Price Discrimination and Trade in Intermediate Goods
(Preliminary Draft)

Anna Ignatenko
Department of Economics
University of California, Davis
aignatenko@ucdavis.edu

March 27, 2018

Abstract

In this paper, I document the existence of price discrimination in firm-to-firm cross-border transactions. First, using firm-level Customs data from Chile, I find that larger buyers of the same inputs are charged lower input prices. To rationalize this finding, I build a novel model of trade in inputs featuring two-sided heterogeneity. Heterogeneous input suppliers compete in prices a la Bertrand and internalize the effect of their decisions on market aggregates. Final goods producers also differ in exogenous productivity, but can reduce the costs of production by integrating backwards into input production. In equilibrium, to discourage entry in the upstream market, input producers charge lower prices to larger final goods producers and thus engage in third-degree price discrimination. I also study the implications of price discrimination for entry and exit of firms, trade and consumer welfare.

*I would like to thank my advisors: Andre Boik, Robert Feenstra, Alan Taylor and Deborah Swenson, for their invaluable guidance and support. All errors are mine.
1 Introduction

In the face of new and more granular firm-level data, a recurring finding is that firms charge different prices to different buyers: a violation of the Law of One Price. The existing trade literature has overwhelmingly explained this through a theory that different destination countries demand different qualities of goods, and that the price variation across buyers is accounted for by differences in qualities. In other words, the Law of One Price is not in fact violated because the goods being sold are different. However, another and perhaps even more natural explanation for the firm-to-firm price variation, is that the goods are in fact the same but firms discriminate across different buyers. This alternative explanation for the price patterns in trade has been demonstrated to be valid in the firm-to-end-consumer context by Simonovska (2015), and has been studied extensively in an industrial organization literature that dates back as early as Robinson (1933). It would also seem natural then that discrimination could also occur in firm-to-firm transactions, which has been studied by industrial organization economists since at least Katz (1987). There are countless anecdotal examples of different firms obtaining different input prices from domestic suppliers: Wal-Mart, for example, is notorious for their lower input prices for identical goods. It would be surprising if firm-to-firm discrimination did not explain at least some of the variation in prices across buyers.

In this paper, I study how input producers determine the prices they charge to their buyers abroad. Imports of intermediate goods account for as much as two-thirds of international trade and are shown to have positive effect on firm productivity (e.g. Blaum et al. (2015), Halpern et al. (2015)). However, all the results related to trade in intermediate goods are derived under the assumption of common prices conditional on quality. In this paper, I show that this assumption is counterfactual by documenting price differentials in firm-to-firm cross-border transactions using multiple data sources. First, using transactions data from Chilean customs authorities, I show that firms buying larger quantities of goods face lower input prices. Second, exploiting detailed product descriptions in the matched exporter-importer transactions data from Paraguay, I confirm that different buyers are often charged different prices by the same seller of a narrowly defined product.

To rationalize these findings, I build a novel model of international trade of inputs, in which price discrimination arises as a result of strategic interaction of buyers and sellers of inputs. Building on the idea proposed in Katz (1987), in this model the production of final goods requires inputs that downstream producers can either buy from upstream producers and/or produce themselves. Learning the upstream technology is costly, and thus only more productive downstream firms find it worthwhile to produce inputs in-house. Because they can
always substitute their own inputs for the expensive ones, firms that “backwards integrate” are more elastic to changes in inputs prices. Since input producers set prices inversely proportional to firm’s demand elasticity, more productive downstream firms are predicted to obtain better input prices. Intuitively, the threat of losing large buyers, which can switch to their own inputs, is what makes input producers low the prices they charge to large buyers. Note that buyer size has radically different implications for prices in the intermediate goods and final goods markets. In the later, consumers with higher willingness to pay are known to be charged higher prices (e.g. Simonovska (2015), Jung et al. (2015) in international trade literature, and Gerardi and Shapiro (2009), Chandra and Lederman (2015) in industrial organization literature). This paper suggests that this is because consumers, unlike final goods producers, can not credibly threaten the sellers with “backwards integration”.

This paper is the first to rationalize the existence of third-degree price discrimination in firm-to-firm international trade transactions. The first main insight of the proposed model is that more efficient firms have a viable threat of substitution when negotiating the price with any seller. The importance of intra-firm trade in global trade flows (e.g. Bernard et al. (2009)) suggests that “backwards integration” can be a natural threat point for many importers. International trade literature also offers other mechanisms resulting in more efficient firms to have more attractive alternative options of sourcing inputs. More efficient firms can afford to search more and find better suppliers (e.g. Bernard et al. (2015)). Larger importers can afford to pay fixed costs of importing from many more countries (e.g. Antras et al. (2017)). In line with these mechanisms, the main prediction of this paper can be interpreted more broadly as: firms with larger extensive margin of sourcing obtain more favorable input prices from their suppliers.

The second insight is that if production technology requires both labor and intermediate goods and the prices of these goods differ across firms, then employment is no longer an appropriate measure of firm productivity or “size”. This is because very efficient firms often obtain low input prices and thus can substitute intermediate goods for labor. It means that the positive relationship between input prices and firm employment documented in the literature (e.g. Kugler and Verhoogen (2011), Blaum et al. (2013)) can not be attributed to quality differences. In this paper I show that the quantity of inputs, as well as the quantity and sales of final goods are theory-consistent measures of firm’s “raw” productivity and size.

Another insight is that trade liberalization can become a source of exogenous variation in final goods sales and help identify a causal effect of buyer size on input prices in a wide range of industries. If final goods are traded globally, firms’ decisions to export and to backwards integrate are complementary: access to foreign markets provides an additional incentive to invest in in-house production of inputs. Hence, firm-specific reductions in tariffs can be used
as instruments for firm sales when studying the relationship between firm size and prices of inputs. In addition, the model predicts heterogeneity in productivity gains across firms from trade liberalization. The most and the least productive firms benefit only through the increased market access, while the medium-productivity firms also gain through reduced input prices.

Having established that the Law of One Price is severely violated in international trade data, I study the implications of price discrimination for firm’s entry and exit decisions as well as consumer welfare. In industries with free entry, larger extend of price discrimination in inputs markets lead to higher expected profits of the downstream firms and fewer active firms on the market. Since only the most productive firms remain on the market, it benefits the final goods consumers through a lower price of a consumption basket.

The reminder of the paper is organized as follows. In Section 2, I document price variation in firm-to-firm transactions that is consistent with the existence of price discrimination. In Section 3, I introduce a new model of trade that explains such variation, in Section 4, I conclude.

2 Suggestive Evidence

2.1 Data

To collect evidence suggestive of the existence of price discrimination in inputs markets, I rely on firm-level Customs data from Chile over the period from 1993 to 2010. On the import side, in each year there are about 18,000 firms importing goods from abroad, and firms are tracked across time with a unique identification number. This identification number is the same as the one used in the data on firm-level exports. In each year about 50% of firms that are engaged in imports also export goods abroad. I use the information about exporting activities of firms to identify their industry and as a proxy for the firm size.

Each good in the data is defined as a 10-digit code in the HS industry classification. On average, each importer buys each product from two different countries. The statistics summarizing firms importing and exporting activities in one year (2005) is provided in Table 1. Although there is no direct measure of per unit price of goods, each shipment is characterized by the total value and the number of goods shipped. The total value is a free-on-board value (FOB), which means that it is not affected by insurance and transportation costs. It is denominated in current pesos. I proxy prices with unit values, calculated as FOB value divided by the number of goods in the shipment.

Next, I explore how thus obtained prices of goods vary across shipments of different size
Table 1: Summary Statistics, 2005

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total imports, 000s pesos</td>
<td>7757.9</td>
<td>486.7</td>
</tr>
<tr>
<td># imported products/firm</td>
<td>61.7</td>
<td>33</td>
</tr>
<tr>
<td>#sourcing countries/product</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>% Exporters</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>Total exports, 000s pesos</td>
<td>87316.5</td>
<td>186.8</td>
</tr>
<tr>
<td># exported products/firm</td>
<td>41.2</td>
<td>15</td>
</tr>
<tr>
<td>Number of observations</td>
<td>254,158</td>
<td></td>
</tr>
<tr>
<td>Number of firms</td>
<td>18,481</td>
<td></td>
</tr>
</tbody>
</table>

and across buyers.

2.2 Price Discrimination in International Trade Data

Traditional models of international trade assume that firms obtain the same prices on the same intermediate goods they buy. To test this assumption, I estimate the following specification:

\[
\ln(p_{ick}) = f_s + f_k + f_c + f_\Sigma + \beta_1 \ln(q_{ick}) + \beta_2 \ln(Size_i) + \epsilon_{ick},
\]

where \(i\), \(c\) and \(k\) denote the buyer, the product and the country of origin of the product, respectively. Apart from buyer’s industry, product and country fixed effects \((f_s, f_k, f_c)\), I also include the so called "sourcing strategy" fixed effect, \(f_\Sigma\). This fixed effect controls for the differences in the extensive margins of trade across firms and is motivated by the recent international trade literature (for example, Antras et al. (2017)). It shows that if there are complementarities across foreign varieties in the production function, the cost reduction from importing a particular input will depend on the entire set of countries a firm is importing from.

Another firm characteristic included in specification (1) is the log of firm size, proxied with either total exports or total imports of firm \(i\). Previous literature (for example, Kugler and Verhoogen (2011), Blaum et al. (2013)) has shown there firm size is positively correlated with the prices of inputs the firm pays. This correlation is often explained through complementarities between firm’s productivity and quality of inputs.

The main relationship of interest in equation (1) is the one between the price of an input paid by a buyer and the purchased quantity of that input. The law of one price would imply that coefficient \(\beta_1\) is equal to zero.

Table 2 reports estimation results for specification (1). In the first two columns, total
imports and total exports are used as a proxy for firm’s size, respectively. The results suggest that prices are not constant across buyers, but rather depend on the amount of inputs firms purchase.

<table>
<thead>
<tr>
<th></th>
<th>(1) lprice</th>
<th>(2) lprice</th>
<th>(3) lprice</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(total imp)</td>
<td>0.0583***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ln(q_{ick})</td>
<td>-0.370***</td>
<td>-0.369***</td>
<td>-0.368***</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>ln(total exp)</td>
<td></td>
<td>0.0453***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.006)</td>
<td></td>
</tr>
<tr>
<td>n.dest</td>
<td></td>
<td></td>
<td>0.0170***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.003)</td>
</tr>
<tr>
<td>Observations</td>
<td>121,620</td>
<td>121,620</td>
<td>121,620</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.808</td>
<td>0.808</td>
<td>0.808</td>
</tr>
</tbody>
</table>

Std errors clustered at the firm level

*** p<0.01, ** p<0.05, * p<0.1

Table 2: The relationship between input prices and quantities

In particular, the coefficient on log quantity is negative, which means that firms buying larger quantities of goods face lower per unit prices.

Specification (1), however, suffers from the usual simultaneity bias that arises when one tries to estimate the relationship between price and quantities. In this case, simultaneity bias is positive, which implies that the obtained estimate of $\beta_1$ is biased upward.

Overall, the documented negative relationship between input prices and quantities at the firm level makes standard trade models based on common prices (conditional on quality) counterfactual. At the same time, such a relationship is consistent with third-degree price discrimination in inputs markets, whereby larger buyers obtain lower input prices.

One of the important drawbacks of the customs data, however, is that the reported transactions are aggregated either across buyers or across sellers. Without knowing the seller in the transaction, it is hard to estimate to what extend the negative relationship between input prices and quantities can be attributed purely to price discrimination. Therefore, in the next subsection I supplement this results with the preliminary analysis of the matched exporter-importer transactions data from Paraguay.
2.3 Additional Evidence from a Matched Exporter-Importer Data

In this subsection, I investigate the extend of price discrimination in the matched exporter-importer international trade transactions data from Paraguay.\(^1\) Compared to the commonly used Customs data, this dataset has several advantages. First, there are both a buyer’s and a seller's identifiers reported for each transaction. Second, apart from having the associated HS-8 digit code, products are described with the name of the brand, country of origin, as well as a very detailed commercial description.

The data contains information on the total value of each shipment (in current US dollars), quantity (in different units, i.e. kilograms, physical units, number of boxes, etc), as well as net and gross weight of the package. To obtain a measure of price per unit, I calculate the ratio of total value over a measure of quantity in two different ways:

1. \( p_q = \frac{\text{total value}}{\text{reported quantity}} \)
2. \( p_w = \frac{\text{total value}}{\text{weight}} \)

For some products, like cars, the reported quantity is a good measure of number of units shipped, while for others - like fruits, weight is a better measure. Using weight to calculate the per unit prices also helps to deal with the problem that sellers can report quantity of the same product in different units - for example, in terms of number of boxes vs. kilograms, grams vs. kilograms, etc. To minimize the measurement error in the constructed per unit price, for each product, I use \( p_q \) if it is associated with smaller variation of prices across buyers of that product, and \( p_w \) otherwise.

To understand if prices vary across different buyers of the same product and to what extent, I calculate standard deviation of prices for each product-supplier pair. I find that 44 out of 137 such pairs, standard deviation is equal to zero, while for remaining 93 pairs it ranges from 0.004 to 20.4. The histogram describing the distribution of price deviations for those 93 pairs is shown in Figure 1.

\(^1\)Results are reported based on a sample of 10 000 shipments (over three consecutive days in November 2017).
Figure 1: Distribution of price deviations across different buyers

Studying the descriptions and product HS codes of goods, whose prices do not change across buyers of the same seller, I find that most of them are agricultural products. Table 3 provides HS codes and their descriptions for those products. In the data sample, those products are sold by two different producers and neither of them engage in price discrimination. This is consistent with the fact that as agricultural products are less differentiated than manufactured products, their sellers do not have enough market power to set up differential prices. Apart from agricultural products, there are only 4 manufacturing products with no price variation across buyers.
<table>
<thead>
<tr>
<th>HS code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>07041000</td>
<td>Vegetables, brassica; cauliflowers and headed broccoli</td>
</tr>
<tr>
<td>07051900</td>
<td>Vegetables; lettuce (lactuca sativa), (other than cabbage lettuce)</td>
</tr>
<tr>
<td>07099300</td>
<td>Vegetables; pumpkins, squash and gourds (Cucurbita spp.)</td>
</tr>
<tr>
<td>07142000</td>
<td>Vegetable roots and tubers; sweet potatoes</td>
</tr>
<tr>
<td>08012100</td>
<td>Nuts, edible; brazil nuts</td>
</tr>
<tr>
<td>08043000</td>
<td>Fruit, edible; pineapples</td>
</tr>
<tr>
<td>08045029</td>
<td>Fruit, edible; mangoes</td>
</tr>
<tr>
<td>08055000</td>
<td>Fruit, edible; lemons, limes</td>
</tr>
<tr>
<td>08071900</td>
<td>Fruit, edible; melons, other than watermelons</td>
</tr>
<tr>
<td>08081000</td>
<td>Fruit, edible; apples</td>
</tr>
<tr>
<td>08093010</td>
<td>Fruit, edible; peaches</td>
</tr>
<tr>
<td>08093020</td>
<td>Fruit, edible; nectarines</td>
</tr>
<tr>
<td>08094000</td>
<td>Fruit, edible; plums and sloes</td>
</tr>
<tr>
<td>08105000</td>
<td>Fruit, edible; kiwifruit</td>
</tr>
<tr>
<td>27132000</td>
<td>Petroleum bitumen; obtained from bituminous minerals</td>
</tr>
<tr>
<td>70099200</td>
<td>Glass mirrors; framed, excluding rear-view mirrors for vehicles</td>
</tr>
<tr>
<td>87032310</td>
<td>Vehicles; with only compression-ignition internal combustion piston engine</td>
</tr>
<tr>
<td>87082919</td>
<td>Vehicles; parts and accessories, of bodies, other than safety seat belts</td>
</tr>
</tbody>
</table>

Table 3: HS Codes and Description of products with no price variation across buyers

On the other hand, it is mostly manufactured products (mostly, parts for vehicles and mechanical appliances), whose prices vary across buyers. There are 93 such products in the data, but Table 4 provides broad descriptions of some of them.

This is additional evidence on the existence of price discrimination, which also shows that the extend of it can vary across sectors.

In the next section, I develop a novel model of international trade in intermediate goods that rationalizes third-degree price discrimination in firm-to-firm transactions.
<table>
<thead>
<tr>
<th>HS code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0806</td>
<td>Fruit, edible; grapes</td>
</tr>
<tr>
<td>3214</td>
<td>Mastics</td>
</tr>
<tr>
<td>4010</td>
<td>Conveyor or transmission belts or belting, of vulcanised rubber</td>
</tr>
<tr>
<td>4016</td>
<td>Articles of vulcanised rubber other than hard rubber</td>
</tr>
<tr>
<td>4823</td>
<td>Paper, paperboard, cellulose wadding and webs of cellulose fibres</td>
</tr>
<tr>
<td>6902</td>
<td>Refractory bricks, blocks, tiles and similar refractory ceramic constructional goods</td>
</tr>
<tr>
<td>7318</td>
<td>Screws, bolts, nuts, coach screws, screw hooks, rivets, cotters, cotter-pins, washers</td>
</tr>
<tr>
<td>7320</td>
<td>Springs and leaves for springs, of iron or steel</td>
</tr>
<tr>
<td>8409</td>
<td>Parts suitable for use solely or principally with the engines of heading</td>
</tr>
<tr>
<td>8421</td>
<td>Centrifuges, including centrifugal dryers; filtering or purifying machinery and apparatus</td>
</tr>
<tr>
<td>8431</td>
<td>Machinery parts; used solely or principally with the machinery of heading</td>
</tr>
<tr>
<td>8703</td>
<td>Motor cars and other motor vehicles; principally designed for the transport of persons</td>
</tr>
<tr>
<td>8903</td>
<td>Yachts and other vessels; for pleasure or sports, rowing boats and canoes</td>
</tr>
<tr>
<td>9403</td>
<td>Furniture and parts thereof</td>
</tr>
<tr>
<td>9503</td>
<td>Tricycles, scooters, pedal cars and similar wheeled toys; dolls' carriages; dolls; other toys</td>
</tr>
</tbody>
</table>

Table 4: Examples of HS Codes and Description of products with no price variation across buyers

3  **Theoretical Framework**

In this section, I incorporate third-degree price discrimination by input producers in the general equilibrium international trade model in order to rationalize the documented empirical findings. I further use the proposed theoretical framework to study the impact of trade liberalization on firm’s productivity and consumer welfare.

3.1  **Environment**

Consider the world consisting of \( N \) countries indexed by \( i \) and \( j \). Each country \( i \) is populated by \( L_i \) consumers that inelastically supply one unit of labor each and consume a continuum of final goods varieties. These varieties are produced by heterogeneous final goods producers, which differ in their productivity \( \phi \). Production of final goods requires intermediate goods, which firms can either produce themselves or purchase from independent input producers upstream. Final goods production technology features increasing returns to scale with fixed costs depending on firm’s decision to engage in in-house production of inputs. There is free entry in the final goods market, and the market structure is monopolistic competition.

Fixed number of intermediate goods producers in each country \( j \) produce substitutable
inputs using labor as the only input in their linear production function. They compete in prices and are large enough relative to the market to internalize the effects of their decisions on aggregate market outcomes. This departure from traditional international trade literature that assume atomistic firms with no market power, brings several new insights. First, it implies that firms charge variable mark-ups of price over marginal costs: input producers with larger market share face lower perceived elasticity of demand and thus can charge higher mark-ups. Second, market power allows same input producers to charge different prices to different buyers for the same good.

For third-degree price discrimination to arise in equilibrium, the following assumptions need to be satisfied. Firstly, intermediate goods producers can observe individual characteristics of their downstream buyers, and, secondly, intermediate goods can only be purchased from their respective producers (in other words, re-selling is not possible).

The sequence of moves in this environment is as follows. First, each potential entrant into the final goods market pay entry costs in terms of labor and learn their productivity. Second, those firms that decide to stay on the market, consider investing additional fixed costs in inputs production technology and exporting. Third, intermediate goods producers decide what prices to charge to their buyers downstream. And in the last stage, final goods producers make their input sourcing and pricing decisions.

In the following sections I describe the details of the model and outline the industry equilibrium.

3.2 Preferences

Consumers in country $i$ have identical preferences represented by the standard CES utility function over a set $\Omega_i$ of final goods’ varieties $\omega$:

$$U_i = \left( \int_{\omega \in \Omega_i} q_i(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$$

These utility function gives rise to the following demand system in country $i$:

$$q_i(\omega) = E_i P_i^{\sigma-1} p_i(\omega)^{-\sigma},$$

where $p_i(\omega)$ is the price of variety $\omega$, $P_i \equiv \left( \int_{\omega \in \Omega_i} p_i(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}}$ is the standard CES price index of final goods, and $E_i$ is country $i$’s aggregate spending on manufacturing goods.

3.3 Technology and market structure

The production side of the economy consists two sectors - upstream sector producing inputs and downstream sector producing final goods. Below I describe the market structures in
downstream and upstream sectors.

**Downstream sector.** Each final goods variety is sold by a single firm in a monopolistically competitive environment with free entry. Firms are heterogeneous in their productivity $\phi$, with which they transform one unit of a composite input $X$ into a final good. The cumulative distribution of productivities across downstream firms is denoted by $G(\phi)$. To enter the downstream sector in country $i$, firms pay fixed entry costs $f_e$ in terms of country $i$’s labor units. In every period, there is an exogenous probability of exit, $\beta$.

After learning their productivity downstream firms decide whether to stay or exit the market. Firms that stay in the market produce final goods using the production function:

$$
Y = \phi \left( L^{\frac{\zeta - 1}{\zeta}} + X^{\frac{\zeta - 1}{\zeta}} \right)^{\frac{1}{\zeta}}
$$

(3)

$$
X = \left( (\alpha_d Q_d)^{\frac{\rho - 1}{\rho}} + (\alpha_f Q_f)^{\frac{\rho - 1}{\rho}} \right)^{\frac{1}{\rho}}
$$

(4)

where $Y$ is the output of downstream firm with productivity draw $\phi$, using labor $L$ and the composite input $X$. The composite input $X$ consists of the domestic intermediate input $Q_d$ and the aggregate imported intermediate good $Q_f$.

The imported composite input $Q_f$ is a CES aggregate over all inputs imported by the firm, either produced in-house with marginal costs $c_v$, $x_v$, or purchased at arm’s length, $x_k, k \in \Sigma$:

$$
Q^S_f = \left( 1_{S=BI}(\delta_v x_v)^{\frac{\eta - 1}{\eta}} + \sum_{k \in \Sigma}(\delta_k x_k)^{\frac{\eta - 1}{\eta}} \right)^{\frac{1}{\eta - 1}}
$$

(5)

where $S = \{O, BI\}$ denotes the sourcing strategy ($O$ stands for “outsourcing” and $BI$ stands for “backwards integration”), and $1_{S=BI}$ is an indicator function, which is equal to one if the firm backwards integrate.

The unit-cost of production associated with the production function detailed in (3) - (5) is:

$$
C^S = \frac{1}{\phi} \left( w^{1-\zeta} + P_x^{S^{1-\zeta}} \right)^{\frac{1}{1-\zeta}}
$$

$$
P^S_x = \left( (P_d/\alpha_d)^{1-\rho} + (P_f/\alpha_f)^{1-\rho} \right)^{\frac{1}{1-\rho}}
$$

(6)

$$
P^S_f = \left( 1_{S=BI}(c_v/\delta_v)^{1-\eta} + \sum_{k \in \Sigma}(p_k/\delta_k)^{1-\eta} \right)^{\frac{1}{1-\eta}}
$$

In-house production of inputs requires larger investment in fixed cost, $nf, n > 1$ compared to the fixed costs cost of production in case of outsourcing, $f$. On the other hand, as the unit-cost function (6) makes it clear, in-house production of inputs lowers firm’s marginal
costs through the “love-of-variety” property of CES function.

Thus, when deciding whether to produce any inputs in-house, the firms choose between two different technologies with the corresponding total cost functions:

\[ TC_O(Y, \phi) = f + YC^O \]
\[ TC_{BI}(Y, \phi) = nf + YC^{BI}, \]

In this setting, a part of firm productivity (\( \phi \)) is the result of pure luck, while another part (\( CS \)) is driven by the decisions of firms in both upstream and downstream sectors. Downstream firms can reduce their marginal costs by producing some inputs in-house, while upstream firms decide on prices of inputs final goods producers pay.

A final goods producer’s problem is to choose price \( p(\phi) \), sourcing strategy \( S = \{O, BI\} \) and quantities of inputs \( x_v, \{x_k\}_{k \in \Sigma} \) in order to maximize firm’s profits.

**Upstream sector.** Each country \( i \) has a fixed (exogenous) number of heterogeneous input producers, \( M^U_i \). They employ labor one-to-one in production and face iceberg trade costs \( \tau_{ij} \geq 1 \) when selling inputs internationally. Firms in each country face the derived demand on their inputs from downstream firms and compete by choosing prices (a l’a Bertrand). The key element of the upstream sector is that input producers worldwide are not assumed to be vanishingly small relative to their sector. In contrast, upstream firms are large enough to affect and internalize the effects of their decisions on the market outcomes of their sector. However, they are small relative to the economy as a whole, and thus ignore the effect of their pricing decisions on the downstream sector’s aggregates.

Upstream producers are assumed to be able to observe the individual characteristics of the downstream buyers and thus they can charge different prices to different buyers of the same input. Then, an input producer’s problem is to choose individual prices for each of the downstream buyers of its inputs to maximize the profits.

Next I describe firms’ optimal behavior conditional on entry and keeping wages fixed.

### 3.4 Equilibrium with Trade in Intermediate Goods

First, consider the case when final goods are not tradeable, while intermediate goods can be sourced from all over the world. Then, conditional on the choice of inputs and given consumer preferences in (2), downstream firm \( \phi \) maximizes its profits in the domestic market:

\[ \pi(\phi) = EP^{\sigma-1}p(\phi)^{-\sigma} \left( p(\phi) - \frac{CS}{\phi} \right) - f - 1_{S=BI}(n - 1)f \]
CES nature of preferences and monopolistic competition imply that the profit maximizing price is a constant mark-up over marginal costs:

\[ p(\phi) = \frac{\sigma}{\sigma - 1} \frac{C_S}{\phi} \] (7)

Given this price, the demand for final goods variety \( \phi \), firm’s revenue and profits (net of fixed costs) are, respectively:

\[ q(\phi) = EP^{\sigma - 1}m^{-\sigma}(C^S)^{-\sigma}\phi^\sigma \]

\[ r(\phi) = E(P/m)^{\sigma - 1}(C^S)^{1-\sigma}\phi^{\sigma - 1} \]

\[ \pi(\phi) = \frac{r(\phi)}{\sigma} - f - 1\mathbb{1}_{s = B1}(n - 1)f, \] (8)

where \( m = \frac{\sigma}{\sigma - 1} \) denotes (common across firms) mark-ups in the downstream industry.

In order to produce \( q(\phi) \) units of final goods, cost minimizing downstream firm \( \phi \) hires labor and buys inputs in the following quantities:

\[ L = \phi^{\sigma - 1}C^{S^{\xi - 1}}w^{1-\xi}m^{-\sigma}EP^{\sigma - 1} \]

\[ X = \phi^{\sigma - 1}C^{S^{\xi - 1}}P_x^{S^{1-\xi}}m^{-\sigma}EP^{\sigma - 1} \] (9)

where \( w \) is a wage rate in the domestic economy. The composite input \( X \) in equilibrium is comprised of domestic and imported inputs in the following quantities:

\[ Q_d = \left( \frac{P_d/\alpha_d}{P_x^S} \right)^{-\rho}X \]

\[ Q_f = \left( \frac{P_f^S/\alpha_f}{P_x} \right)^{-\rho}X \] (10)

Then the demand for an input produced by upstream supplier \( k \) is:

\[ x_k = \left( \frac{p_k/\delta_k}{P_f^S} \right)^{-\eta} \left( \frac{P_f^S/\alpha_f}{P_x} \right)^{-\rho}X \] (11)

Also, if a firm decides to backwards integrate in input production, it produces \( x_v \) quantities of inputs:

\[ x_v = \left( \frac{c_v/\delta_v}{P_f^S} \right)^{-\eta} \left( \frac{P_f^S/\alpha_f}{P_x} \right)^{-\rho}X \] (12)

And finally, when deciding whether to backwards integrate in the input production, the
firm compares the total profits from both options, $\pi^O(\phi)$ and $\pi^{BI}(\phi)$. Downstream firm with productivity $\phi$ will choose to backwards integrate if $\pi^{BI}(\phi) \geq \pi^O(\phi)$. This condition determines the cut-off productivity above which firms find it profitable to invest in the upstream technology:

$$\phi_I = \left( \frac{\sigma f(n-1)}{E(\gamma - 1)} \right)^{\frac{1}{\sigma - 1}} \frac{CO}{P_m}, \quad (13)$$

where $\gamma \equiv \left( \frac{C_{BI}}{C^O} \right)^{1-\sigma} > 1$ reflects the per-unit cost advantage of firms with in-house production of inputs. Therefore, in equilibrium, downstream firms with sufficiently large initial productivity draws, $\phi \geq \phi_I$, backwards integrate into the input production, while those with lower productivity draws, $\phi < \phi_I$ outsource all their inputs.

Apart from being more productive, firms that produce inputs in-house also have more elastic demand for inputs they purchase from the upstream sector. If upstream producers have a non-negligible market shares, downstream firm’s demand elasticity for input $k$ can be expressed as

$$\varepsilon^S_k = -\eta + (\eta - \rho) s^S_k + (1 - \zeta + \rho) s^S_k s^S_f, \quad (14)$$

where $s^S_k = \left( \frac{p_k/\delta_k}{P^S_k} \right)^{1-\eta}$ is the share of firm’s expenditures on input $k$ in its expenditures on imported inputs, and $s^S_f = \left( \frac{P^S_f/\alpha_f}{P^S_k} \right)^{1-\rho}$ is the share of firm’s expenditures on imported inputs in total inputs expenditures. The first term in (14) is a standard demand elasticity: in models with vanishingly small firms the demand elasticity is equal to the elasticity of substitution. The second and the third terms in (14) reflect the market power input supplier $k$ has when setting prices to each of the buyers in a Bertrand model of competition. These two terms decompose the decline in firm $k$ sales to any buyer, when it unilaterally increases the price charged to that buyer. First, the buyer can start buying more inputs from a different supplier, which will cause the expenditure share $s^S_k$ to go down. And second, if input $k$’s price spikes, the buyer can switch to a domestic substitute, thus, reducing the share of expenditures on imported inputs, $s^S_f$.

This decomposition of (14) shows that equilibrium input price differentials can be accounted for by differences in “cross-price elasticity” as well as differences in “industry-demand elasticity” (where imported inputs are defined as an industry) (Borenstein (1985), Holmes (1989)). In particular, it can be shown that the input demand elasticity increases with the price index of imported inputs and since $P^{BI}_f < P^O_f$, downstream firms that backwards integrate have higher input demand elasticity. Intuitively, unlike other firms, those that backwards integrate can always use more of their own input in production if the prices of all other inputs are too high. This makes them more sensitive to input price changes.
These differences in demand elasticities across firms is important for the upstream firms that set their input prices according to the Lerner index:

\[
\frac{p_{kd}^S - c_{kd}}{p_{kd}^S} = \frac{1}{|\varepsilon_{kd}^S|}
\] (15)

So long as large input producers can tell apart the firms that can backwards integrate from those that can not, they will engage in price discrimination, under no arbitrage possibility. Equation (15) makes it clear that since firms with in-house production of inputs have more elastic demand, they will be charged a lower input price by the same supplier:

\[
\forall k, d : \quad p_{kd}^{BI} < p_{kd}^O
\] (16)

In this model, downstream firms with better initial (exogenous) productivity draws, \( \phi \), obtain (endogenous) cost advantages through several channels. First, due to the larger scale of production, they find it profitable to invest in in-house production of inputs and thus benefit through “love-of-variety” property of the CES production function. Second, the threat to (imperfectly) substitute outsourced inputs for those produced in-house, allows larger firms to obtain lower input prices from the upstream producers. The last channel can also be interpreted through differences in input demand elasticities across firms. Downstream firms with in-house production of inputs have smaller share of their expenditures on the purchased inputs, and thus are more elastic to price changes.

This model thus rationalizes third-degree price discrimination by intermediate goods producers: they charge higher prices to the small buyers, and lower prices - to the large buyers of inputs.\(^2\) This prediction is the opposite of what is known in the final goods markets, where larger buyers (richer consumers) of final goods are charged higher prices. The reason is that, unlike consumers, producers often can take actions to influence the price of inputs they face. In case of this paper, larger final goods producers can organize in-house production of inputs and, by threatening input producers with competition, obtain lower input prices.

Apart from rationalizing price discrimination across firms in the same industry, the model also predicts differences in prices across buyers and sellers in different industries. First, all else equal, as inputs become more substitutable with each other and with labor (elasticities of substitution \( \zeta, \eta, \rho \) increase), it forces input producers to reduce their prices to all buyers. Second, upstream firms producing higher quality inputs charge higher prices to all their buyers compared to low quality input producers.

To understand what determines the extent of price discrimination, consider the variance

\(^2\)In Melitz (2003)-type models firm productivity is perfectly positively correlated with firm size.
of the demand elasticity for input $k$ \((14)\):

$$Var \left( \varepsilon_{S_k} \right) = (\eta - \rho)^2 Var \left( s_{k_i}^S \right) + (1 - \zeta + \rho)^2 Var \left( s_{k_f}^F S_{k_f}^F \right) + 2 (\eta - \rho)(1 - \zeta + \rho) Cov \left( s_{k_i}^S, s_{k_f}^F S_{k_f}^F \right),$$

where \(Cov \left( s_{k_i}^S, s_{k_f}^F S_{k_f}^F \right)\) can be shown to be positive: firms with higher share of input $k$ in their expenditures on imported inputs also have higher share of that input in total expenditures. From here, it is easy to see that the variance of the input demand elasticity across buyers increases in input substitutability \(\eta\). It implies tougher competition in the upstream sector as well as the larger extent of price discrimination. In other words, downstream firms that backwards integrate benefit relatively more from tougher competition upstream. This is because their own input becomes more substitutable with inputs they purchase, which makes the threat of switching more credible.

When testing the negative relationship between firm productivity and input prices suggested by the model in the data, the challenge is to find an empirical equivalent for the exogenous, "raw", productivity draw, \(\phi\). In the next section I discuss how the model can be used to guide the choice of firm productivity measures.

### 3.5 Firm size and Input Prices

In standard Melitz (2003)-type trade models with labor as the only factor of production, the exogenous firm productivity, \(\phi\), is positively correlated with employment. This has motivated the use of employment as a measure of firm productivity or “firm size” even in setting with multiple inputs of production. For example, when studying the relationship between input quality and firm size, Kugler and Verhoogen (2012) and Blaum et al. (2015) proxy firm size with log employment. In this subsection I show that employment is not a monotonic function of firm productivity if firms face different input prices and propose different measures of firm productivity.

As expression \(9\) shows, in equilibrium, firm’s employment depends on its “raw” productivity as well as the factors’ prices:

$$L = \phi^{\sigma - 1} C S^{\zeta - \sigma - 1} w^{1 - \zeta} m^{-\sigma} E P^{\sigma - 1}$$

If the Law of One Price holds and all downstream firms face the same input prices, employment is indeed an increasing function of firm productivity. It means that one either side of the productivity cut-off \(\phi_I\), employment and firm’s productivity are positively correlated.
However, price discrimination in the inputs markets imply that more productive firms face lower input prices \((C^{BI} < C^O)\). The effect of this differential pricing on employment depends on how the elasticity of substitution between labor and inputs \((\zeta)\) compares to the elasticity of substitution between final goods varieties \((\sigma)\). In industries with high elasticity of inputs and relatively low elasticity of final products in consumption \((\zeta > \sigma + 1)\), some backwards integrated firms hire fewer people than fully outsourcing firms.

Figure 2 illustrates the relationship between employment and firms’ initial productivity, predicted by the model. Consider two downstream firms: one with productivity draw \(\phi_1\) large enough for a firm to backwards integrate, and another one with productivity draw \(\phi_0\), which allows only outsourcing of all inputs. Then the model predicts that although \(\phi_1 > \phi_0\), \(L_1 < L_0\), because of the differences in inputs prices faced by the two firms. With the two factors of production, labor and intermediate goods, more productive firms facing lower input prices substitute intermediate goods for labor. Therefore, employment is positively correlated with firms’ productivity only when comparing firms on either side of the productivity cut-off, \(\phi_1\), where input prices are the same across firms. However, if a sample includes both types of firms, employment can be a misleading measure of firm productivity.

![Figure 2: Firm productivity and Employment](image)

Total quantity of intermediate goods, \(X\), on the other hand, always increases in firm productivity, for any values of the parameters. If a firm faces lower input prices, the demand for its final goods increases, which further increases the firm’s demand for intermediate goods. Figure 3 illustrates the relationship between firm productivity and total quantity of intermediate inputs purchased. It follows that ranking downstream firms by the quantities of inputs they source results in the true ranking of their productivities.
The problem with this measure of firm productivity is that when using Customs data quantities and prices of domestically sourced inputs remain unknown to the researcher. However, the quantity of imported inputs from each supplier is often observable, and corresponds to the following expression in equilibrium of the model:

\[ x_k^S = \left( \frac{p_k^S}{\delta_k} \right)^{-\eta} \left( \frac{P_f^S / \alpha_f}{P_x^S} \right)^{-\rho} X^S \]  

Both total input quantities, \( X^S \), and the share of expenditures on input \( k \), \( \left( \frac{p_k^S}{\delta_k} \right)^{-\eta} \left( \frac{P_f^S / \alpha_f}{P_x^S} \right)^{-\rho} \) decrease in input \( k \)'s price, \( p_k^S \). Since we know that firms that backwards integrate are charged lower input prices in equilibrium, it means that they purchase more inputs from each common supplier. Then the relationship between firm productivity and the quantity of each imported input looks similar to the one shown in Figure 3. Therefore, the individual imported inputs quantities can be used as a measure of firm size and productivity. One of the drawbacks of this measure, however, is that it causes simultaneity bias, when studying the relationship between input prices and firm size.

An alternative method is to use downstream firm’s output or total sales as a measure of productivity. Recall that in equilibrium, output and total sales can be expressed as functions of firm productivity \( \phi \) as, respectively:

\[ q(\phi) = EP^{\sigma-1}m^{-\sigma} \left( C^S \right)^{-\sigma} \phi^\sigma \]

\[ r(\phi) = E \left( P/m \right)^{\sigma-1} \left( C^S \right)^{1-\sigma} \phi^{\sigma-1} \]

Not only firms that backwards integrate are more productive than the ones that do not, they also face lower input prices precisely because they can credibly threaten to replace any
inputs with the ones they produce in-house. As a result, more productive firms have larger total output and total sales. Thus, both total output and total sales can be used as measures of firm productivity to study the relationship between firm productivity and input prices. This measure suffers from the reserves causality issues. In the next subsection I discuss how the instances of trade liberalization in the downstream sector can become a source of plausibly exogenous variation in total output and total sales.

3.6 Trade Liberalization Downstream

Now I relax the assumption that only intermediate goods are traded internationally and allow for exports of final goods. I introduce the following notation: subscript $d$ denotes domestic economy, while subscript $i$ denotes any foreign country.

Exporting final goods to any foreign country $i$ requires investing $f_x$ fixed costs. Then, downstream firms decide whether to export and backwards integrate by comparing the total profits of the four possible options, described below.

Profits if only serving the domestic market and outsourcing all inputs:

$$
\pi^O_d = \frac{1}{\sigma} E_d (P_d/m)^{\sigma-1} (C^O)^{1-\sigma} \phi^{\sigma-1} - f
$$

Profits if only serving the domestic market with in-house production of inputs:

$$
\pi^{BI}_d = \frac{1}{\sigma} E_d (P_d/m)^{\sigma-1} (C^{BI})^{1-\sigma} \phi^{\sigma-1} - n f
$$

Profits if exporting to country $i$ and outsourcing all inputs:

$$
\pi^O_x = \frac{1}{\sigma} (C^O)^{1-\sigma} \phi^{\sigma-1} (E_d (P_d/m)^{\sigma-1} + \tau_{di}^{1-\sigma} E_i (P_i/m)^{\sigma-1}) - f - f_x
$$

Profits if exporting to country $i$ with in-house production of inputs:

$$
\pi^{BI}_x = \frac{1}{\sigma} (C^{BI})^{1-\sigma} \phi^{\sigma-1} (E_d (P_d/m)^{\sigma-1} + \tau_{di}^{1-\sigma} E_i (P_i/m)^{\sigma-1}) - n f - f_x
$$

Exporting decision as well as the choice of a sourcing strategy $S = \{BI, O\}$ are illustrated in Figure 4, where the four profit functions are plotted against firm productivity $\phi$.

In equilibrium depicted in Figure 4, downstream firms self-select into four groups: the least productive firms ($\phi^{\sigma-1} < \phi^*_{I-1}$) exit the market, the low productivity firms ($\phi^*_{I-1} \leq \phi^{\sigma-1} \leq \phi^I_{I-1}$) outsource all their inputs and only serve the domestic final goods consumers, the medium productivity firms ($\phi^I_{I-1} \leq \phi^{\sigma-1} \leq \phi^I_{I-1}$) still outsource all their inputs but also export their final goods, and finally, the most productive firms ($\phi^{\sigma-1} > \phi^I_{I-1}$) both export
and produce some of their inputs in-house.

Note that in Figure 4, the parameters are such that the strategy of serving only domestic consumers and producing some inputs in-house is always dominated by other strategies. It implies that there are no firms that invest in in-house production of inputs and do not export, which reflects the complementarity between exporting and in-house production.

![Image](image.jpg)

**Figure 4: Exporting and Input sourcing modes**

In equilibrium, the demand for input $k$ by downstream firms that outsource their inputs and by those that backwards integrate is, respectively:

$$ x^O_k = \left( \frac{p^O_k}{\delta_k} \right)^{-\eta} \left( \frac{P^O_f}{P^O_x} \right)^{-\rho} (C^O)^{-\sigma} \left( \phi/m \right)^{\sigma} \left( E_d P_d^{\sigma-1} + 1_x \tau_{di}^{\sigma-1} E_i P_i^{\sigma-1} \right) $$

$$ x^{BI}_k = \left( \frac{p^{BI}_k}{\delta_k} \right)^{-\eta} \left( \frac{P^{BI}_f}{P^{BI}_x} \right)^{-\rho} (C^{BI})^{-\sigma} \left( \phi/m \right)^{\sigma} \left( E_d P_d^{\sigma-1} + \tau_{di}^{\sigma-1} E_i P_i^{\sigma-1} \right) \quad (24) $$

where $1_x$ is an indicator function, which is equal to one if the firm is an exporter and zero otherwise.

To study how trade liberalization (i.e., reduction in bilateral iceberg trade costs $\tau_{di}$) affects firms’ incentives to backwards integrate and export, it is useful to write down the
cut-off productivities, $\phi_*$, $\phi_x$ and $\phi_I$.

The exit productivity cut-off $\phi_*$ is determined from the zero-profit condition:

$$\pi^O_d(\phi_*) = 0 \iff \frac{1}{\sigma}E_d(P_d/m)^{\sigma-1} \left(C^O\right)^{1-\sigma} \phi_*^{\sigma-1} - f = 0 \quad (25)$$

Since the marginal exporter from $d$ to $i$ outsources all its inputs, the exporting productivity cut-off $\phi_x$ can be expressed as a function of $\phi_*$ using $\pi^O_d(\phi_x) = \pi^O_x(\phi_x)$ as:

$$\phi_x = \phi_* \left(\frac{f_x/(E_iP_i^{\sigma-1})}{f/(E_dP_d^{\sigma-1})}\right)^{\frac{1}{\sigma-1}} \tau_{di} \quad (26)$$

Hence, as long as $\frac{f_x/(E_iP_i^{\sigma-1})}{f/(E_dP_d^{\sigma-1})} > 1$, $\phi_x > \phi_*$, as illustrated in Figure 4.

Finally, the least productive firm that can produce inputs in-house is an exporter. The productivity of this firm, $\phi_I$, is found from $\pi^B_I(\phi_I) = \pi^O_x(\phi_I)$ as:

$$\phi_I = \phi_* \left(\frac{n-1}{\gamma - 1} \frac{E_dP_d^{\sigma-1}}{E_dP_d^{\sigma-1} + \tau_{di}^{1-\sigma} E_iP_i^{\sigma-1}}\right)^{\frac{1}{\sigma-1}} \quad (27)$$

From the expressions (26) - (27) it follows that both exporting and backward integration productivity cut-offs are increasing in iceberg trade costs $\tau_{di}$. In other words, the reduction in trade costs due to trade liberalization with country $i$ allows firms that previously did not export to start exporting. Moreover, some firms that found it profitable to export even before trade liberalization, now find it also profitable to invest in the upstream technology. This is because trade liberalization works as a (arguably exogenous) shock to the demand for goods produced by exporters, which makes backward integration more profitable.

The described effects of trade liberalization in the downstream sector are illustrated in Figure 5.
Figure 5: The effects of trade liberalization

Figure 5 makes it clear that gains from trade liberalization are heterogeneous across different downstream firms. For example, firms that were large exporters of final goods even before trade liberalization are not expected to gain through lower input prices, as they already obtain low input prices due to their size. On the other hand, very small domestic producers of final goods still can not export even after the decrease in transportation costs. It is only the more productive new exporters and less productive old exporters that are predicted to gain through lower input prices. After the reduction in trade costs, those firms experience a positive demand shock, which makes in-house production of inputs more profitable and allows them to obtain lower input prices from the upstream producers.

Being positively correlated with firm sales, reductions in tariffs on final goods can be used as an instrumental variable for firm size when studying its effect on input prices faced by final goods producers.

In what follows I explore the implications of third-degree price discrimination in inputs markets for the downstream industry equilibrium.

### 3.7 Industry Equilibrium

Downstream industry equilibrium in country \(d\) consists of the price of final goods \(P_d\), (endogenous) number of firms \(M_d\) and the average profits of active firms.

Free entry to the downstream sector requires that the sunk entry cost \(f_e\) equals the present value of expected profits:

\[
f_e = (1 - G(\phi_*)) \frac{1}{\beta} \tilde{\pi},
\]

where \(1 - G(\phi_*)\) is the share of potential entrant that stay active after learning their pro-
ductivity, and $\bar{\pi}$ is an expected per-period profits of active firms. The expected per-period profits can be expressed as the sum of expected profits from domestic sales and expected profits from exporting:

$$\bar{\pi} = \bar{\pi}_d + p_x \bar{\pi}_x,$$

where $p_x = \frac{1 - G(\phi_x)}{1 - G(\phi_\ast)}$ is the share of exporting firms in the downstream sector. For the ease of derivations, I will further assume that $G(\phi)$ is a Pareto cumulative distribution function with the shape parameter $\kappa$:

$$G(\phi) = 1 - \phi^{-\kappa}$$

Under this distributional assumption, the expected profits become:

$$\bar{\pi} = \sigma - 1 \kappa + 1 f \Delta$$

$$\Delta = 1 + \left( f_j \frac{1}{f} \right)^{-\kappa + \frac{1}{\sigma - 1}} \left( \frac{A_j}{A_i} \right)^{-\kappa + \frac{1}{\sigma - 1}} \frac{1}{n - 1} \frac{\sigma - 1}{\sigma + 1} \frac{1}{f_e} \left( \frac{A_d}{A_d + f_e A_i} \right)^{-\kappa + \frac{1}{\sigma - 1}} \left( 1 + \frac{\kappa}{\sigma - 1} \frac{A_j \tau^{-\kappa}}{f_e A_d} \right),$$

where $A_j = E_j (P_j / m)^{\sigma - 1}$.

As $\Delta$ is increasing in the marginal cost advantage of in-house production $\gamma$, so is the average profits in the downstream sector.

Using the solution for expected profits (30) in the free entry condition (28), one can find the exit productivity cut-off as a function of parameters, including $\Delta$:

$$\phi_\ast = \left( \frac{\sigma - 1}{\kappa - \sigma + 1} \frac{f}{\beta f_e \Delta} \right)^{\frac{1}{\kappa}}$$

This cut-off allows to solve for the number of active firms in the downstream sector of country $d$:

$$M_d = 1 - G(\phi_\ast) = \frac{\kappa - \sigma + 1 \beta f_e}{\sigma - 1} \frac{\Delta f}{\lambda}$$

Therefore, larger cost reductions due to in-house production implies fewer firms in the downstream sector in equilibrium. This is because price discrimination in inputs markets leads to higher expected profits in the downstream sector. Under free entry and constant mark-ups, higher expected profits can only be sustained with fewer firms on the market, hence - smaller $M_d$.  

\footnote{Standard assumption that found empirical support in international trade literature}

\footnote{For expected profits to be positive, the following restriction on the parameters should be satisfied: $\kappa > \sigma - 1$}
Two other important productivity cut-offs, \( \phi_x \) and \( \phi_I \) can be easily obtained from (26) and (27):

\[
\phi_x = \left( \frac{\sigma - 1}{\kappa - \sigma + 1 \beta f_e \Delta} \right)^{\frac{1}{\kappa}} \left( \frac{f_x/\tau_{d_i}^{1-\sigma} A_i}{f/A_d} \right)^{\frac{1}{\sigma - 1}} \tau_{d_i} \tag{33}
\]

\[
\phi_I = \left( \frac{\sigma - 1}{\kappa - \sigma + 1 \beta f_e \Delta} \right)^{\frac{1}{\kappa}} \left( \frac{n - 1}{\gamma - 1} \frac{A_d}{A_d + \tau_{d_i}^{1-\sigma} A_i} \right)^{\frac{1}{\sigma - 1}} \tag{34}
\]

Finally, the price index in the downstream sector can be solved for using the solution for \( \phi_* \) and the zero-profit condition for the least productive active firm on the market (25):

\[
P_d = \left( \frac{\sigma - 1}{\kappa - \sigma + 1 \beta f_e \Delta} \right)^{-\frac{1}{\kappa}} \left( \frac{f\sigma}{E_d} \right)^{\frac{1}{\sigma - 1}} mP_x \tag{35}
\]

Thus, final goods consumers gain from price discrimination, as it reduces the price of the consumer goods: as \( \gamma \) increases, the final goods price index \( P_d \) falls.
4 Conclusion

The existence of price discrimination has been long documented and studied in industrial organization, yet the international trade literature neglects the possibility of different firms getting different price for exact same product. In this paper, using firm-level Customs data, I showed that the assumption of common prices does not seem to hold in the data. When purchasing the same input, buyers with larger quantities obtain lower input prices. To rationalize this observation, I build a model of trade in intermediate goods, in which there are differences in endogenous demand elasticity across buyers of inputs. In this model, heterogeneous downstream firms can decide to produce inputs in-house and export their goods. Both exporting and in-house production are associated with larger fixed costs. As a result, only initially more productive firms sort into in-house production of inputs and exporting. As more productive firms can substitute inputs produced in-house for the one they buy from upstream suppliers, their demand on inputs is more elastic. Since input prices are inversely proportional to the demand elasticity, upstream suppliers charge lower prices to larger (more productive) downstream firms.

Incorporating price discrimination into the general equilibrium trade model allows to study its implications for market aggregates. For instance, wider possibility for price discrimination in the upstream sector increases the expected profit of the downstream sectors and reduces the number of active firms in that sector. This, in turn, implies that consumers benefit from price discrimination through lower production costs of the final goods producers as well as the selection of more productive firms.

This paper also showed that firms decisions to export and engage in in-house production of inputs are complementary. On the one hand, by reducing firm's production costs and thus increasing operational profits, in-house production of inputs allows firms to overcome the fixed costs of exporting. On the other hand, by offering larger economies of scale, exporting itself encourages firms to set-up the production of inputs. Thus, instances of trade liberalization in the downstream sectors can be used as exogenous shocks to identify the causal effect of firm's productivity of the prices of inputs it faces.

The proposed framework with price discrimination in the inputs markets can be further used to empirically study the role of imported intermediates in firms productivity. When firms face different prices on same inputs, it results in heterogeneity in productivity gains from trade liberalization in the upstream sectors.
References


