

# Asset Price Comparative Statics in a Model of Trade Flows

Barrot, Loualiche, Sauvagnat

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# 1 Introduction

In this note we take the simplest model of trade with firm and industry heterogeneity. We derive implications for asset prices starting from standard models of Melitz (2003), augmented in Chaney (2008).

We derive implications for domestic cash-flows and consumption of shocks to 1. foreign labor productivity and 2. trade barriers . We find conditions under which industries are more exposed than others to trade “risk”, and which firms within industries are most impacted. We also characterize how consumption covaries with foreign productivity shocks. We find under some conditions, financial autarky for example, consumption decreases in response to higher foreign productivity.

We setup the model in Section 2, then we analyze the impact of a change in productivity on quantities in Section 3; finally Section 4 details solution to our model.

## 2 Model Description

We start by setting up the model. We derive most technical results in Section (4). As in Chaney (2008), there are  $N$  countries that produce goods using labor as sole input. Each country has a labor force  $L_n$ , that determines the size of its economy. In each country consumers derive utility from the consumption of goods across  $H + 1$  industries. Industry 0 serves as a numeraire; there is a single good produced in industry 0, and it is freely tradable such that its price is unique across countries. In the  $H$  other industries multiple firms coexist and produce differentiated varieties of the same good. Households' utility of consuming the set  $q_n^h(\cdot)$  of differentiated variety in industry  $h$  is summarized according to a constant elasticity of substitution (CES) aggregator:

$$Q_n^h = \left[ \int_{\Omega_n^h} q_n^h(\omega)^{\frac{\sigma_h-1}{\sigma_h}} d\omega \right]^{\frac{\sigma_h}{\sigma_h-1}},$$

where  $\sigma_h$  represents the industry specific elasticity of substitution across varieties, and  $\Omega_n^h$  is the set of varieties available to households in industry  $h$  of country  $n$ . Finally the upper-tier utility  $\mathcal{U}$  over the  $H + 1$  industries is of the Cobb-Douglas form:

$$\mathcal{U}_n = q_0^{\mu_0} \prod_{h=1}^H (Q_n^h)^{\mu_h},$$

where  $\mu_h$  represents the expenditure shares of each industry, when we impose  $\sum_{h \geq 0} \mu_h = 1$ .

**Supply Side** — The homogenous good, in industry 0, is traded freely and serves as the numeraire in the global economy. Hence the relative productivity of each country for the good pins down the local wage rate  $w_n$ . For the other  $H$  industries, production is simple as firms operate a linear technology in labor. Within an industry firms differ by their productivity  $\varphi$ . Firms can produce so as to export into another country. We define a market as a triplet  $\{j, i, h\}$  of firms from country  $j$  exporting into country  $i$  in industry  $h$ . Firms face two types of costs, variable *iceberg* costs,  $\tau$  and fixed costs  $f$  that are both market specific. Thus the cost of producing  $q$  units of a good in market  $\{j, i, h\}$  is:

$$c_{ji}^h(q; \varphi) = \frac{w_j}{\varphi} \tau_{ji}^h q + f_{ji}^h.$$

Iceberg costs are such that for each unit of the good produced only a fraction  $1/\tau$  makes it to the importing country. The fixed costs are market specific as they represent the overhead of a firm in a market.<sup>1</sup>

Within each industry firms operate in a monopolistically competitive environment: they take households' demand curve as given and set their prices accordingly. Given households' constant elasticity of substitution,  $\sigma_h$ , across varieties, firm prices are set at a constant markup over marginal cost:

$$p_{ji}^h(\varphi) = m_h w_j \tau_{ji}^h / \varphi,$$

where  $m_h = \sigma_h / (\sigma_h - 1)$  is the markup in industry  $h$ .

Firm productivity is random; firms draw their productivity level  $\varphi$  upon entry into an industry from a Pareto distribution with tail parameter  $\gamma_h$ :<sup>2</sup> the probability of a draw below a given level  $\varphi$ , is:

$$\Pr\{\tilde{\varphi} < \varphi\} = G_h(\varphi) = 1 - \varphi^{-\gamma_h}.$$

Our framework is static. We do not allow for firm entry that could be endogenous to the industry structure or profits.<sup>3</sup> Hence we assume there is a fixed supply of entrants at the industry level; as in Chaney (2008) or Eaton and Kortum (2002) we assume the supply of entrants is proportional to the size of the domestic economy. Hence firms earn profits from their monopolistic position. We are interested in higher frequency movements where the supply of entrants is relatively inelastic. So movements in profits are largely due to entry and exit of existing firms into a market.

**Equilibrium Quantities** — Our main interest lies in the firms' profit functions and how they respond to changes in the competitive structure. Firm profits depend directly on the elasticity of substitution across goods in an industry and their idiosyncratic productivity  $\varphi$ . The building block is the local firm profit from operating in market  $\{j, i, h\}$ :

$$\pi_{ji}^h(\varphi) = \frac{\mu_h}{\sigma_h} Y_i \cdot \left[ \frac{\sigma_h}{\sigma_h - 1} \frac{w_j \tau_{ji}^h / \varphi}{P_i^h} \right]^{1-\sigma_h} - f_{ji}^h,$$

<sup>1</sup>We rule out triangular arbitrage by imposing  $\tau_{ik} \leq \tau_{ij} \cdot \tau_{jk}$

<sup>2</sup>The Pareto distribution assumption follows Chaney (2008); it reflects the actual distribution of firm sizes in the U.S.

<sup>3</sup>See Loualiche (2016) for a dynamic analysis in a closed economy.

where  $P_i^h$  is the price index of all varieties in industry  $h$  of country  $i$ . The equilibrium price index is simply  $P_i^h = \kappa_1^h \cdot \theta_i^h \cdot Y_i^{\frac{1}{\gamma_h} - \frac{1}{\sigma_h - 1}}$ .  $\kappa_1^h$  is a constant defined in appendix 4. The coefficient  $\theta_i^h$  represents an index of the remoteness of country  $i$ , it is expressed as a function of the weighted trade costs on market  $\{k, i, h\}$ ,  $\vartheta_{ki}^h$  as

$$\theta_i^{-\gamma_h} = \sum_k \vartheta_{ki}^h,$$

$$\text{where } \vartheta_{ki}^h = w_k L_k (w_k \tau_{ki}^h)^{-\gamma_h} f_{ki}^{1 - \frac{\gamma_h}{\sigma_h - 1}}$$

From the profit function we understand why firms get in and out of markets. If  $\varphi$  is too low a firm's profit cannot cover the fixed cost of operation in the market. Hence a firm's productivity level determines if they enter a market or not. We define the productivity cutoff for market  $\{j, i, h\}$  as  $\underline{\varphi}_{ji}^h = (\pi_{ji}^h)^{-1}(0)$ . We detail the full expression of the productivity cutoff in the appendix. The cutoff productivity  $\underline{\varphi}_{ji}^h$  is such that only firms with productivity above it choose to enter the market. That cutoff represents a second margin of adjustment of trade flows to changes in trade costs: the extensive margin. If a market's cutoff becomes larger because of an increase in trade costs than all supramarginal firms stop their operation on that market.

However the key quantity of interest for us is the average profit in an industry. To get the average profit we integrate over all the productivity levels  $\varphi$ :

$$\pi_{ji}^h = \int \pi_{ji}^h(\varphi) dG_h(\varphi) = \frac{\mu_h}{\gamma_h} \cdot \frac{\sigma_h}{\sigma_h - 1} \cdot Y_i \cdot (w_j \tau_{ji}^h)^{-\gamma_h} (f_{ji}^h)^{1 - \frac{\gamma_h}{\sigma_h - 1}} (\theta_i^h)^{\gamma_h},$$

such that total aggregate profits is simply:

$$w_j L_j \pi_{ji}^h = \frac{\mu_h}{\gamma_h m_h} \cdot \frac{\vartheta_{ji}^h}{\sum_k \vartheta_{ki}^h} \cdot Y_i.$$

Profit is higher in larger export markets (large  $Y_i$ ) and whenever both countries are "relatively" close to each other as summarised by  $\vartheta_{ji}^h$  compared to the other distances.

### 3 The Role of Trade Shocks

#### 3.1 Consequences of a Change in Trade Costs

**A change in tariff** — We reevaluate the results theoretically in the light of the Melitz-Chaney model. Then we explore which economic characteristics affect the elasticity of profits to a change in tariffs and more generally a change in the terms of trade on market  $\{j, i, h\}$ .

$$-\frac{\partial \log \pi_{ii}^h}{\partial \log \tau_{ji}^h} = -\gamma_h \cdot \alpha_{ji}^h,$$

where,  $\alpha_{ji}^h = \frac{\vartheta_{ji}^h}{\sum_k \vartheta_{ki}^h}$

In industry  $h$ , the distance weighted share of country  $j$  for country  $i$  is  $\alpha_{ji}^h$ . For example, if  $h$  is say the energy sector and country  $j$  is the largest world gas producer, then its contribution to industry  $h$  in country  $i$  will be large and  $\alpha_{ji}^h$  will be closer to one. So the effect of a decrease in tariffs from country  $i$  to country  $j$  has adverse effects on the average firm's profit in country  $i$ . The elasticity of average profits to tariffs is increasing in  $\gamma_h$ , the tail parameter of the firms' productivity distribution: if  $\gamma_h$  is large, the industry is more homogeneous and a larger share of the output is concentrated among less productive firms. In that case the displacement from import competition is strongest. To understand the heterogeneous effect of a decline in tariffs on firms of country  $i$ , we estimate the change of the productivity threshold for domestic production  $\varphi_{ii}^h$ . Movements in the productivity threshold correspond to displacement at the extensive margin, i.e. firms shutting down their operation in a specific market. We estimate the elasticity of the extensive margin to tariffs:

$$-\frac{\partial \log \varphi_{ii}^h}{\partial \log \tau_{ji}^h} = \alpha_{ji}^h. \tag{1}$$

Hence whenever tariffs decrease, the productivity threshold increases. The extent of this movement depends on the relative importance of country  $j$  for production of good  $h$  in country  $i$ ,  $\alpha_{ji}^h$ . Now a decrease in tariffs also affects the intensive margin, and even though firms above the productivity threshold stay in business, they lose market shares. The effects on profits at the individual firm level are:

$$-\frac{\partial \log \pi_{ii}^h(\varphi)}{\partial \log \tau_{ji}^h} = (\sigma_h - 1) \alpha_{ji}^h \cdot \left( 1 + \frac{f_{ii}^h}{\pi_{ii}(\varphi)} \right). \tag{2}$$

The effects are strongest when the households' demand curve is elastic, that is whenever the elasticity of substitution  $\sigma_h$  is high. Moreover the elasticity is decreasing with profitability but increasing with the fixed costs at the industry level.

**A change in import competition** — More generally we are interested in the domestic response of a change in the terms of trade in market  $\{j, i, h\}$ . Our goal is to assess how a change in import competition affect the domestic incumbents. To quantify this margin, we derive the elasticity of both the extensive and intensive margin of domestic firms' operation to a decrease in the cost of labor in country  $j$  (or an increase in relative productivity in country  $j$ ):

$$-\frac{\partial \log \varphi_{ii}^h}{\partial \log w_j} = \left(1 - \frac{1}{\gamma}\right) \cdot \alpha_{ji}^h. \quad (3)$$

$$-\frac{\partial \log \pi_{ii}^h(\varphi)}{\partial \log w_j} = (\sigma_h - 1) \left(1 - \frac{1}{\gamma}\right) \cdot \alpha_{ji}^h \cdot \left(1 + \frac{f_{ii}^h}{\pi_{ii}(\varphi)}\right). \quad (4)$$

In line with a decline in tariffs, domestic profits decrease after a shock to import competition. In our first empirical section we have established the role of shipping costs as moats: they protect incumbents from the displacement of foreign firms. From both elasticities (3 and 4) we confirm formulate testable predictions.

Firms in industries with higher shipping costs (or other variable costs  $\tau_{ji}^h$ ) are shielded from import competition. Both elasticities decline with an increase in variable costs. The results stems from the role played by  $\alpha_{ji}^h$ , the relative importance of country  $j$  for country's  $i$  consumption of goods in industry  $h$ . The elasticities are large whenever country  $j$  is a relative large exporter to country  $i$ . Whenever the level of shipping costs is high in an industry the role of country  $j$  declines and so does the impact of a shock of import competition from country  $j$ . Hence firms in industries with lower shipping costs are more exposed to the displacement risk of import competition than firms in high shipping costs industries. This is best summarized by the elasticity of relative importance of country  $j$  to variable costs:

$$-\frac{\partial \log \alpha_{ji}^h}{\partial \log \tau_{ji}^h} = \gamma_h \cdot \left(1 - \frac{\vartheta_{ji}^h}{\sum_k \vartheta_{ki}^h}\right) \quad (5)$$

Furthermore the elasticity of profits to import competition in equation 4 provides further empirical predictions not foreseen by our initial empirical analysis: firms with higher levels of fixed costs ( $f_{ii}^h$ ) are more sensitive to displacement risk, their elasticity to import competition is greater than firms with low fixed costs; firms with low productivity are also more sensitive since either they cease to operate (extensive margin channel) through (equation 3) or their cash-flows decline through greater competition (equation 4).

Now we turn to the general equilibrium implications of the model. We have established import competition is a source of risk for domestic incumbents, especially in low variable trade costs industries. However to predict the price attached to that risk, we need to understand how and how much investors care about it.

### 3.2 Role of trade shocks for aggregate risk

In a perfect risk sharing economy, a decrease in trade costs is welfare improving. However the assumption of openness to trade as uniformly welfare improving has come under increasing scrutiny in the recent literature (see for example Autor, Dorn, and Hanson (2013)).

In this section, we propose a mechanism through which households might suffer from import competition, even though it improves their consumption basket. We assume households suffer from home bias when deciding on their stock portfolio investments: they do not invest in foreign firms. Under this assumption there is only limited risk sharing in the global economy. We show households are ambivalent about an increase in import competition: on the one hand it lowers the price of consumption good ( $-\partial P_i^h/\partial w_j < 0$ ), what we refer to as the “price effect”. On the other hand, it displaces incumbent domestic firms by stealing their market shares, hence it lowers the total wealth of domestic households ( $-\partial Y_i/\partial w_j < 0$ ), what we refer to as the “income effect”.

To understand the trade-off faced by households, we estimate the change in domestic utility,  $\mathcal{U}_i$ , after an increase in import competition. We decompose the total effect on utility between a price effect (positive) and an income effect (negative):

$$-\frac{\partial \log \mathcal{U}_i}{\partial \log w_j} = \sum_h \mu_h \left(1 - \frac{1}{\gamma_h}\right) \alpha_{ji}^h \left[ 1 - \left(\sum_l \mu_l \left(1 - \frac{1}{\gamma_l}\right)\right) \cdot \frac{\frac{1}{m_h \gamma_h} \alpha_{ii}^h}{1 - \sum_l \frac{\mu_l}{m_l \gamma_l} \alpha_{ii}^l} \right]$$

The income effect dominates whenever the industries being displaced constitute a large part of country  $i$  economy, that is if  $\alpha_{ii}^h$  is large enough.



Furthermore the income effect is strongest whenever  $\gamma_h$  and  $\sigma_h$  are big. That is whenever displacement is severe at the intensive and at the extensive margin.

To summarize, within a standard Melitz-Chaney model of trade flows, we are able to formulate two main predictions about asset prices: first we confirm the results of Barrot, Loualiche, and Sauvagnat (2016), that firms in industries with higher trade barriers are insulated from potential tariff shocks or any other shocks that would affect import competition. Second import competition affects domestic aggregate consumption. Hence firms with lower trade barriers have a higher exposure to the aggregate risk of import competition. The sign of the price of risk depends on the sign of the impact of import competition on the contemporaneous utility. If the income effect dominates (which is negative), then import competition has an adverse effect and the price of risk is negative. In that case investors will command higher risk premia for holding stocks in firms within industries with low trade barriers. The risk premia would be of the opposite sign were the price effect to dominate. In the subsequent section, we build on our theoretical framework to understand the sign of the risk of import competition.

## 4 Model Solution

### 4.1 Setup

We write the model staying close to Chaney (2008). Recall firm level productivity through a cost function, for a sector  $h$  in country  $i$  exporting to country  $j$  (note the arrows (they might drop at some point!))

$$c_{i \rightarrow j}^h(q) = \frac{w_i}{\varphi} w_i \tau_{i \rightarrow j}^h q + f_{i \rightarrow j}^h \quad (6)$$

Monopolistic competition with isoelastic demand curve. Elasticity at the sector level is determined exogenously by  $\sigma_h$

$$p_{i \rightarrow j}^h(\varphi) = \frac{\sigma_h}{\sigma_h - 1} \frac{w_i}{\varphi} \tau_{i \rightarrow j}^h \quad (7)$$

Write the price index in sector  $h$  of country  $j$  as  $P_j^h$ . Demand  $q_{i \rightarrow j}^h$  for the good in sector  $h$  in country  $j$  from country  $i$ , and the corresponding trade flow  $x_{i \rightarrow j}^h$

$$q_{i \rightarrow j}^h(\varphi) = \mu_h Y_j \left( \frac{p_{i \rightarrow j}^h(\varphi)}{P_j^h} \right)^{-\sigma_h} \frac{1}{P_j} \quad (8)$$

$$x_{i \rightarrow j}^h(\varphi) = p_{i \rightarrow j}^h(\varphi) q_{i \rightarrow j}^h(\varphi) = \mu_h Y_j \left( \frac{p_{i \rightarrow j}^h(\varphi)}{P_j^h} \right)^{1-\sigma_h} \quad (9)$$

### 4.2 Firm level quantities

Now that we figure out how firms produce and their demand curve we can derive some information about their profits. First what is the productivity cutoff  $\underline{\varphi}_{i \rightarrow j}^h$ . This is simply done setting the profit equal to zero in equilibrium,  $\pi_{i \rightarrow j}^h(\underline{\varphi}_{i \rightarrow j}^h) = 0$ . Note that you could think of firms composed of multiple entities for each country, since each of the export branches are insulated from each other. The ZCP condition applied to each branch of the firm for each export decision (think separable discrete choice problem).

$$\underline{\varphi}_{i \rightarrow j}^h = \frac{\sigma_h}{\sigma_h - 1} \left( \frac{\sigma_h}{\mu_h} \right)^{\frac{1}{\sigma_h - 1}} \left( \frac{f_{i \rightarrow j}^h}{Y_j} \right)^{\frac{1}{\sigma_h - 1}} \frac{w_i \tau_{i \rightarrow j}^h}{P_j^h} \quad (10)$$

An equally useful quantity is the sheer profit earned by firms operating in some markets for a given level of productivity:

$$\pi_{i \rightarrow j}^h(\varphi) = \underbrace{(m_h - 1)}_{\text{net markup}} \left[ \underbrace{\frac{w_i \tau_{i \rightarrow j}^h / \varphi}{P_J^h}}_{\text{relative price elasticity}} \right]^{1 - \sigma_h} \underbrace{\mu_h Y_j}_{\text{share of cons.}} - f_{i \rightarrow j}^h \quad (11)$$

Finally for a sector within a country towards another  $(h, i, j)$ , we define the average profitability. This is based on the firm distribution in the sector. It is taken constant across country, just sectoral dependent:  $G_h(\varphi) = 1 - \varphi^{-\gamma_h}$ :

$$\langle \pi_{i \rightarrow j}^h \rangle = \int \pi_{i \rightarrow j}^h(\varphi) dG_h(\varphi) \quad (12)$$

$$= (m_h - 1) \mu_h Y_j \left( \frac{w_i \tau_{i \rightarrow j}^h}{P_j^h} \right)^{1 - \sigma_h} \frac{\sigma_h - 1}{1 + \gamma_h - \sigma_h} \left( \frac{\varphi_{i \rightarrow j}^h}{P_j^h} \right)^{\sigma_h - 1 - \gamma_h} \quad (13)$$

Replacing for the lower productivity cutoff, we have the following:

$$\langle \pi_{i \rightarrow j}^h \rangle = \frac{\mu_h}{\gamma_h m_h} \cdot Y_j \cdot (w_i \tau_{ij}^h)^{-\gamma_h} \cdot f_{ij}^{1 - \frac{\gamma_h}{\sigma_h - 1}} \cdot \theta_j^h \gamma_h \quad (14)$$

It is time to define a few constants. First most importantly, at the sectoral level demand curves are isoelastic and this yields constant markups:

$$m_h = \frac{\sigma_h}{\sigma_h - 1} \quad (15)$$

Next we also define some of Chaney's constant because they come in handy:

$$\lambda_1 = \frac{\sigma_h}{\sigma_h - 1} \left( \frac{\sigma_h}{\mu_h} \right)^{\frac{1}{\sigma_h - 1}} \quad (16)$$

3 Finally we define what will become the main component of the trade barrier variable in the gravity equation:

$$\theta_i^h = \sum_k w_k L_k \cdot (w_k \tau_{ki})^{-\gamma_h} \cdot f_{ki}^{1 - \frac{\gamma_h}{\sigma_h - 1}} \quad (17)$$

### 4.3 Industry Level Quantities

In the case of extreme home bias, we are interested in the value of firms in country  $i$  uniquely. That is take all the firms in country  $i$ , that export to any country, add all the profits they make and give it back to the consumers of country  $i$  for their enjoyment:

Sector by sector:

$$\begin{aligned} \langle \pi_{i \rightarrow}^h \rangle &= \langle \pi_i^h \rangle = \sum_j \langle \pi_{i \rightarrow j}^h \rangle \\ &= \frac{\mu_h}{\sigma_h} \left( \frac{\sigma_h - 1}{\sigma_h} \right)^{\sigma_h - 1} \frac{\sigma_h - 1}{\gamma_h - (\sigma_h - 1)} w_i^{1 - \sigma_h} \sum_j \left( \frac{\tau_{i \rightarrow j}^h}{P_j^h} \right)^{1 - \sigma_h} \left( \varphi_{i \rightarrow j}^h \right)^{\sigma_h - 1 - \gamma_h} \end{aligned} \quad (18)$$

After rearranging:

$$\langle \pi_i^h \rangle = \frac{\mu_h}{\sigma_h} \left( \frac{\sigma_h - 1}{\sigma_h} \right)^{\sigma_h - 1} \frac{\sigma_h - 1}{\gamma_h - (\sigma_h - 1)} w_i^{-\gamma_h} \Theta_i^h \quad (19)$$

$$= \kappa_h w_i^{-\gamma_h} \sum_k \tau_{ik}^h^{-\gamma_h} \cdot f_{ik}^h \cdot f_{ik}^{1 - \frac{\gamma_h}{\sigma_h - 1}} \cdot \theta_k^{\gamma_h} Y_k \quad (20)$$

With

$$\kappa_h = \lambda_1^{\sigma_h - 1 - \gamma_h} \lambda_2^{\gamma_h} \lambda_3 = \frac{\mu_h}{m_h \gamma_h}. \quad (21)$$

and

$$\Theta_i^h = \sum_j \theta_j^h \lambda_2^{\gamma_h} \left( f_{i \rightarrow j}^h \right)^{1 - \frac{\gamma_h}{\sigma_h - 1}} \left( \tau_{i \rightarrow j}^h \right)^{-\gamma_h} \quad (22)$$

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