t(z)}{P^d_{t-1}(z)}$$

Under flexible prices, the markup becomes $\mu^{d,desired}_t(z) = \frac{\Theta^d_t(z)}{\Theta^d_t(z) - 1}$. Unlike monopolistic competition, the desired markup is not constant over time but depends on the firm's price elasticity of demand ($\Theta^d_t(z)$) that is negatively related to its market share: $\Theta_t^d(z) = \theta - (\theta - \sigma)\xi_t^d(z)$.[14]

The standard monopolistic case is nested into my model for specific parameters restrictions. *(1)* If $\theta = \sigma$, i.e. the elasticity of substitution within a sector is equal to the elasticity of substitution between sectors, then the model collapses to the monopolistic case since the price elasticity of demand becomes $\Theta(z) = \theta - (\theta - \theta)\xi(z) = \theta = \sigma$ and $\mu_t^{d,desired}(z) = \frac{\theta}{\theta-1}$. Indeed, since there is an infinity of sectors, if the elasticity of substitution within a sector is equal to the one between sectors, the strategic interactions -that were taking place within a sector- vanish. *(2)* If the market share $\xi_t^d(z)$ tends to zero (the number of domestic or foreign firms goes to infinity), the market structure also becomes monopolistic with $\Theta(z) = \theta$. *(3)* If there is only one firm per sector, then $P_t^x(z) = P_t$ and thus $\Theta(z) = \theta - (\theta - \sigma)1 = \sigma$.

Maximization of the exports component of profits by domestic firms

See details of the program in Appendix B.3.

Optimality conditions : $\frac{P_t^{d*}(z)}{P_t^*} = p_t^{d*}(z) = rer_t^{-1}\mu_t^{d*}(z)\tau\frac{w_t}{A_t z}$ where rer_t is the real exchange rate, $rer_t = \frac{e_t P_t^*}{P_t}$ with e_t the nominal exchange rate.[15]

Firms' dividends

For a firm z in country D, the dividend (expressed in units of domestic consumption) is the sum of the profit from sales on the domestic market and the profit from sales on the foreign market, $d_t(z) = d_t^d(z) + d_t^{d*}(z)$, where:

[14] The elasticity of substitution across goods within a sector (θ) is greater than the elasticity of substitution between sectoral goods (σ).

[15] The nominal exchange rate should be read as "1 unit of F currency = e_t units of D currency".

$$d_t^d(z) = \left[1 - \frac{1}{\mu_t^d(z)} - \frac{\phi_p}{2}[\Pi_t^d(z) - 1]^2\right] x_t^d(z) \frac{P_t^d(z)}{P_t}$$

$$d_t^{d*}(z) = \begin{cases} 0 & \text{if the firm does not export.} \\ rer_t \left[1 - \frac{1}{\mu_t^{d*}(z)} - \frac{\phi_p}{2}[\Pi_t^{d*}(z) - 1]^2\right] x_t^{d*}(z) \frac{P_t^{d*}(z)}{P_t^*} - f_X u_f & \text{otherwise.} \end{cases}$$

Cutoff values and firms average

Suppose that firms are distributed within each sector following the same discrete bounded distribution on $S = \{z_{min}, z_2, z_3, ..z_{max}\}$. Suppose also that the number of values characterizing the distribution support is large enough so that the sum of the frequency distribution bins can be approximated by an integral (in the spirit of the Riemann sum).

The ***average price*** set by domestic firms serving the domestic market is :
$\widetilde{P_t^d} = \left[\sum_{z \in S} P_t^d(z)^{1-\theta} \mathbb{P}(Z = z)\right]^{\frac{1}{1-\theta}} = \left[\int_{z_{min}}^{z_{max}} P_t^d(z)^{1-\theta} g(z) dz\right]^{\frac{1}{1-\theta}}$.

And the ***average profit*** can be written as:

$$\begin{aligned} \tilde{d_t^d} &= \sum_{z \in S} \left[1 - \frac{1}{\mu_t^d(z)} - \frac{\phi_p}{2}[\Pi_t^d(z) - 1]^2\right] p_t^d(z)^{(1-\theta)} Y_t^c \mathbb{P}(Z = z) \\ &= \int_{z_{min}}^{z_{max}} \left[1 - \frac{1}{\mu_t^d(z)} - \frac{\phi_p}{2}[\Pi_t^d(z) - 1]^2\right] p_t^d(z)^{(1-\theta)} Y_t^c g(z) dz. \end{aligned}$$

The underlying continuous distribution $g(.)$ is a Pareto one with shape parameter k. The Pareto Probability Density Function is $g(z) = \frac{k z_{min}^k}{z^{k+1}} \frac{1}{1 - \left(\frac{z_{min}}{z_{max}}\right)^k}$, $\forall z \in [z_{min}, z_{max}]$.

Its Cumulative Density Function is $G(z) = \mathbb{P}(Z \leq z) = \frac{1 - \left(\frac{z_{min}}{z}\right)^k}{1 - \left(\frac{z_{min}}{z_{max}}\right)^k}$.

- **Cutoff productivity value for a firm to export**

  Similarly to Ghironi and Melitz [25], it is profitable for a firm z in country D to export if its productivity draw z is above the cutoff value $\overline{z_{X,t}}$ =

$\inf\left\{z, \text{ st. } d_t^{d*}(z) \geq 0\right\}$. The cutoff value, $\overline{z_{X,t}}$, for the export component of profit to be positive is defined by:

$$rer_t\left[1 - \frac{1}{\mu_t^{d*}(\overline{z_{X,t}})} - \frac{\phi_p}{2}[\Pi_t^{d*}(\overline{z_{X,t}}) - 1]^2\right] p_t^{d*}(\overline{z_{X,t}})^{(1-\theta)} Y_t^{c*} = f_X u_f \tag{2.2}$$

and the probability for an active domestic firm to export at time t is $\mathbb{P}(Z \geq \overline{z_{X,t}}) = 1 - G(\overline{z_{X,t}})$.

- **Average values from exports**

  The ***average price*** set by domestic firms that are exporting is $\widetilde{P_t^{d*}} = \left[\int_{z_{min}}^{z_{max}} P_t^{d*}(z)^{1-\theta}\gamma_t^X(z)dz\right]^{\frac{1}{1-\theta}}$, where $\gamma_t^X(z)$ is the density function of productivity conditional on exporting, i.e. $\gamma_t^X(z) = \begin{cases} \frac{g(z)}{1-G(\overline{z_{X,t}})} & \text{if } z \geq \overline{z_{X,t}} \\ 0 & \text{otherwise.} \end{cases}$

  Hence:

$$\widetilde{P_t^{d*}} = \left[\frac{1}{1 - G(\overline{z_{X,t}})} \int_{\overline{z_{X,t}}}^{z_{max}} P_t^{d*}(z)^{1-\theta} g(z)dz\right]^{\frac{1}{1-\theta}}$$

  The ***average profit*** from exports is[16]

$$\tilde{d}_t^{d*}(z) = \int_{z_{min}}^{z_{max}} \left\{rer_t\left[1 - \frac{1}{\mu_t^{d*}(z)} - \frac{\phi_p}{2}[\Pi_t^{d*}(z) - 1]^2\right] p_t^{d*}(z)^{(1-\theta)} Y_t^{c*} - f_X u_f\right\} \gamma_t^X(z)dz$$

2.2.3 Aggregate Equilibrium Conditions

Aggregate accounting equation for households Budget Constraint:

Total expenditures (aggregate consumption and investment in new firms) is equal to the aggregate total income from labor and dividends.

$$C_t = w_t L + N^d \tilde{d}_t$$

[16] See details in Appendix B.3.

Market clearing :

- Bonds market : $b_t = \frac{B_t}{P_t} = 0$,
- Labor market: $L = \int_0^1 \left(N^d \int_{z_{min}}^{z_{max}} h_t^d(z) g(z) dz + N_t^{d*} \int_{z_{min}}^{z_{max}} \tau_t h_t^{d*}(z) \gamma_t^X(z) dz \right) dk$.
- Final consumption good market : the total amount of final good consumed (households consumption plus cost of adjusting prices and export market penetration costs) is equal to the total amount of final good produced, i.e. $Y_t^{c,absorbtion} = Y_t^{c,supply}$ with $Y_t^{c,absorbtion} = C_t + PAC_t + N_t^{d*} f_X$ and

$$Y_t^{c,supply} = \left[N^d \int_{z_{min}}^{z_{max}} x_t^d(z)^{\frac{\theta-1}{\theta}} g(z) dz + N_t^f \int_{z_{min}}^{z_{max}} x_t^f(z^*)^{\frac{\theta-1}{\theta}} \gamma_t^X(z^*) dz^* \right]^{\frac{\theta}{\theta-1}} \tag{2.3}$$

All those equilibrium conditions hold symmetrically for the foreign country.[17]

Trade Balance

Under financial autarky, trade should be balanced : $rer_t N_t^{d*} \widetilde{p^{d*}}^{(1-\theta)} Y_t^{c*} = N_t^f \widetilde{p^f}^{(1-\theta)} Y_t^c$.

2.3 Steady State

Definition 1 *A competitive equilibrium is defined as a set of quantities* $\left\{ N_t^{d*}, C_t, Y_t^c, \overline{z_{X,t}}, \widetilde{d_t^d}, \widetilde{d_t^{d*}} \right\}$ *and prices* $\left\{ R_t, w_t, \widetilde{p_t^d}, \widetilde{p_t^{d*}}, \pi_t, \pi_t^d, \pi_t^{d*}, rer_t \right\}$ *for the domestic and symmetrically for the foreign country, such that :*

- *given the sequences of prices, the optimality conditions are satisfied for all the agents in the domestic and in the foreign country;*

[17] If fixed costs are paid in units of production, then $N_t^{d*} f_X$ disappears in the final consumption goods equilibrium condition and the labor market clearing condition becomes $L = N^d \int_{z_{min}}^{z_{max}} (h_t^d(z) + h_{H,t}(z)) g(z) dz + N_t^{d*} \int_{z_{min}}^{z_{max}} (\tau_t h_t^{d*}(z) + h_{X,t}(z)) \gamma_t^X(z) dz$ where $h_{X,t}(z) = \frac{f_X}{A_t}$ since the fixed costs are expressed in units of effective labor.

- *labor market, bonds market and final consumption good market clear;*
- *trade is balanced, i.e.* $0 = rer_t N^{d*} \widetilde{p^{d*}}^{(1-\theta)} Y_t^{c*} - N^f \widetilde{p^f}^{(1-\theta)} Y_t^c$.

2.3.1 Optimality and Equilibrium Conditions in steady State

I suppose that the two countries are symmetric (thus the real exchange rate is 1). Inflation is zero in steady state. Entry costs are paid in units of consumption. Importantly, I assume in the rest of the paper that sectors are symmetric (i.e the distribution of firms within each sector is the same). Thus, for notational simplicity, I can drop the index k because in equilibrium, $\forall k, P_t(k) = P_t$ and $Y_t^c(k) = Y_t^c$. I summarize all the equilibrium conditions in steady state in Table 2.1. The superscript indicates the origin of the firm (d or f) and the destination market that the firm is serving (nothing for country D or '$*$' for country F).[18]

2.3.2 Solving for the steady state

Lemma 1 *In steady state equilibrium, the optimal relative pricing rule defined as*

$$p^x(z) = \frac{\theta - (\theta - \sigma) p^x(z)^{1-\theta}}{\theta - 1 - (\theta - \sigma) p^x(z)^{1-\theta}} s_e^r$$

is a monotone increasing convex function in the real effective marginal cost[19] s_e^r.

Proof. See Appendix B.5.

This Lemma is a necessary step because, contrary to a standard monopolistic setup with no strategic interactions, the optimal relative price is a non linear function

[18] See in Appendix B.2 a summary of the notations.

[19] For non-exporters, the effective marginal cost is simply $s_e^r = s^r = \frac{w}{Az}$. For exporters, their effective marginal cost on the foreign market is scaled-up by the iceberg cost : $s_e^r = s^r \tau = \frac{w}{Az}\tau$.

in the real marginal cost: $p = \frac{\theta-(\theta-\sigma)p^{1-\theta}}{\theta-(\theta-\sigma)p^{1-\theta}-1}s$. Therefore I want to make sure that for a given marginal cost, the firm can choose one and only one optimal relative price.

In order to highlight the key difference with the standard case, I go back to the textbook case, where firms take price as given and there is no love-for variety effect in the Consumer Price Index. Then I add step by step each additional assumption in Table 2.2.

As long as there is no strategic interaction (columns 1 and 2), the optimal relative price set by a firm is a linear function of its real marginal cost. Thus, the real marginal cost of a firm pins down uniquely its relative price.

Once strategic interactions are introduced, the optimal price rule is implicitly defined by a non linear equation : $p^x(i) = \frac{\Theta(\xi(i))}{\Theta(\xi(i))-1}s^r$ where $\xi(i) = \left(\frac{P^x(i)}{P(k)}\right)^{1-\theta} = p^x(i)^{1-\theta}$ and $P(k)$ is the sectoral price in sector k.
By symmetry across sectors, $\forall k : P(k) = P$ in equilibrium. Thus the previous pricing rule can be simplified as:

$$p^x(i) = \frac{\theta - (\theta-\sigma)p^x(i)^{1-\theta}}{\theta - 1 - (\theta-\sigma)p^x(i)^{1-\theta}} s^r.$$

In equilibrium, the optimal relative price is implicitly defined by the non linear equation in s^r. This suggests that potentially, there might be more than one optimal relative price that corresponds to a given real marginal cost. If this were the case, multiple equilibria issues would arise. This is the reason why I check that the solution is unique. As a result, I get the optimal relative price as a monotonic increasing convex function in the real marginal cost.

Corollary 1 *In equilibrium, the optimal relative price p is a decreasing convex function in productivity z.*

Proof.:

The corollary follows directly from the previous Lemma since $s = \frac{w}{Az}\tau$ with $\frac{dp}{ds}(s) \geq 0$. Thus $\frac{dp}{dw}(w) = \frac{dp}{ds}\frac{ds}{dw}(w) \leq 0$.

Figure 2.1 illustrates the bijection between s and p and between z and p. With that tool in hands, it is possible to simplify the system that characterizes the steady state equilibrium in Table 2.1 to a system composed of two equations with two unknowns $\{w, Y^c\}$.

$$\frac{1}{N^d} = \widetilde{p^d}^{1-\theta} + \mathbb{P}(Z \geq \overline{z_X})\widetilde{p^{d*}}^{1-\theta} \tag{2.4}$$

$$C(w, Y^c) = wL + N^d\tilde{d}(w, Y^c) \tag{2.5}$$

Recall that in a symmetric equilibrium, $p^{d*} = p^f$ and $N^{d*} = N^f$. Thus, for any pair $\{w, Y^c\}$, all the remaining endogenous variables can be recovered:

(a) Get the cutoff price for export using Equation (2.2)

(b) Find the associated cutoff productivity value using the Corollary 1

(c) Get N^{d*} from $N^{d*} = N^d\mathbb{P}(Z \geq \overline{z_X})$

(d) Having the cutoff productivity value, I can compute average prices and average profits for serving the domestic market and the export market as described in section 2.2.2. Thus I get $\tilde{d} = \tilde{d}^d + \mathbb{P}(Z \geq \overline{z_X})\tilde{d}^{d*}$ with

- $\tilde{d}^d = \int_{zmin}^{\infty}\{Y^c p^d(z)^{1-\theta}\left[\frac{1}{\Theta^d(z)}\right]\}g(z)dz$
- $\tilde{d}^{d*} = \int_{\overline{z_X}}^{\infty}\{Y^{c*}p^{d*}(z)^{1-\theta}\left[\frac{1}{\Theta^{d*}(z)}\right] - f_X u_f\}\gamma^X(z)dz$

(e) C comes from $Y^c = C + N^{d*} f_X$.

Proposition 1 *The reduced steady state system composed of equations (2.4) and (2.5) has a unique solution.*

Proof. Sketch of the proof.

Equation (2.4) defines w as an increasing function of Y^c whose slope is very small. Equation (2.5) also defines w as an increasing function of Y^c, whose slope is always larger than the slope of the curve implicitly defined by (2.4).

Thus, I show that those two lines might cross at most once. In other words: if there is a solution, then the solution has to be unique.

See details of the proof in Appendix B.6.

Practically, the numerical algorithm aims at finding the solution of a system composed of 2 non linear equations and 2 unknowns. I know that this system has at most one solution. The routine is organized as follows:

1. Start with a guess on w and Y^c

2. Create all the endogenous variables : $p^X_{cutoff}(w, Y^c), z^X_{cutoff}(w, Y^c), N^{d*}(w, Y^c), \tilde{p}^d(w, Y^c), \tilde{p}^{d*}(w, Y^c), \tilde{d}^d(w, Y^c), \tilde{d}^{d*}(w, Y^c), C(w, Y^c)$ as functions of $\{w, Y^c\}$ following the steps (a) to (e) enumerated just above.

3. Using all the previous functions, write the simplified steady state system composed of Equations (2.5)and (2.4) as

$$
\begin{aligned}
G(w, Y^c) &= \widetilde{p^d}^{1-\theta} + \mathbb{P}(Z \geq \overline{z_X})\widetilde{p^{d*}}^{1-\theta} - \frac{1}{N^d} = 0 \\
F(w, Y^c) &= C(w, Y^c) - wL - N^d \tilde{d}(w, Y^c)
\end{aligned}
\tag{2.6}
$$

4. Find the pair $\{w, Y^c\}$ that solves the previous system.

- Define $T(w, Y^c) = G(w, Y^c)^2 + F(w, Y^c)^2$
- Find the pair $\{w, Y^c\}$ that minimizes $T(w, Y^c)$ and check that it is zero.

2.4 The New-Keynesian Phillips Curve

The goal of this section is to compare the dynamics of short-run inflation around the pre-globalization steady state and the post-globalization state. A decline in the sensitivity of inflation to marginal cost has been observed in the data[20] and I show that a drop in the iceberg trade costs, τ, can generate the same feature in my model. Since I consider heterogeneous firms with strategic interactions, two changes appear with respect to the standard new-Keynesian Phillips curve framework.

First, at the firm level, the slope of the Phillips curve depends on the firm productivity - that pins down its market share. More productive firms have a larger market share and exhibit a flatter Phillips curve. They are less prone to transmit marginal cost fluctuations into inflation compared to smaller firms. Intuitively, larger firms are the ones who are the more concerned about losing market share as the markup elasticity is increasing in the market share. Therefore, the real rigidities are increasing with firm size, and the pass-through of marginal cost into inflation declines.

Second, the Phillips curve exhibits a new term on the right-hand side that captures cyclical adjustments in the desired markup due to fluctuations in firms' market power. Results regarding the firm level Phillips curve are derived in Section 2.4.1. The impact of globalization on the aggregate Phillips curve is discussed in Section 2.4.2.

[20] See for instance Matheson and Stavrev [34].

2.4.1 Dynamics around the Steady State for an individual firm z

Loglinearizing the actual markup $\mu_t^d(z)$ from equation (2.1) around the steady state gives the augmented Phillips curve in (2.7). Hat denotes the logdeviation of a variable from the steady state. The only stochastic disturbance is an aggregate productivity shock.

$$\widehat{\Pi_t^d}(z) = -\frac{\Theta_{ss}^d(z) - 1}{\phi_p}\left[\hat{\mu}_t^d(z) - \hat{\mu}_t^{d,desired}(z)\right] + \beta \mathbb{E}_t \widehat{\Pi_{t+1}^d}(z) \tag{2.7}$$

For notational simplicity, as gross inflation is one in steady state, I rewrite the log-deviation of inflation as $\widehat{\Pi_t^d}(z) = \Pi_t^d(z) - 1 = \pi_t^d(z)$. Then,

$$\pi_t^d(z) = \frac{\Theta_{ss}^d(z) - 1}{\phi_p}\left[\hat{mc}_t^d(z) + \hat{\mu}_t^{d,desired}(z)\right] + \beta \mathbb{E}_t \pi_{t+1}^d(z) \tag{2.8}$$

where $\hat{mc}_t^d = \hat{W}_t - \hat{A}_t - \hat{P}_t^d(z) = \hat{w}_t - \hat{A}_t - \hat{p}_t^d(z)$ and symbol "hat" denotes log-deviations from the steady state. $\hat{\mu}_t^{d,desired}(z)$ is the log-deviation from the steady state of the desired markup.[21] Contrary to the monopolistic competition case, the desired markup is not constant and fluctuates with the price elasticity of demand : $\mu_t^{d,desired}(z) = \frac{\Theta_t^d(z)}{\Theta_t^d(z)-1}$ and $\hat{\mu}_t^{d,desired}(z) = -\frac{1}{\Theta_{ss}^d(z)-1}\hat{\Theta}_t^d(z)$. Thus:

$$\pi_t^d(z) = \frac{\Theta_{ss}^d(z) - 1}{\phi_p}\hat{mc}_t^d(z) - \frac{1}{\phi_p}\hat{\Theta}_t^d(z) + \beta \mathbb{E}_t \pi_{t+1}^d(z) \tag{2.9}$$

Proposition 2 (Cyclical fluctuations in the price elasticity of demand matter for inflation dynamics)

In a sticky price environment à la Rotemberg, under oligopolistic competition, individual firm inflation depends ***positively*** *on changes in the real marginal cost and on inflation expectations and* ***negatively*** *on the cyclical fluctuations in the perceived*

[21] The markup prevailing under a flexible price environment.

price-elasticity of demand, $\hat{\Theta}_t^d$*. A decline in* $\hat{\Theta}_t^d$ *should be interpreted as a strengthening of firm's market power, which pushes up inflation. Conversely, an increase in* $\hat{\Theta}_t^d$ *is associated with a decline in real rigidities and reduces inflation.*

Proof. See equation (2.9).

Intuitively, the distance between the actual perceived price elasticity of demand and the one prevailing without strategic interactions, $|\Theta_t(z) - \theta|$, can be interpreted as a proxy for a firm market power. It is a measure of the strategic interactions or real rigidities. A decline in $\Theta(z)_t$ increases the distance to monopolistic competition. The larger the distance, the higher the market power of the firm z and the higher its desired markup. Conversely, an increase in the perceived price elasticity of demand indicates that the firm gets closer to the monopolistic competition case : strategic interactions are vanishing.

The price elasticity of demand is negatively related to the firm market share ($\xi_t^d(z)$).

$$\hat{\Theta}_t^d(z) = -\frac{(\theta - \sigma)\xi_{ss}^d(z)}{\Theta_{ss}^d(z)}\hat{\xi}_t^d(z) = -\frac{(\theta - \Theta_{ss}^d(z))}{\Theta_{ss}^d(z)}\hat{\xi}_t^d(z)$$

Thus

$$\pi_t^d(z) = \frac{\Theta_{ss}^d(z) - 1}{\phi_p}\hat{mc}_t^d(z) + \frac{1}{\phi_p}\frac{(\theta - \Theta_{ss}^d(z))}{\Theta_{ss}^d(z)}\hat{\xi}_t^d(z) + \beta\mathbb{E}_t\pi_{t+1}^d(z) \tag{2.10}$$

Corollary 2 (Cyclical fluctuations in the market share matter for inflation dynamics)
In a sticky price environment, under oligopolistic competition, individual firm short run inflation is increasing in its market share.

Proof. See equation (2.10). A market share decline is equivalent to a strengthening in competitive pressures[22] faced by a firm. The decline in market share results in a decline in the desired markup and consequently a fall in inflation. Conversely, an increase in the market share means that the desired markup increases, which pushes up inflation.

The previous proposition (2) and the associated corollary (2) describe the determinants of inflation at the firm level. Importantly, the weight of each factor (marginal cost and market share) is firm specific.

Proposition 3 (The steady state Price Elasticity of Demand perceived by a firm pins down the Phillips curve slope)

Under oligopolistic competition with sticky prices à la Rotemberg, the lower a firm steady state price elasticity of demand (or equivalently the higher its market power), the less reactive its inflation to marginal cost fluctuations and the more responsive to market share fluctuations.

Proof. See equation (2.10). The Phillips curve slope refers precisely to the coefficient pondering the real marginal cost term.

$$\pi_t^d(z) = \overbrace{\frac{\Theta_{ss}^d(z) - 1}{\phi_p}}^{\text{high for small firms}} \hat{mc}_t^d(z) + \overbrace{\frac{1}{\phi_p} \frac{(\theta - \Theta_{ss}^d(z))}{\Theta_{ss}^d(z)}}^{\text{high for large firms}} \hat{\xi}_t^d(z) + \beta \mathbb{E}_t \pi_{t+1}^d(z)$$

Large firms face a low steady state price elasticity of demand. They are relatively unreactive to marginal cost shocks and more responsive to market share movements -standing for the pro-competitive pressures. For small firms (with low productivity), their price elasticity of demand is already very close to the monopolistic competition

[22] That might come from an increase in competitors prices or a decrease in the number of competitors.

case.[23] The strategic interactions channel is very weak. Consequently, the slope of their Phillips curve is steeper because they cannot absorb marginal costs shocks into their desired markup and have to transmit those shocks proportionally into price adjustments.

Noting that the steady state market share of a firm is a monotonic increasing function in its productivity draw, the previous proposition can be re-stated as follows:

Corollary 3 (Large firms exhibit a flatter Phillips curve)
High-productivity firms are large and exhibit a flatter Phillips curve compared to less productive (small) firms.

Proof.: The sensitivity of inflation to marginal cost is increasing in the steady state price elasticity of demand, and the latter is decreasing in firm's productivity.

In the end, the sensitivity of inflation to real marginal cost is lower for large firms. The aggregate Phillips curve slope will depend on the relative proportion of big versus small firms in the economy.

2.4.2 The aggregate Phillips curve

The previous section gives the intuition that globalization might affect the aggregate Phillips curve by rendering big firms bigger (for those who enter the export market) and therefore increasing the average degree of market power. If the share of exporters (high-productivity firm) increases, then a flattening of the Phillips curve should be expected as those firms essentially respond less to marginal cost fluctuations.

[23] $|\theta - \Theta(z)| \longrightarrow 0$

Production Price Index Inflation

As I am interested in the impact of globalization on domestic firms' behavior, I focus on domestic inflation measured as the percent change in the Production Price Index (here the PPI is equivalent to the GDP deflator). It corresponds to the weighted sum of prices of all goods produced by domestic firms either for domestic consumption or for export). I define the Production Price Index as the Laspeyres price index, and I take the steady state values for the base quarter.

PPI is defined as $PPI_t = \frac{N^d PPI_t^d \widetilde{x_{ss}^d} + N_{ss}^{d*} PPI_t^{d*} e_t \widetilde{x_{ss}^{d*}}}{N^d PPI_{ss}^d \widetilde{x_{ss}^d} + N_{ss}^{d*} PPI_{ss}^{d*} \widetilde{x_{ss}^{d*}}}$.

Consequently: $\widehat{PPI_t} = \omega_{ss} \widehat{PPI_t^d} + (1 - \omega_{ss}^*)(\widehat{PPI_t^{d*}} + \hat{e}_t)$

And thus: $\widehat{\Pi_t^{ppi}} = \left[\omega_{ss} \widehat{\Pi_t^{ppi,d}} + (1 - \omega_{ss}^*)(\widehat{\Pi_t^{ppi,d*}} + \Delta \hat{e}_t) \right]$

where $\omega_{ss} = N^d \widetilde{\xi_{ss}^d}$ and by symmetry between countries $1 - \omega_{ss}^* = 1 - \omega_{ss} = N_{ss}^{d*} \widetilde{\xi_{ss}^{d*}}$. See more detailed calculations in Appendix B.4.

I need to compute the PPI inflation for goods sold on the domestic market (PPI_t^d) and for goods sold on the foreign market (PPI_t^{d*}). Typically, the weights for the production price index in the United States are updated every five years. In the model, I account for the change in the market structure (N^{d*} and N^f) between the pre- and the post-globalization steady states since the transition lasts more than five years.But as far as the cyclical fluctuations around a steady state are concerned, the set of goods is kept constant, consistently with the empirical Production Price Index.

Phillips curve for domestic firms on the domestic market

The average production price set by domestic firms for serving the domestic market is defined as

$$PPI_t^d = \frac{\int_{z_{min}}^{z_{max}} P_t^d(z)x_{ss}^d(z)g(z)dz}{\int_{z_{min}}^{z_{max}} P_{ss}^d(z)x_{ss}^d(z)g(z)dz} \Rightarrow \widehat{P_t^d} = \int_{z_{min}}^{\infty} \frac{\xi_{ss}^d(z)}{\tilde{\xi}_{ss}^d} \widehat{PPI_t^d(z)} g(z)dz.$$

$$\Rightarrow \pi_t^{ppi,d} = \widehat{\Pi_t^{ppi,d}} = \int_{z_{min}}^{z_{max}} \frac{\xi_{ss}^d(z)}{\tilde{\xi}_{ss}^d} \widehat{\Pi_t^d(z)} g(z)dz. \tag{2.11}$$

where $\tilde{\xi}_{ss}^d = \int_{z_{min}}^{z_{max}} p_{ss}^{d\ (1-\theta)}(z)g(z)dz = \int_{z_{min}}^{z_{max}} \frac{P_{ss}^d(z)x_{ss}^d(z)}{P_{ss}Y_{ss}^c} g(z)dz$. Now, by plugging the firm specific Phillips curve equations within the second term of equation (2.11), I get a link between average inflation $pi_t^{ppi,d}$ and firms' marginal cost.

$$\begin{aligned} \pi_t^{ppi,d} = & \int_{z_{min}}^{z_{max}} \frac{\xi_{ss}^d(z)}{\tilde{\xi}_{ss}^d} \frac{\Theta_{ss}^d(z) - 1}{\phi_p} (\hat{W}_t - \hat{A}_t - \widehat{P_t^d}(z)) g(z)dz \\ & + \int_{z_{min}}^{z_{max}} \frac{\xi_{ss}^d(z)}{\tilde{\xi}_{ss}^d} \frac{1}{\phi_p} \frac{(\theta - \Theta_{ss}^d(z))}{\Theta_{ss}^d(z)} \hat{\xi}_t^d(z) g(z)dz + \beta \mathbb{E}_t \pi_{t+1}^d \end{aligned} \tag{2.12}$$

$\frac{\theta - \Theta_{ss}^d(z)}{\Theta_{ss}^d(z)}$ captures the relative distance to the monopolistic steady state price elasticity of demand, i.e. the one prevailing in the absence of strategic interactions. The larger this term, the more market power has the firm.

Phillips curve for domestic firms on the export market

The average price set by domestic firms for exporting (expressed in foreign currency unit) is $PPI_t^{d*} = \frac{\int_{\overline{z_{X,ss}}}^{z_{max}} P_t^{d*}(z)x_{ss}^{d*}(z)\gamma_{ss}^X(z)dz}{\int_{\overline{z_{X,ss}}}^{z_{max}} P_{ss}^{d*}(z)x_{ss}^{d*}(z)\gamma_{ss}^X(z)dz}$

$$\Rightarrow \pi_t^{ppi,d*} = \widehat{\Pi_t^{ppi,d*}} = \int_{\overline{z_{X,ss}}}^{z_{max}} \frac{\xi_{ss}^{d*}(z)}{\tilde{\xi}_{ss}^d} \widehat{\Pi_t^{d*}(z)} \gamma_{ss}^X(z)dz. \tag{2.13}$$

Plugging firm specific Phillips curve into the previous equation, I get:

$$
\begin{aligned}
\pi_t^{ppi,d*} =& \beta \mathbb{E}_t \pi_{t+1}^{ppi,d*} \\
&+ \underbrace{\int_{\overline{z_{X,ss}}}^{z_{max}} \frac{\xi_{ss}^{d*}(z)}{\tilde{\xi}_{ss}^{d*}} \frac{\Theta_{ss}^{d*}(z)-1}{\phi_p} \hat{mc}_t^{d*}(z) \gamma_{ss}^X(z) dz}_{\text{Marginal Cost effect}} + \underbrace{\int_{\overline{z_{X,ss}}}^{z_{max}} \frac{\xi_{ss}^{d*}(z)}{\tilde{\xi}_{ss}^{d*}} \frac{1}{\phi_p} \frac{(\theta - \Theta_{ss}^{d*}(z))}{\Theta_{ss}^{d*}(z)} \hat{\xi}_t^{d*}(z) \gamma_{ss}^X(z) dz}_{\text{Short run competitive pressures}}
\end{aligned} \tag{2.14}
$$

where $\hat{mc}_t^{d*}(z) = \hat{W}_t - \hat{e}_t - \hat{A}_t - \hat{P}_t^{d*}(z) = \hat{w}_t - \hat{A}_t - \hat{p}_t^{d*}(z) - \hat{rer}_t$.

AGGREGATE PHILLIPS CURVE

$$
\pi_t^{ppi} = \beta \mathbb{E}_t \pi_{t+1}^{ppi} + \Gamma(\overline{z_{X,ss}}) \hat{mc}_t + \text{MP}_t + \text{Exch. Rate}_t \tag{2.15}
$$

where

$$
\Gamma(\overline{z_{X,ss}}) = \omega_{ss} \int_{z_{min}}^{z_{max}} \frac{\xi_{ss}^{d}(z)}{\widetilde{\xi_{ss}^{d}}} \frac{\Theta_{ss}^{d}(z)-1}{\phi_p} g(z) dz + (1-\omega_{ss}) \int_{\overline{z_{X,ss}}}^{z_{max}} \frac{\xi_{ss}^{d*}(z)}{\widetilde{\xi_{ss}^{d*}}} \frac{\Theta_{ss}^{d*}(z)-1}{\phi_p} \gamma_{ss}^X(z) dz
$$

$$
\text{MP}_t = \begin{cases} \omega_{ss} \int_{z_{min}}^{z_{max}} \frac{\xi_{ss}^{d}(z)}{\phi_p \widetilde{\xi_{ss}^{d}}} \left(\frac{\theta - \Theta_{ss}^{d}(z)}{\Theta_{ss}^{d}(z)} + \frac{\Theta_{ss}^{d}(z)-1}{\theta-1} \right) \hat{\xi}_t^{d}(z) g(z) dz \\ +(1-\omega_{ss}) \int_{\overline{z_{X,ss}}}^{z_{max}} \frac{\xi_{ss}^{d*}(z)}{\phi_p \widetilde{\xi_{ss}^{d*}}} \left(\frac{\theta - \Theta_{ss}^{d*}(z)}{\phi_p \Theta_{ss}^{d*}(z)} + \frac{\Theta_{ss}^{d*}(z)-1}{\theta-1} \right) \hat{\xi}_t^{d*}(z) \gamma_{ss}^X(z) dz \end{cases}
$$

$$
\text{Exch. Rate}_t = (1-\omega_{ss}) \left(\Delta \hat{e}_t + \int_{\overline{z_{X,ss}}}^{z_{max}} \frac{\xi_{ss}^{d*}(z)}{\widetilde{\xi_{ss}^{d*}}} \frac{\Theta_{ss}^{d*}(z)-1}{\phi_p} \hat{rer}_t \gamma_{ss}^X(z) dz \right).
$$

2.5 RESULTS

Definition 2 *Globalization is defined as a permanent fall in the per unit trade cost* τ.

Proposition 4 (The share of exporters increases with globalization)

The probability for an active firm to export is decreasing in the trade cost τ.

Proof.:

$\frac{d\mathbb{P}(z\geq\overline{z_{X,ss}})}{d\tau} = -k\frac{z_{min}^k}{\overline{z_{X,ss}}^{k+1}}\frac{d\overline{z_{X,ss}}}{d\tau}$

and $\frac{d\overline{z_{X,ss}}}{d\tau} = \underbrace{\frac{\partial\overline{z_{X,ss}}}{\partial w}\frac{dw}{d\tau}}_{\leq 0} + \underbrace{\frac{\partial\overline{z_{X,ss}}}{\partial Y^c}}_{\leq 0}\underbrace{\frac{dY^c}{d\tau}}_{\leq 0} + \underbrace{\frac{\partial\overline{z_{X,ss}}}{\partial\tau}}_{\geq 0}$

The third term on the right-hand side is of first order magnitude compared to the changes going trough the induced effect due do the increase in w: $\left|\frac{\partial\overline{z_{X,ss}}}{\partial w}\frac{dw}{d\tau}\right| \ll \frac{\partial\overline{z_{X,ss}}}{\partial\tau}$. Thus $\frac{d\mathbb{P}(z\geq\overline{z_{X,ss}})}{d\tau} \geq 0$.

Proposition 5 (Openness to trade increases with globalization)

The openness to trade in steady state $(1-\omega_{ss})$ is decreasing in the trade cost (τ).

Proof.:

$$\frac{d\omega_{ss}}{d\tau} = N^d\frac{d\tilde{\xi_{ss}^d}}{d\tau}$$

And $\frac{d\tilde{\xi_{ss}^d}}{d\tau} \geq 0$ because $\frac{d\tilde{p_{ss}^d}}{d\tau} \leq 0$

This comes from $\frac{d\tilde{p_{ss}^d}}{d\tau} = \frac{d\tilde{p_{ss}^d}}{dY^c}\frac{dY^c}{d\tau} + \frac{d\tilde{p_{ss}^d}}{dw}\frac{dw}{d\tau}$ with $\frac{d\tilde{p_{ss}^d}}{dY^c} = 0$ and $\frac{d\tilde{p_{ss}^d}}{dw} \geq 0$

and : $\frac{dw}{d\tau} \leq 0$.

More details are given in Appendix B.6.

Thus $\frac{d\omega_{ss}}{d\tau} \geq 0$ and the openness to trade $(1-\omega_{ss})$ is decreasing in the trade cost: $\frac{d(1-\omega_{ss})}{d\tau} \leq 0$.

Proposition 6 (Exporters have on average more market power than non exporters)

If fixed export penetration costs are large enough, then exporters are on average more productive than the domestic firms, despite their productivity being scaled down by *iceberg trade costs. Thus, the market shares of exporters in steady state are on average larger than the average market share of the whole population of firms.*

Proof.:

The average market share of domestic firms on the domestic market is defined as $\widetilde{\xi^d_{ss}} = \int_{z_{min}}^{z_{max}} {p^d_{ss}}^{(1-\theta)}(z)g(z)dz$ and the average market share of domestic firms on the export market as $\widetilde{\xi^{d*}_{ss}} = \int_{\overline{z_{X,ss}}}^{z_{max}} p^{d*(1-\theta)}_{ss}(z)\gamma^X_{ss}(z)dz$.

For a cutoff productivity $\overline{z_{X,ss}}$ sufficiently high, the higher average productivity of exporters offsets the effect of the iceberg trade cost (that penalizes their effective marginal cost) on prices. In the end, the average price of traded goods is lower than non traded goods because they are produced by much more productive firms. Thus the average market share of exporters is higher than the market share of the whole set of domestic firms.

In the parameterization, I choose values such that that $\mathbb{P}(z \geq \overline{z_{X,ss}}) \leq 20\%$, which ensures that this proposition is satisfied.

This result is really key in understanding the impact of globalization on the Philips curve slope. It is fundamentally different from setups where globalization is modeled as an increase in the number of varieties produced by firms that are homogeneous in productivity. In this case, openness to international trade uniformly squeezes out firms' market share. Then globalization necessarily leads to a decline in the average firms' market power, which is equivalent to relaxing the degree of real rigidities. In the end the Phillips curve steepens.

On the contrary, once globalization is modeled as a fall in trade costs with an endogenous selection of exporters, then globalization might increase the “average market share" in the economy as the relative proportion of big firms increases. This aggregate strengthening of firms' market power is the force driving the flattening of the Phillips curve.

Proposition 7 (The aggregate Phillips curve flattens in response to globalization)
The slope of the aggregate Phillips curve defined in equation (2.15) as $\Gamma(\overline{z_{X,ss}})$ *decreases in response to globalization for a parameterization of the model that replicates standard features of international trade.*

Proof. see Numerical Example.

2.6 Numerical Example

2.6.1 Calibration

I consider quarterly frequency and set $\beta = 0.99$, which yields a 4% real interest rate. The risk aversion coefficient γ is 1 to have a log utility from consumption. The distribution of firm relative productivity is a Pareto with parameter $z_{min} = 0.01$ and $z_{max} = 5$. The shape parameter k is set following Ghironi and Melitz [25]: $k = 3.4$. Note that z_{max} is such that, for a non bounded Pareto distribution, $\mathbb{P}(z \geq z_{max}) \leq 10^{-9}$. This means that the results I get with the truncated Pareto distribution are very closed to those I would have with a non truncated distribution (as in [25]). But the advantage of the bounded distribution is that the productivity averages are always finite, whereas in the non-bounded case, some parameters restrictions are needed to ensure convergence.

As far as the elasticity of substitution is concerned, I set $\theta = 10$ and $\sigma = 1.01$ as in Atkeson and Burstein [2], which implies that the intra-sectoral elasticity of substitution is higher than the inter-sectoral, consistently with Broda and Weinstein [15] findings.[24]

The number of firms per sector and the fixed export costs are chosen in order to match a openness to trade equal to 98% pre-globalization and around 80% post-globalization. In the benchmark case, $N^d = 25$ and $f_X = 0.001$.

I model globalization as a structural shock captured through a fall in iceberg costs τ. The per-unit trade cost may reflect different type of barriers to trade. Table 2.3 presents the range of values for τ in the literature.

I consider a large fall in the iceberg trade costs from 3 to 1. This range corresponds to a share of domestic goods in the domestic consumption basket equal to 0.98 pre-globalization (for $\tau = 3$); 0.81 post-globalization (for $\tau = 1.4$) and 0.57 in the extreme case where $\tau = 1$.

Regarding nominal rigidities, standard results in the literature estimate a duration of prices equal to three quarters, corresponding to a probability of being unable to re-optimize a price in the Calvo setup $\alpha = 0.66$. I choose the price adjustment cost in order for the Phillips curve slope in the Rotemberg setup (with price adjustment cost ϕ_p) to match the Phillips curve slope arising in models à la Calvo. So I impose ϕ_p to be such that

$$\underbrace{\frac{\theta - 1}{\phi_p}}_{\text{Rotemberg PC slope}} = \underbrace{\frac{(1-\alpha)(1-\alpha\beta)}{\alpha}}_{\text{Calvo PC slope}}$$

Consequently I derive $\phi_p = 28$. As I am interested in the change of the Phillips curve slope before and after globalization, this parameter doesn't influence my con-

[24] Anderson and van Wincoop [1] find that the inter-sectoral elasticity of substitution lies between 5 and 10.

clusions. It scales up or down the slope of the Phillips curve, but the relative change caused by globalization is unaffected.

2.6.2 Numerical results

Figure 2.2 shows the changes in the aggregate Phillips curve slope under two specifications. The solid blue line represents the slope of the Phillips curve when firms are *heterogeneous* in productivity and thus the high-productivity firms self-selection mechanism is at play. The red dashed line stands for the slope of the Phillips curve is an economy that exhibits the same average productivity[25] but in which all firms are *homogeneous* in productivity. For sake of comparison, I impose the same number of firms in the homogeneous productivity economy as in the heterogeneous economy, for each value of τ. Hence the pro-competitive channel, due to the enlargement in the set of competitors, is at work in the homogeneous productivity economy, but the composition effect (due to self-selection of high-productivity firms) is shut down.

Two results are brought to light.

First, for a same average productivity, the economy with homogeneous firms exhibits a much higher Phillips curve slope than the economy with heterogeneous productivity firms. This result highlights the crucial non-linearities in the model. Large firms play a very important role in driving the response of inflation to marginal cost shocks.

Second, the slope of the Phillips curve responds in opposite direction to globalization in the two economies. In the heterogeneous productivity case, the Phillips curve

[25] The average productivity is constructed as $z_{average} = \left(\int_{z_{min}}^{z_{max}} z^{\theta-1} g(z) dz\right)^{\frac{1}{\theta-1}} + \mathbb{P}(z \geq \overline{z_X}) \left(\int_{\overline{z_X}}^{z_{max}} z^{\theta-1} \gamma_X(z) dz\right)^{\frac{1}{\theta-1}}$

flattens because the composition effect (self-selection of big firms) offsets the pro-competitive effect due to more competitors. Shutting down the composition channel causes a steepening of the Phillips curve.

As a quantitative exercise, I suppose that the iceberg trade cost falls from 3 to 1. Figure 2.3 gives the corresponding home bias (ω), going from 0.98 to 0.57 in the extreme case where $\tau = 1$ (i.e. there is no more unit iceberg cost). The model predicts that the slope of the aggregate Phillips curve would increase by 3% if only the pro-competitive channel were active. Once the composition channel (coming from the self-selection mechanism) is added, then the slope of the Phillips curve drops by 11%.

2.7 Conclusion

I have developed a general equilibrium setup that can rationalize the flattening of the Phillips curve in response to a fall in trade costs.

Two forces are simultaneously playing in opposite directions in response to globalization. On the one hand, the increase in the number of goods competing on the domestic market reduces firms' market power. This decline in real rigidities renders price adjustments more responsive to marginal cost fluctuations. Thus, the pro-competitive force favors a steepening of the Phillips curve.

On the other hand, the distribution of firms changes because the share of big producers in the economy increases due to the self-selection of high-productivity firms. The post-globalization economy comprises relatively more large firms. As large firms have more market power than the average population, the overall degree of real rigidities in the economy increases. This composition effect reduces the responsiveness of inflation to marginal cost shocks.

At the aggregate level, the Phillips curve does flatten if the composition effect dominates the pro-competitive effect. I show that it is indeed the case: for a parameterization of the model that replicates standard features of international trade, the sensitivity of domestic production price inflation to domestic marginal cost decreases by 11%.

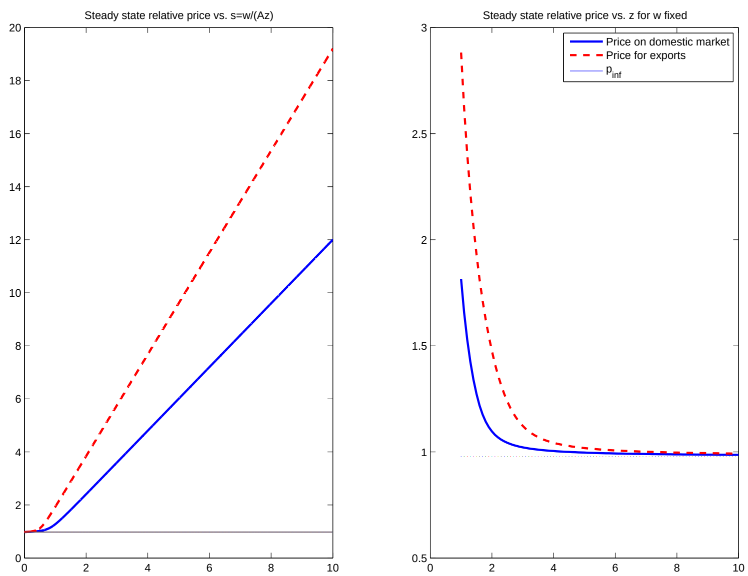


Figure 2.1: Optimal Relative Price

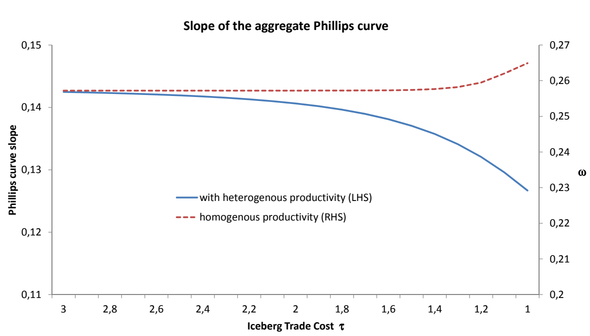


Figure 2.2: Phillips Curve Slope

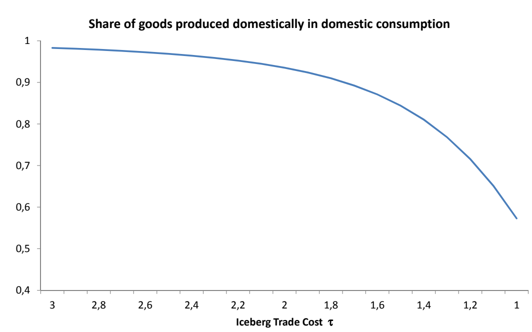


Figure 2.3: Home Bias

Table 2.1: Steady State Equilibrium.

	Country D	Country F
Pricing for domestic sales $\forall z$	$\frac{p^d(z)}{\mu^d(z)} = \frac{w}{Az} = s(z)$	$\frac{w^*}{A^*z^*} = s^*(z^*) = \frac{p^{f*}(z^*)}{\mu^{f*}(z*)}$
Pricing for exports $\forall z$	$\frac{p^{d*}(z)}{\mu^{d*}(z)} = \tau s(z)$	$\frac{p^f(z^*)}{\mu^f(z*)} = \tau s^*(z^*)$
Desired Markup $\forall z$	$\mu^d(z) = \frac{\Theta^d(z)}{\Theta^d_{ss}(z)-1}$	$\mu^{f*}(z^*) = \frac{\Theta^{f*}(z^*)}{\Theta^{f*}(z^*)-1}$
	$\mu^{d*}(z) = \frac{\Theta^{d*}(z)}{\Theta^{d*}(z)-1}$	$\mu^f(z^*) = \frac{\Theta^f(z^*)}{\Theta^f(z^*)-1}$
Price-elasticity of demand $\forall z$	$\Theta^d(z) = \theta - (\theta-\sigma)p^d(z)^{1-\theta}$	$\Theta^{f*}(z^*) = \theta - (\theta-\sigma)p^{f*}(z^*)^{1-\theta}$
	$\Theta^{d*}(z) = \theta - (\theta-\sigma)p^{d*}(z)^{1-\theta}$	$\Theta^f(z^*) = \theta - (\theta-\sigma)p^f(z^*)^{1-\theta}$
Cutoff z for exports	$f_X u_f = Y^{c*}p^{d*}(\overline{z_X})^{1-\theta}\frac{1}{\Theta^{d*}(\overline{z_X})}$	$f^*_X u_{f*} = Y^c p^f(\overline{z^*_X})^{1-\theta}\frac{1}{\Theta^f(\overline{z^*_X})}$
Domestic comp. of Profit	$\tilde{d}^d = \int_{z_{min}}^{z_{max}}\{Y^c p^d(z)^{1-\theta}\left[\frac{1}{\Theta^d(z)}\right]\}g(z)dz$	$\tilde{d}^{f*} = \int_{z_{min}}^{z_{max}}\{Y^{c*}p^{f*}(z^*)^{1-\theta}\left[\frac{1}{\Theta^{f*}(z^*)}\right]\}g(z^*)dz^*$
Export comp. of Profit	$\tilde{d}^{d*} = \int_{\overline{z_X}}^{z_{max}}\{Y^{c*}p^{d*}(z)^{1-\theta}\left[\frac{1}{\Theta^{d*}(z)}\right] - f_X\}\gamma^X(z)dz$	$\tilde{d}^f = \int_{\overline{z^*_X}}^{z_{max}}\{Y^c p^f(z^*)^{1-\theta}\left[\frac{1}{\Theta^f(z^*)}\right] - f^*_X\}\gamma^H(z^*)dz^*$
Dividend	$\tilde{d} = \tilde{d}^d + \mathbb{P}(Z \geq \overline{z_X})\tilde{d}^{d*}$	$\tilde{d}^* = \tilde{d}^{f*} + \mathbb{P}(Z \geq \overline{z^*_X})\tilde{d}^f$
Aggregate output	$Y^c = C + N^{d*}f_X$	$Y^{c*} = C^* + N^f f^*_X$
Aggregate expenditures	$Y^c = wL + N^d\tilde{d}$	$Y^{c*} = w^*L^* + N^{f*}\tilde{d}^*$
Demand in country D $\forall z$	$x^d(z) = p^d(z)^{-\theta}Y^c$	$x^f(z*) = p^f(z^*)^{-\theta}Y^c$
Demand in country F $\forall z$	$x^{d*}(z) = p^{d*}(z)^{-\theta}Y^{c*}$	$x^{f*}(z^*) = p^{f*}(z^*)^{-\theta}Y^{c*}$
Consumer Price Index	$1 = N^d\widetilde{p^d}^{1-\theta} + N^f\widetilde{p^f}^{1-\theta}$	$1 = N^{f*}\widetilde{p^{f*}}^{1-\theta} + N^{d*}\widetilde{p^{d*}}^{1-\theta}$
Labor Market Clearing	$L = N^d\widetilde{h^d} + N^{d*}\widetilde{h^{d*}}$	$L^* = N^{f*}\widetilde{h^{f*}} + N^f\widetilde{h^f}$
Bonds	$b = 0$	$b^* = 0$
Balance of Payments	$0 = rerN^{d*}\widetilde{p^{d*}}^{(1-\theta)}Y^{c*} - N^f\widetilde{p^f}^{(1-\theta)}Y^c$	

Table 2.2: Optimal Pricing Rules

	(1)	(2)	(3)
Competition	Monopolistic	Monopolistic	Oligopolistic
⇒ Optimal nominal price rule :	$P^x(i) = \frac{\theta}{\theta-1}s^n$	$P^x(i) = \frac{\theta}{\theta-1}s^n$	$P^x(i) = \frac{\Theta(\xi(i))}{\Theta(\xi(i))-1}s^n$
Love for varieties effect in CPI	No	Yes	Yes
⇒ Consumption Price index :	$\forall i : P^x(i) = P$	$NP^x(i)^{1-\theta} = P^{1-\theta}$	$NP^x(i)^{1-\theta} = P^{1-\theta}$
Dividing both side of the optimal nominal pricing rule by the aggregate price level :			
Optimal relative price rule	$1 = \frac{\theta}{\theta-1}s^r$	$p^x(i) = \frac{P^x(i)}{P} = \frac{\theta}{\theta-1}s^r$	$p^x(i) = \frac{P^x(i)}{P} = \frac{\Theta(\xi(i))}{\Theta(\xi(i))-1}s^r$

Note: s^n is the nominal marginal cost. In this table, I assume that all firms produce differentiated goods i but have the same productivity of labor (A) and hence the same marginal cost $s^n = \frac{W}{A}$. The real marginal cost s^r is defined as $\frac{s^n}{P}$.

Table 2.3: Per Unit Iceberg Costs in the Literature

	value range	target
Atkeson and Burstein [2008]	[1.34; 1.58]	exports to GDP ratio = 16.5%, exporting firms= 25%
Ghironi and Melitz [2005]	[1.1; 1.3]	target 21% of exporters
Obstfeld and Rogoff [1995]	1.25	ad hoc
Anderson and van Wincoop [2004]	1.65	
Alessandria and Choi [2012]	1.738 in 1987	export intensity 9.9%
	1.529 in 2007	export intensity 15.5%

Appendix A

Impact of Globalization on Inflation: Dissecting the Transmission Channels

A.1 Household's Optimality Conditions

The optimality conditions for the representative household are summarized in table A.1.

Table A.1: First Order Conditions

	Country D	Country F
$(\frac{\partial \mathcal{L}}{\partial C_t})$	$\frac{U'(C_t)}{P_t} = \mathbb{E}_t \frac{U'(C_{t+1})}{P_{t+1}} R_t \beta$	$\frac{U'(C_t^*)}{P_t^*} = \mathbb{E}_t \frac{U'(C_{t+1}^*)}{P_{t+1}^*} R_t^* \beta$
$(\frac{\partial \mathcal{L}}{\partial L_t})$	$\frac{W_t}{P_t} = \frac{U'(L_t)}{U'(C_t)} = L_t^{\nu} C_t^{\gamma}$	$\frac{W_t^*}{P_t^*} = \frac{U'(L_t^*)}{U'(C_t^*)} = L_t^{*\nu} C_t^{*\gamma}$
$(\frac{\partial \mathcal{L}}{\partial B_t^d})$	$U'(C_t)\left[1 + \phi_b b_t^d\right] = R_t \beta \mathbb{E}_t \left[\frac{U'(C_{t+1})}{\Pi_{t+1}}\right]$	$U'(C_t^*)\left[1 + \phi_b b_t^{f*}\right] = R_t^* \beta \mathbb{E}_t \left[\frac{U'(C_{t+1}^*)}{\Pi_{t+1}^*}\right]$
$(\frac{\partial \mathcal{L}}{\partial B_t^f})$	$U'(C_t)\left[1 + \phi_b b_t^f\right] = \frac{R_t^* \beta}{rer_t} \mathbb{E}_t \left[\frac{U'(C_{t+1}) rer_{t+1}}{\Pi_{t+1}^*}\right]$	$U'(C_t^*)\left[1 + \phi_b b_t^{d*}\right] = R_t rer_t \beta \mathbb{E}_t \left[\frac{U'(C_{t+1}^*)}{\Pi_{t+1} rer_{t+1}}\right]$
$(\frac{\partial \mathcal{L}}{\partial u_t})$	$\tilde{v}_t = \beta(1-\delta)\mathbb{E}_t \left[\frac{U'(C_{t+1})}{U'(C_t)}(\tilde{v}_{t+1} + \tilde{d}_{t+1})\right]$	$\tilde{v}_t^* = \beta(1-\delta)\mathbb{E}_t \left[\frac{U'(C_{t+1}^*)}{U'(C_t^*)}(\tilde{v}_{t+1}^* + \tilde{d}_{t+1}^*)\right]$

Iterating forward the Euler equation for share holdings :

$$\tilde{v}_t = \beta(1-\delta)\mathbb{E}_t \left[\frac{U'(C_{t+1})}{U'(C_t)}(\tilde{v}_{t+1} + \tilde{d}_{t+1})\right] \Leftrightarrow \tilde{v}_t = \mathbb{E}_t \left[\sum_{j=t+1}^{\infty} (1-\delta)^{j-t} \beta^{j-t} \frac{U'(C_j)}{U'(C_t)} \tilde{d}_j\right]$$

A.2 Net Foreign Assets Position and Trade Balance

In the aggregate, the fee rebate equals the total cost of adjusting bonds:

$$P_t \frac{\phi_b}{2} \left(\frac{B_t^d}{P_t}\right)^2 + P_t \frac{\phi_b}{2} \left(\frac{B_t^f}{P_t^*}\right)^2 = T_t^B$$

The aggregate budget constraint can thus be written as

$$B_t^d + e_t B_t^f = R_{t-1}B_{t-1} + e_t R_{t-1} B_{t-1} + W_t L_t + \tilde{N}_t^d \tilde{d}_t^d P_t + \tilde{N}_t^f \tilde{d}_t^f P_t - \tilde{N}_{e,t}\tilde{v}_t P_t - P_t C_t - T_t^G$$

In real terms:

$$b_t^d + rer_t b_t^f = \frac{R_{t-1}}{\Pi_t} b_{t-1}^d + rer_t \frac{R_{t-1}^*}{\Pi_t^*} b_{t-1}^f + w_t L_t + \tilde{N}_t^d \tilde{d}_t^d + \tilde{N}_t^f \tilde{d}_t^f - \tilde{N}_{e,t}\tilde{v}_t - C_t - \frac{T_t^G}{P_t}$$

Using the Government Budget constraint, the market clearing condition for final consumption good, the free entry condition and the appropriate definition of profits for exporters and non exporters, I get:

$$b_t^d + rer_t b_t^f = NFA_t = \frac{R_t}{\Pi_t} b_t^d + rer_t \frac{R_t^*}{\Pi_t^*} + rer_t N_t^{d*} p_t^{d*} x_t^{d*} - N_t^f p_t^f x_t^f$$

Defining Trade Balance as $TB_t = rer_t N_t^{d*} p_t^{d*} x_t^{d*} - N_t^f p_t^f x_t^f$, it follows:

$$NFA_t = \frac{R_t}{\Pi_t} b_t^d + rer_t \frac{R_t^*}{\Pi_t^*} + TB_t$$

Symmetrically for the foreign country:

$$b_t^{f*} + \frac{b_t^{d*}}{rer_t} = \frac{R_{t-1}^*}{\Pi_t^*} b_{t-1}^{f*} + \frac{1}{rer_t}\frac{R_{t-1}}{\Pi_t} b_{t-1}^{d*} + w_t^* L_t^* + \tilde{N}_t^{f*} \tilde{d}_t^{f*} + \tilde{N}_t^{d*} \tilde{d}_t^{d*} - \tilde{N}_{e,t}^* \tilde{v}_t^* - C_t^* - \frac{T_t^{G*}}{P_t^*}$$

and hence:

$$b_t^{f*} + \frac{b_t^{d*}}{rer_t} = NFA_t^* = \frac{R_{t-1}^*}{\Pi_t^*} b_{t-1}^{f*} + \frac{1}{rer_t}\frac{R_{t-1}}{\Pi_t} b_{t-1}^{d*} + TB_t^*$$

where $TB_t^* = -\frac{1}{rer_t} * TB_t$.

By definition, $CA_t = NFA_t - NFA_{t-1}$. Hence:

$$CA_t = (b_t^d - b_{t-1}^d) + rer_t (b_t^f - b_{t-1}^f) = (\frac{R_{t-1}}{\Pi_t} - 1) b_{t-1}^d + rer_t (\frac{R_{t-1}^*}{\Pi_t^*} - 1) b_{t-1}^f + TB_t$$

Besides, from the worldwide zero net supply of bonds condition and the FOCs, I got $b_t^d = -b_t^{d*}$, $b_t^f = -b_t^{f*}$, $b_t^f = b_t^d$ and $b_t^{f*} = b_t^{d*}$.

Thus I can check that country D borrowing equals country F lending (expressed in the same unit): $CA_t + rer_t * CA_t^* = 0$

A.3 Impulse Response Functions

The figures A.1, A.2 and A.3 show the impulse response functions for a large range of endogenous variables in countries D and F to a TFP shock in country D. The solid line is the response pre-globalization and the dashed line represents the response post-globalization, i.e. when the economy is more open to international trade.

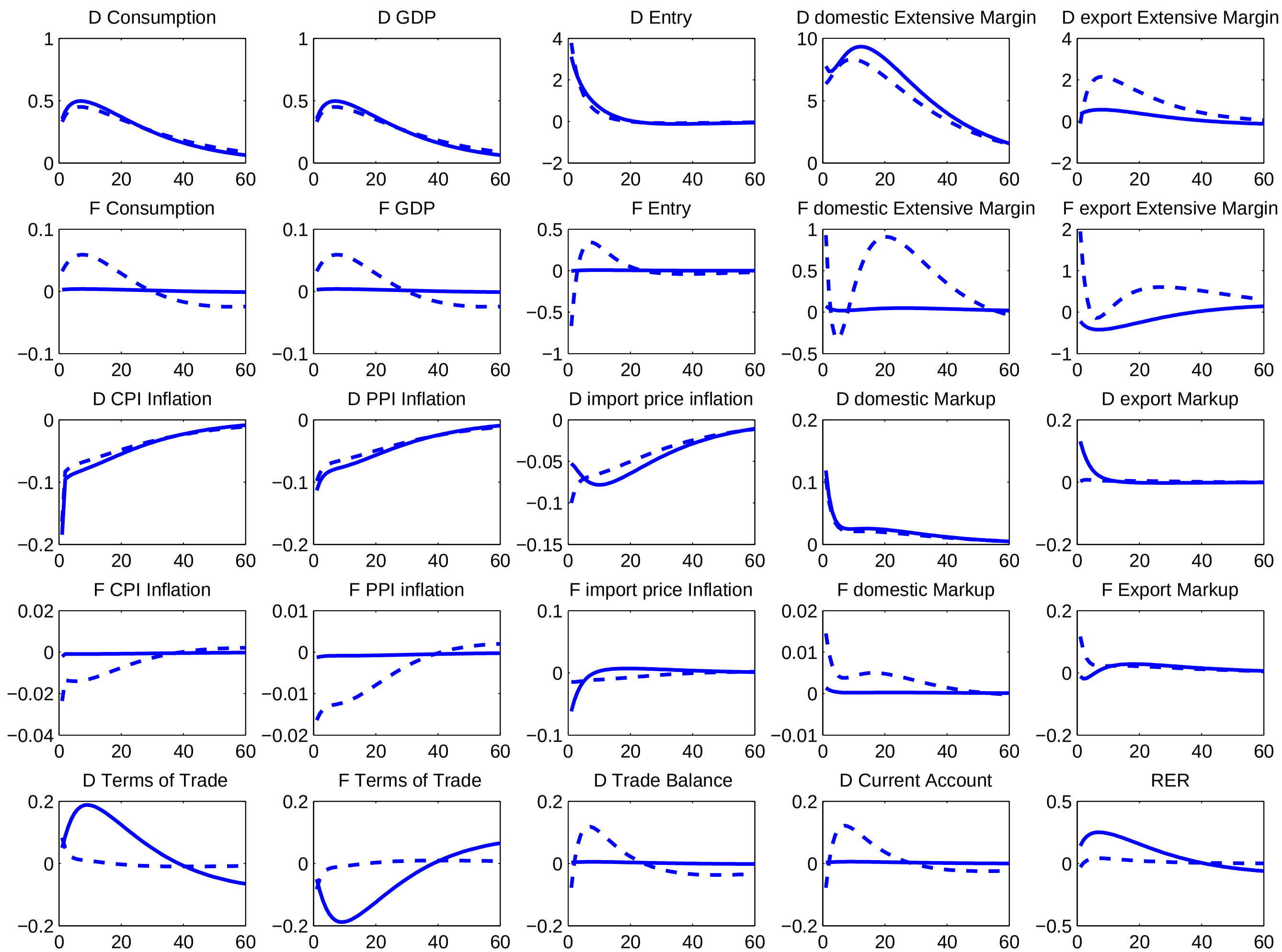


Figure A.1: Responses in Countries D and F to a TFP Shock in Country D - Deviation from Steady State in Level

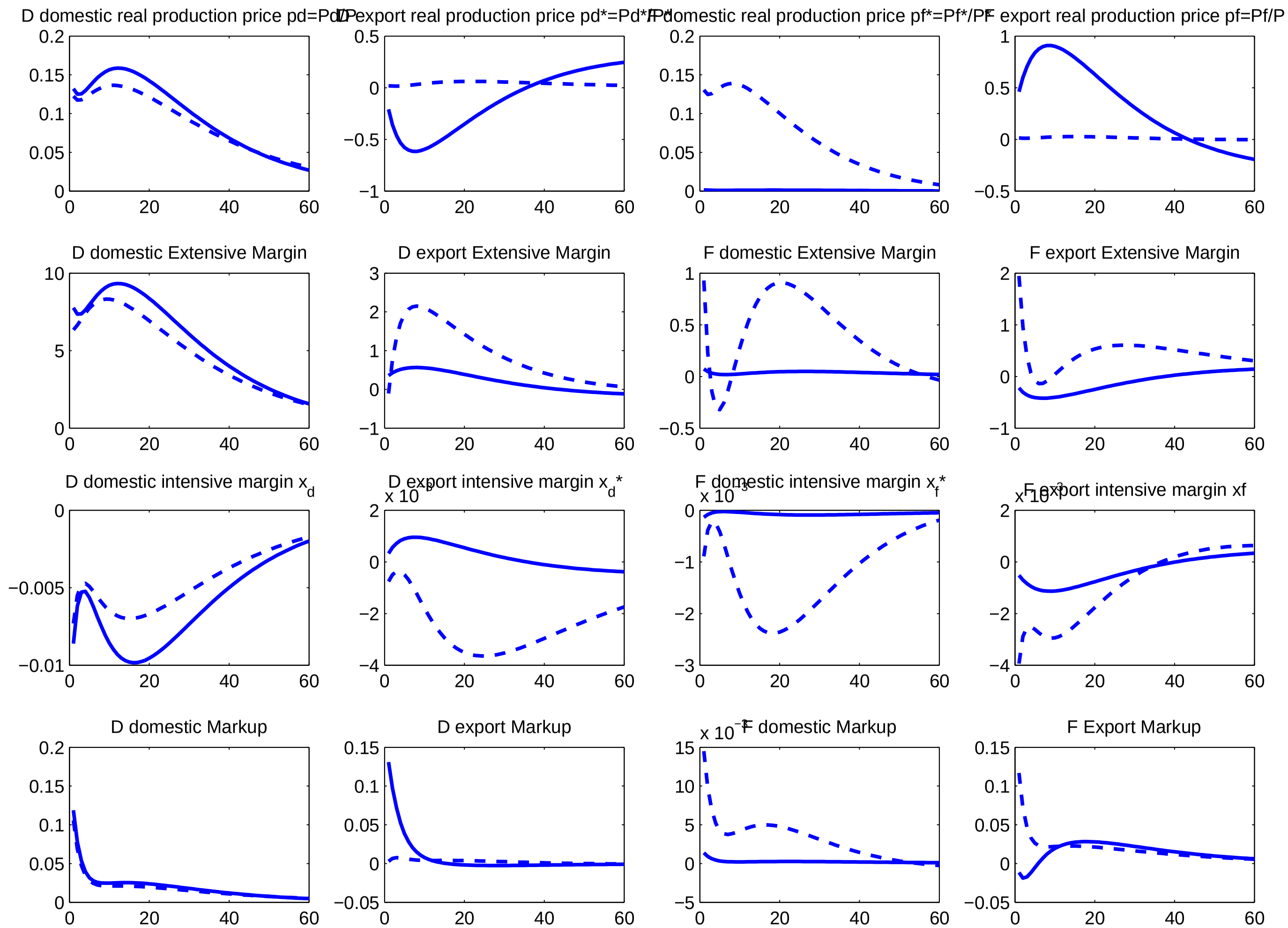


Figure A.2: Responses in Countries D and F to a TFP Shock in Country D - Deviation from Steady State in Level

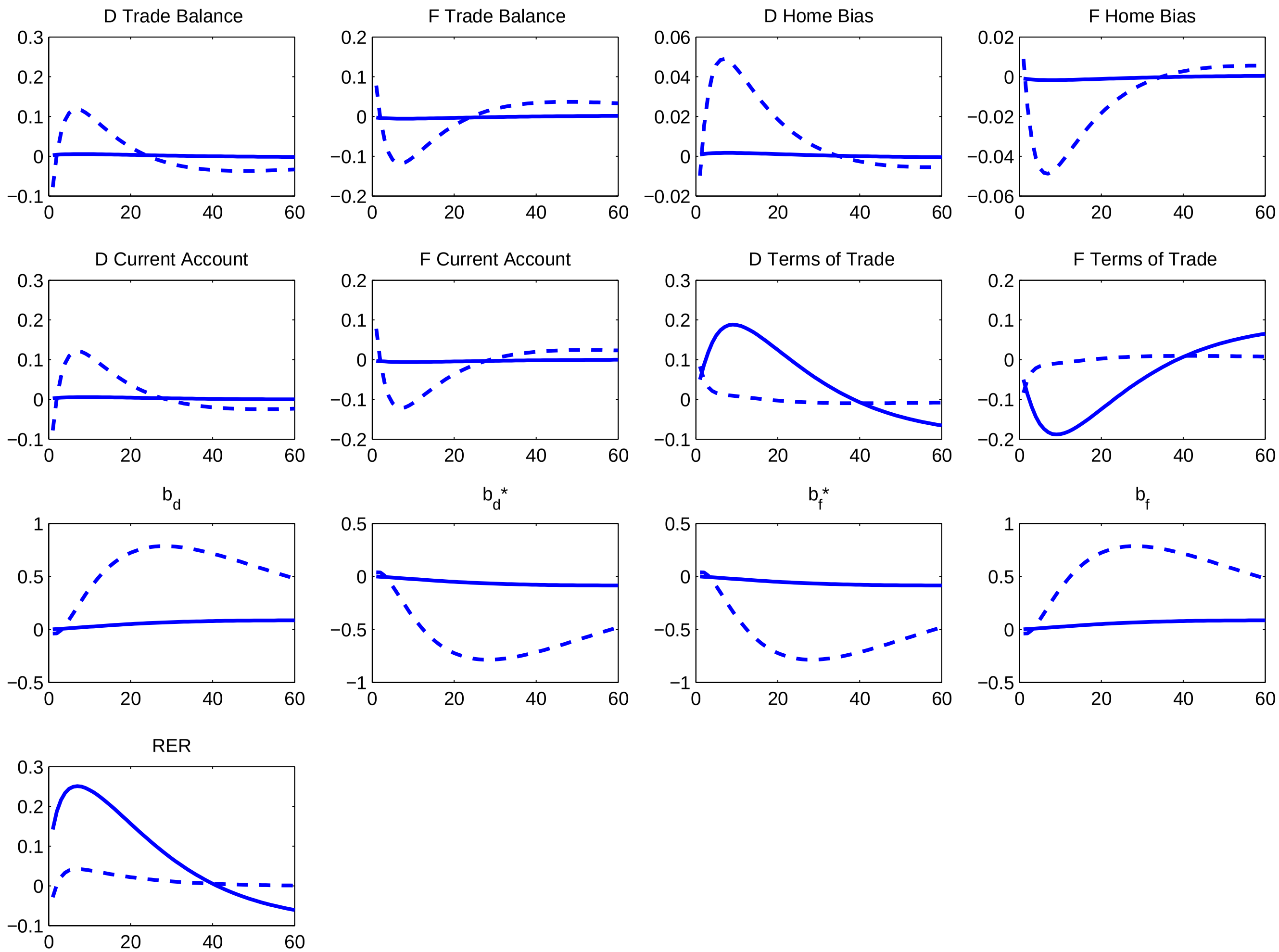


Figure A.3: Responses in Countries D and F to a TFP Shock in Country D - Deviation from Steady State in Level

Appendix B

Globalization, Market Structure and the Flattening of the Phillips Curve

B.1 Closing the General Equilibrium

B.1.1 Households

The problem of the representative household in country D is

$$\max_{\{C_t, B_t\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t)$$

$$\text{s.t. : } P_t C_t + B_t \leq R_{t-1} B_{t-1} + W_t L + N^d \tilde{d}_t P_t$$

where C_t is the consumption of final good at time t, β is a subjective discount factor, L is the inelastic supply of hours of work and the utility function is $U(C_t) = \left[\frac{C_t^{1-\gamma}}{1-\gamma}\right]$. W_t is the nominal wage determined competitively on the labor market and P_t is the consumption price. Households can invest in domestic risk free bonds. B_t is the quantity of domestic risk-free bonds purchased at $t-1$ and $R_t = 1 + r_t^n$ is the nominal return on those bonds from $t-1$ to t. Under financial autarky, domestic bonds are only traded among domestic households.

Households own the firms that pay dividends ($N^d \tilde{d}_t P_t$). $\tilde{d}_t$ is the average firms' dividends and N^d is the number of firms located in country D.

Optimality Conditions:

I denote $\Pi_t = \frac{P_t}{P_{t-1}}$ the gross CPI inflation rate in country D.

$$U'(C_t) = R_t \beta \mathbb{E}_t \left[\frac{U'(C_{t+1})}{\Pi_{t+1}} \right]$$

B.1.2 Monetary Policy

The monetary authority in each country follows a Taylor rule to set the nominal interest rate R_t:

$$log(R_t) = log(R) + \gamma_\pi (log(\Pi_t) - log(\Pi))) + \gamma_y (log(Y_t)) - log(Y))$$

where $Y_t = GDP_t^v = N^d \tilde{p}_t^d \tilde{x}_t^d + N_t^{d*} \tilde{p}_t^{d*} rer_t \tilde{x}_t^{d*} = w_t L + N^d \tilde{d}_t$

B.2 Notations

The notations read as follows:

Notation	**refers to**
d	a firm from country D serving market D
$d*$	a firm from country D serving market F
$f*$	a firm from country F serving market F
f	a firm from country F serving market D
N^d ; N^{f*}	the number of firms located respectively on the market D and F
$\frac{N^{d*}}{N^d}$; $\frac{N^f}{N^{f*}}$	the share of exporters in country D and F

B.3 Export Component of Profit for Intermediate Goods Producer

Maximization of the exports component of profits

$$\max_{P^{d*}_{t+j}(z)} \sum_{j=0}^{\infty} \mathbb{E}_t \Bigg[(1-\delta)^j Q_{t,t+j} \Bigg(P^{d*}_{t+j}(z) x^{d*}_{t+j}(z) - \tau_t \frac{W_{t+j}/e_t}{A_{t+j} z^*(z)} x^{d*}_{t+j}(z) \\ - \frac{\phi_p}{2} \left(\frac{P^{d*}_{t+j}(z)}{P^{d*}_{t+j-1}(z)} - 1 \right)^2 P^{d*}_{t+j}(z) x^{d*}_{t+j}(z) - \frac{f_{X,t+j} P^*_{t+j}}{rer_{t+j}} u_f \Bigg) \Bigg]$$

s.t.

$$x_t^{d*}(z) = \left(\frac{P_t^{d*}(z)}{P_t^*}\right)^{-\theta} Y_t^{c*}$$

$$Q_{t,t+j} = \beta^j \frac{U'(C_{t+j})}{U'(C_t)} \frac{P_t}{P_{t+j}}$$

rer_t is the real exchange rate and e_t the nominal exchange rate: $rer_t = \frac{P_t^* e_t}{P_t}$

Optimality conditions :

$$\frac{P_t^{d*}(z)}{P_t^*} = p_t^{d*}(z) = rer_t^{-1} \mu_t^{d*}(z) \tau_t \frac{w_t}{A_t z}$$

B.4 Openness to Trade

$$\begin{aligned}
\omega_{ss} &= N_{ss}^d \frac{\widetilde{P^d}_{ss} \widetilde{x^d}_{ss}}{P_{ss} Y_{ss}^c} = N_{ss}^d \frac{\int_{z_{min}}^{z_{max}} x_{ss}^d(z) P_{ss}^d(z) g(z) dz}{Y_{ss}^c P_{ss}} \\
&= N_{ss}^d \frac{\int_{z_{min}}^{z_{max}} x_{ss}^d(z) p_{ss}^d(z) g(z) dz}{Y_{ss}^c} = N_{ss}^d \frac{\int_{z_{min}}^{z_{max}} {p_{ss}^d}^{1-\theta}(z) Y_{ss}^c g(z) dz}{Y_{ss}^c} \\
&= N_{ss}^d \frac{\widetilde{p_{ss}^d}^{1-\theta} Y_{ss}^c}{Y_{ss}^c} = N_{ss}^d \widetilde{p_{ss}^d}^{1-\theta}
\end{aligned}$$

and

$$1 - \omega_{ss}^* = 1 - \omega_{ss}$$

because by symmetry, in steady state: $N^f = N^{d*}$ and $p^f(z) = p^{d*}(z)$.

$$\begin{aligned}
1 - \omega_{ss} &= N_{ss}^f \frac{\widetilde{P^f}_{ss} \widetilde{x^f}_{ss}}{P_{ss} Y_{ss}^c} = N_{ss}^f \frac{\int_{\overline{z_{X,ss}}}^{z_{max}} x_{ss}^f(z) P_{ss}^f(z) \gamma_{ss}^X(z) dz}{Y_{ss}^c P_{ss}} \\
&= N_{ss}^f \frac{\int_{\overline{z_{X,ss}}}^{z_{max}} x_{ss}^f(z) p_{ss}^f(z) \gamma_{ss}^X(z) dz}{Y_{ss}^c} = N_{ss}^f \frac{\int_{\overline{z_{X,ss}}}^{z_{max}} {p_{ss}^f}^{1-\theta}(z) Y_{ss}^c \gamma_{ss}^H(z) dz}{Y_{ss}^c} \\
&= N_{ss}^f \frac{\widetilde{p_{ss}^d}^{1-\theta} Y_{ss}^c}{Y_{ss}^c} = N_{ss}^d \widetilde{p_{ss}^d}^{1-\theta}
\end{aligned}$$

B.5 Optimal Relative Price as an Increasing Convex Function in the Real Marginal Cost

In the monopolistic case there is a linear relationship between the optimal relative price and the real marginal cost, $p = \mu s^r$. In the oligopolistic case, equation (**??**) relates the optimal relative price to firm's real marginal cost in a non linear way:

$$p = \frac{\Theta(p)}{\Theta(p)-1}s^r = \frac{\theta-(\theta-\sigma)p^{1-\theta}}{(\theta-1)-(\theta-\sigma)p^{1-\theta}}s^r$$

$$\Leftrightarrow \mathcal{H}(p,s^r) = (\theta-1)p^\theta - \theta s^r p^{\theta-1} - (\theta-\sigma)p + (\theta-\sigma)s^r = 0$$

I want to check that for any given real marginal cost s^r, a firm can choose one and only one optimal relative price p._

To that end I study s^r as a function of p and show that it is a bijection: s^r is a monotonic increasing concave function in p on $[1,+\infty]$. Thus p is the inverse function and is strictly increasing and convex in s^r.

STEP 1: I show that $\frac{\partial s^r}{\partial p} \geq 0$

$$\frac{\partial s^r}{\partial p} = \frac{\theta^2(p^{2\theta}-p^{\theta+1}+p^2)-\theta(p^{2\theta}-\sigma p(p^\theta-2p)+\sigma^2p^2)}{(\theta(p^\theta-p)+\sigma p)^2}$$

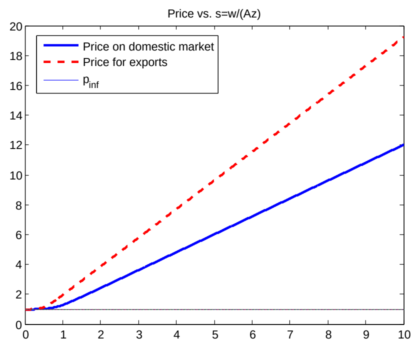
$$\Rightarrow \forall p \geq 1, \frac{\partial s^r}{\partial p} \geq 0$$

STEP 2: I show that $\frac{\partial^2 s^r}{\partial p^2} \leq 0$

$$\frac{\partial^2 s^r}{\partial p^2} = -\frac{(\theta-1)\theta(\theta-\sigma)p^\theta(-2p^\theta+\theta(p^\theta+p)-\sigma p)}{(\theta(p^\theta-p)+\sigma p)^3}$$

STEP 3:

If s^r is a monotonic increasing and concave function in p, then there exists a reciprocal function: $p(.)$ that is monotonically increasing and convex in s^r.



B.6 Steady State Uniqueness

Suppose that countries are symmetric (then $Y^c = Y^{c*}$, $w = w*$ and $p^f = p^{d*}$), labor supply is inelastic (L is fixed) and entry costs are paid in units of consumption good.

STEP 1. Show that (2.4) defines w as a monotonic increasing function in Y^c

1.1. **Equation (2.4) can be rewritten as $G(w, Y^c) = 0$ with $\frac{dG}{dw} \leq 0$ and $\frac{dG}{dY^c} \geq 0$.**

$$G(w, Y^c) = \widetilde{p^d}^{1-\theta} + \mathbb{P}(Z \geq \overline{z_X})\widetilde{p^{d*}}^{1-\theta} - \frac{1}{N^d} = 0 \tag{B.1}$$

I want to compute $\frac{dG}{dY^c}(w, Y^c)$ and $\frac{dG}{dw}(w, Y^c)$.

Let's find first some useful intermediate derivatives. Define the cutoff price (for exporting).

$$\overline{p_X} = \left[\frac{Y^c}{\theta f_X u_f} + \frac{(\theta - \sigma)}{\theta}\right]^{\frac{1}{\theta-1}} \tag{B.2}$$

$$\boxed{\frac{d\overline{p_X}}{dY^c} \geq 0} \tag{B.3}$$

$$\overline{z_X} = \frac{\tau}{\overline{p_X}} \frac{w}{A} \frac{\theta - (\theta - \sigma)\overline{p_X}^{1-\theta}}{(\theta - 1) - (\theta - \sigma)\overline{p_X}^{1-\theta}} \tag{B.4}$$

$$\begin{aligned} \frac{d\overline{z_X}}{dw} &\geq 0 \\ \frac{d\overline{z_X}}{dY^c} &= \frac{d\overline{z_X}}{d\overline{p_X}} \frac{d\overline{p_X}}{dY^c} \leq 0 \end{aligned} \tag{B.5}$$

Besides, $\mathbb{P}(Z \geq \overline{z_X}) = \left(\frac{z_{min}}{\overline{z_X}}\right)^k$.

Hence:

$$\begin{aligned} \frac{d\mathbb{P}(Z \geq \overline{z_X})}{dw} &= \frac{d\mathbb{P}(Z \geq \overline{z_X})}{d\overline{z_X}} \frac{d\overline{z_X}}{dw} \leq 0 \\ \frac{d\mathbb{P}(Z \geq \overline{z_X})}{dY^c} &= \frac{d\mathbb{P}(Z \geq \overline{z_X})}{d\overline{z_X}} \frac{d\overline{z_X}}{dY^c} \geq 0 \end{aligned} \tag{B.6}$$

Turning to the average price conditional on serving the domestic (resp. foreign) market:

$$\widetilde{p^d}^{1-\theta} = \int_{z_{min}}^{z_{max}} p^d(z,w)^{1-\theta} g(z) dz \tag{B.7}$$

$$\Rightarrow (1-\theta)\widetilde{p^d}^{-\theta} \frac{d\widetilde{p^d}}{dw} = \int_{z_{min}}^{z_{max}} (1-\theta) p^{d^{-\theta}}(z,w) \frac{dp^d(z,w)}{dw} g(z) dz \tag{B.8}$$

$$\frac{d\widetilde{p^d}}{dw} = \widetilde{p^d}^{\theta} \int_{z_{min}}^{z_{max}} p^{d^{-\theta}}(z,w) \frac{dp^d(z,w)}{dw} g(z) dz \geq 0 \tag{B.9}$$

and for exporting:

$$\begin{aligned} \widetilde{p^{d*}}^{1-\theta} &= \int_{\overline{z_X}}^{z_{max}} p^{d*}(z,w)^{1-\theta} \gamma_t^X(z) dz \\ \Leftrightarrow \widetilde{p^{d*}}^{1-\theta} &= \int_{\overline{z_X}}^{z_{max}} p^{d*}(z,w)^{1-\theta} \frac{g(z)}{\mathbb{P}(Z \geq \overline{z_X})} dz \end{aligned} \tag{B.10}$$

$$\begin{aligned} \Rightarrow (1-\theta)\widetilde{p^{d*}}^{-\theta} \frac{d\widetilde{p^{d*}}}{dw} &= \int_{\overline{z_X}}^{z_{max}} (1-\theta) p^{d*^{-\theta}}(z,w) \frac{dp^{d*}(z,w)}{dw} \frac{g(z)}{\mathbb{P}(Z \geq \overline{z_X})} dz \\ &+ \frac{d\overline{z_X}}{dw} \left[\frac{k}{z_{min}^k} \overline{z_X}^{k-1} \int_{\overline{z_X}}^{z_{max}} p^{d*^{1-\theta}}(z,w) g(z) - \frac{p^{d*^{1-\theta}}(\overline{z_X}, w) g(\overline{z_X})}{\mathbb{P}(Z \geq \overline{z_X})} \right] \end{aligned} \tag{B.11}$$

$$\frac{d\widetilde{p^{d*}}}{dw} = \widetilde{p^{d*}}^{\theta}\Bigg(\overbrace{\int_{\overline{z_X}}^{z_{max}} p^{d*-\theta}(z,w)\frac{dp(z,w)}{dw}\frac{g(z)}{\mathbb{P}(Z\geq\overline{z_X})}dz}^{\text{Pricing Function Adjustment (PFA)}} - \frac{1}{(\theta-1)}\underbrace{\frac{d\overline{z_X}}{dw}\frac{k}{\overline{z_X}}\left[\widetilde{p^{d*}}^{1-\theta} - p^{d*1-\theta}(\overline{z_X},w)\right]}_{\text{Set of Varieties Adjustment (SVA)}}\Bigg) \tag{B.12}$$

Thus:

$$\frac{d\widetilde{p^{d*}}}{dw} = \widetilde{p^{d*}}^{\theta}\Bigg(\underbrace{PFA}_{>0} - \frac{1}{(\theta-1)}\underbrace{\frac{d\overline{z_X}}{dw}\frac{k}{\overline{z_X}}\left[\widetilde{\xi^{d}} - \xi^{d}(\overline{z_X})\right]}_{>0}\Bigg) \tag{B.13}$$

$$\frac{d\widetilde{p^{d*}}}{dw} \geq 0$$

$$\Leftrightarrow \underbrace{\int_{\overline{z_X}}^{z_{max}} p^{d*-\theta}(z,w)\frac{dp^{d*}(z,w)}{dw}\frac{g(z)}{\mathbb{P}(Z\geq\overline{z_X})}dz}_{\text{Pricing Function Adjustment}} \geq \underbrace{\frac{1}{(\theta-1)}\frac{d\overline{z_X}}{dw}\frac{k}{\overline{z_X}}\left[\widetilde{\xi^{d*}} - \xi^{d*}(\overline{z_X})\right]}_{\text{Set of Varieties Adjustment}} \tag{B.14}$$

$\forall C : \frac{d\widetilde{p^{d}}}{dY^c} = 0$ and $\forall C : \frac{d\widetilde{p^{d*}}}{dY^c} \geq 0$ because

$$\frac{d\widetilde{p^{d}}}{dY^c} = \widetilde{p^{d}}^{\theta}\left(\int_{z_{min}}^{z_{max}} p^{d-\theta}(z,w)\overbrace{\frac{dp^{d}(z,w)}{dY^c}}^{=0}\frac{g(z)}{\mathbb{P}(Z\geq\overline{z_H})}dz\right) = 0 \tag{B.15}$$

and

$$\frac{d\widetilde{p^{d*}}}{dY^c} = \widetilde{p^{d*}}^{\theta}\left(\int_{\overline{z_X}}^{z_{max}} p^{d*-\theta}(z,w)\overbrace{\frac{dp^{d*}(z,w)}{dY^c}}^{=0}\frac{g(z)}{\mathbb{P}(Z\geq\overline{z_X})}dz - \frac{1}{(\theta-1)}\underbrace{\frac{d\overline{z_X}}{dY^c}}_{\leq 0}\frac{k}{\overline{z_X}}\left[\widetilde{\xi^{d*}} - \xi^{d*}(\overline{z_X})\right]\right) \tag{B.16}$$

Going back to $G(w, Y^c)$:

$$G(w,Y^c) = \widetilde{p^{d}}^{1-\theta} + \mathbb{P}(Z\geq\overline{z_X})\widetilde{p^{d*}}^{1-\theta} - \frac{1}{N^d}$$

Then :

$$\begin{aligned}\frac{dG}{dY^c}(w,Y^c) =& (1-\theta)\widetilde{p^{d}}^{-\theta}\frac{d\widetilde{p^{d}}}{dY^c} + \frac{\mathbb{P}(Z\geq\overline{z_X})}{dY^c}\widetilde{p^{d*}}^{1-\theta} \\ &+ \mathbb{P}(Z\geq\overline{z_X})(1-\theta)\widetilde{p^{d*}}^{-\theta}\frac{\widetilde{p^{d*}}}{dY^c}\end{aligned}$$

Thus $\frac{dG}{dY^c}(w, Y^c) \geq 0$.

Besides,

$$\begin{aligned}\frac{dG}{dw}(w, Y^c) =& (1-\theta)\widetilde{p^d}^{-\theta}\frac{d\widetilde{p^d}}{dw} + \frac{\mathbb{P}(Z \geq \overline{z_X})}{dw}\widetilde{p^{d*}}^{1-\theta} \\ &+ \mathbb{P}(Z \geq \overline{z_X})(1-\theta)\widetilde{p^{d*}}^{-\theta}\frac{\widetilde{p^{d*}}}{dw}\end{aligned}$$

Thus $\frac{dG}{dw}(w, Y^c) \leq 0$

1.2. **Apply implicit function theorem**

By implicit function theorem: there exists an implicit function g such that $w = g(Y^c)$ and $\frac{\partial g}{\partial Y^c}(Y^c) = -\frac{\frac{\partial G}{\partial Y^c}(w,Y^c)}{\frac{\partial G}{\partial w}(w,Y^c)}$. Thus $\frac{\partial g}{\partial Y^c}(Y^c) \geq 0$.

STEP 2. Show that (2.5) defines w as a monotonic increasing function to Y^c

2.1. **Equation (2.5) can be rewritten as $F(w, Y^c) = 0$ with $\frac{dF}{dw} \leq 0$ and $\frac{dF}{dY^c} \geq 0$.**

$$F(w, Y^c) = C(w, Y^c) - wL - N^d\tilde{d}(w, Y^c)$$

$$F(w, Y^c) = Y^c - wL - N^dY^c\left(\frac{1}{\theta\widetilde{p^d}^{\theta-1} - (\theta-\sigma)} + \mathbb{P}(Z \geq \overline{z_X})\frac{1}{\theta\widetilde{p^f}^{\theta-1} - (\theta-\sigma)}\right)$$

$$F(w, Y^c) = Y^c\left(1 - N^d\left(\frac{1}{\theta\widetilde{p^d}^{\theta-1} - (\theta-\sigma)} + \mathbb{P}(Z \geq \overline{z_X})\frac{1}{\theta\widetilde{p^f}^{\theta-1} - (\theta-\sigma)}\right)\right) - wL$$

$$\frac{dF(w,Y^c)}{dY^c} = 1 - N^d\left(\frac{-\theta(\theta-1)\frac{d\widetilde{p^d}}{dY^c}\widetilde{p^d}^{\theta-2}}{(\theta\widetilde{p^d}^{\theta-1}-(\theta-\sigma))^2} + \mathbb{P}(Z\geq\overline{z_X})\frac{-\theta(\theta-1)\frac{d\widetilde{p^f}}{dY^c}\widetilde{p^f}^{\theta-2}}{(\theta\widetilde{p^f}^{\theta-1}-(\theta-\sigma))^2}\right.$$
$$\left. + \frac{d\mathbb{P}(Z\geq\overline{z_X})}{dY^c}\frac{1}{\theta\widetilde{p^f}^{\theta-1}-(\theta-\sigma)}\right)$$

The second term in brackets on the right-hand-side is small compared to the first order effect $\frac{dY^c}{dY^c}=1$. Thus $\frac{dF(w,Y^c)}{dY^c}\geq 0$

$$\frac{dF(w,Y^c)}{dw} = -L - N^d\left(\frac{-\theta(\theta-1)\frac{d\widetilde{p^d}}{dw}\widetilde{p^d}^{\theta-2}}{(\theta\widetilde{p^d}^{\theta-1}-(\theta-\sigma))^2} + \mathbb{P}(Z\geq\overline{z_X})\frac{-\theta(\theta-1)\frac{d\widetilde{p^f}}{dw}\widetilde{p^f}^{\theta-2}}{(\theta\widetilde{p^f}^{\theta-1}-(\theta-\sigma))^2}\right.$$
$$\left. + \frac{d\mathbb{P}(Z\geq\overline{z_X})}{dw}\frac{1}{\theta\widetilde{p^f}^{\theta-1}-(\theta-\sigma)}\right)$$

The second term in brackets on the right-hand-side is small (in absolute value) compared to the first order effect $\frac{dwL}{dw}=L$. Thus $\frac{dF(w,Y^c)}{dw}\leq 0$

2.2. **Apply implicit function theorem**

By implicit function theorem: there exists an implicit function f such that $w=f(Y^c)$ and $\frac{\partial f}{\partial Y^c}(Y^c) = -\frac{\frac{\partial F}{\partial Y^c}(w,Y^c)}{\frac{\partial F}{\partial w}(w,Y^c)}$. Thus $\frac{\partial f}{\partial Y^c}(Y^c)\geq 0$.

STEP 3. $\frac{dg}{dY^c}(Y^c) - \frac{df}{dY^c}(Y^c)$ is monotonic.

$$\frac{dg}{dY^c}(Y^c) - \frac{df}{dY^c}(Y^c) = -\frac{\frac{\partial G}{\partial Y^c}(w,Y^c)}{\frac{\partial G}{\partial w}(w,Y^c)} + \frac{\frac{\partial F}{\partial Y^c}(w,Y^c)}{\frac{\partial F}{\partial w}(w,Y^c)} \tag{B.17}$$

I know that $Y^c\geq w$ by (2.5).

I check numerically that, for the set of parameters considered in the paper, $\frac{\frac{\partial G}{\partial Y^c}(w,Y^c)}{\frac{\partial G}{\partial w}(w,Y^c)}\simeq 0$. Besides $\frac{\frac{\partial F}{\partial Y^c}(w,Y^c)}{\frac{\partial F}{\partial w}(w,Y^c)}\leq 0$.

Figure B.1 illustrates graphically this idea.

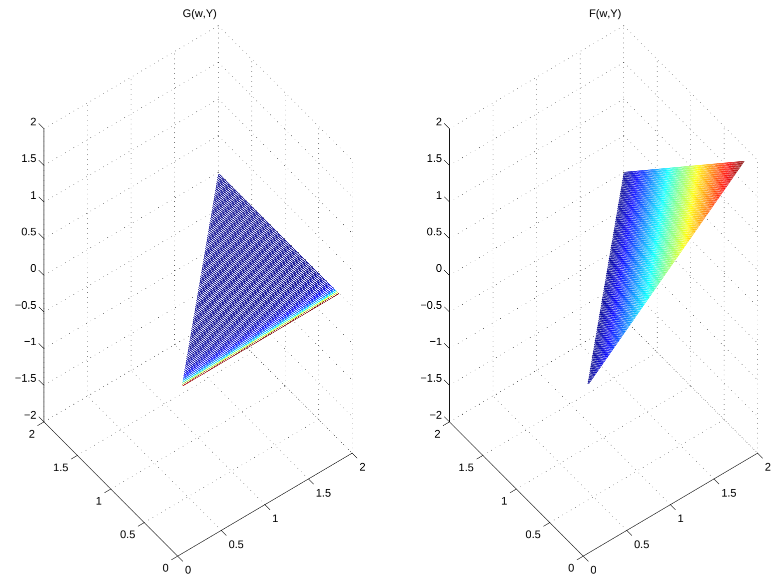


Figure B.1: Functions $G(w, Y^c)$ and $F(w, Y^c)$

Thus, $\frac{dg}{dY^c}(Y^c) - \frac{df}{dY^c}(Y^c)$ is monotonically decreasing in Y^c. $\frac{dg}{dY^c}(Y^c) - \frac{df}{dY^c}(Y^c)$ crosses at most once the zero axis. Consequently there is at most one solution to the previous system: if a solution exists, it has to be unique.

B.7 Cournot versus Bertrand Competition

I focus on competition *à* la Bertrand, in which firms internationalize the effect of their *price* decision on the sectoral price, entailing a perceived elasticity of demand $\Theta^{\text{Bertrand}}(\xi) = \theta - (\theta - \sigma)\xi$. Alternatively I could have considered firms competing *à* la Cournot, i.e. in quantities, internalizing the effect of their choice on the aggregate sectoral supply. Under Cournot competition, the perceived price elasticity of demand becomes $\Theta^{\text{Cournot}}(\xi) = \left[\frac{1}{\theta} - (\frac{1}{\theta} - \frac{1}{\sigma})\xi\right]^{-1}$.

The perceived price demand elasticity is different under the two setups but the same important properties still hold:

1. If $\xi \neq 0$ then the market share, that depends on the degree of competition, does affect the pricing behavior of firm.

2. The perceived price elasticity of demand $\Theta^{\text{Cournot}}(\xi)$ falls as the firm market share ξ rises.

3. If $\xi \longrightarrow 0$, then the model boils down to the monopolistic case and $\Theta^{\text{Bertrand}}(\xi) = \Theta^{\text{Cournot}} = \theta$. Pro-competitive effects are ruled-out.

4. If $\sigma = \theta$, then the model boils down to the monopolistic case with $\Theta^{\text{Bertrand}}(\xi) = \Theta^{\text{Cournot}} = \theta = \sigma$.

Hence: the same qualitative results are confirmed with Cournot competition instead of Bertrand.

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