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The Effect Of Trade In Demand For Skill In Emerging Economies

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The Effect Of Trade In Demand For Skill In Emerging Economies

Abstract
This dissertation explores the effect of trade in demand for skill in an unskilled labor abundant country. I use the case of Mexico to document that exporters are on average more skill-intensive than non exporters, yet conditional on exporting skill intensity is negatively correlated with export sales. I build a model to explain these two observations simultaneously and estimate it for two Mexican manufacturing industries in 2003. A counterfactual analysis illustrates that when trade costs decrease, resources are reallocated to the most skilled-intensive firms within industries but toward the unskilled-intensive tasks within industries. When trade costs are high, the first effect dominates and skill premium increases. When trade costs are sufficiently low, comparative advantage in unskilled intensive activities dominates and skill premium decreases. This pattern matches the observed behavior of skill premium in Mexican manufacturing industry following trade liberalization reforms.

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THE EFFECT OF TRADE IN DEMAND FOR SKILL IN EMERGING ECONOMIES

María José Orraca Corona

A DISSERTATION

in

Economics

Presented to the Faculties of the University of Pennsylvania

in

Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy

2018

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THE EFFECT OF TRADE IN DEMAND FOR SKILL IN EMERGING ECONOMIES

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To you
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ABSTRACT

THE EFFECT OF TRADE IN DEMAND FOR SKILL IN EMERGING ECONOMIES

María José Orraca Corona

Ana Cecilia Fieler

This dissertation explores the effect of trade in demand for skill in an unskilled labor-abundant country. I use the case of Mexico to document that exporters are on average more skill-intensive than non exporters, yet conditional on exporting skill intensity is negatively correlated with export sales. I build a model to explain these two observations simultaneously and estimate it for two Mexican manufacturing industries in 2003. A counterfactual analysis illustrates that when trade costs decrease, resources are reallocated to the most skilled-intensive firms within industries but toward the unskilled-intensive tasks within industries. When trade costs are high, the first effect dominates and skill premium increases. When trade costs are sufficiently low, comparative advantage in unskilled intensive activities dominates and skill premium decreases. This pattern matches the observed behavior of skill premium in Mexican manufacturing industry following trade liberalization reforms.
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DISCLAIMER

The empirical analysis in this paper was conducted at the Microdata Processing Laboratory of the Mexican Institute of Statistics and Geography (INEGI) in Mexico City. All results have been reviewed to ensure that no confidential information is disclosed. The discussion and conclusions of this study are exclusively the author’s, do not reflect those of INEGI, and are not part of the official statistics of the Institute.
CHAPTER 1 : Trade and Demand for Skill in Emerging Economies: Comparative or Competitive Advantage?

1.1. Introduction

A large strand of literature has focused on understanding how trade affects the demand for skill in emerging economies. Neoclassical trade theory predicts that resources are reallocated towards the industries where the country has a comparative advantage (Stolper-Samuelson result). If emerging economies are abundant in unskilled labor (relative to their industrialized trading partners), this theory predicts that unskilled-intensive industries grow with trade liberalization.¹ New trade literature on the other hand predicts that because productivity is skill-biased, trade increases demand for skill in all countries because resources are reallocated to most productive firms within industries, which that are also the most skill-intensive industries.² Trade is predicted to increase demand for skill through other mechanisms like quality and technology upgrading and technological spillovers.³

The two channels highlighted above—comparative and competitive advantage— have been put together by Bernard et al. (2007b). These authors link firm heterogeneity with relative factor abundance and conclude that trade liberalization amplifies productivity gains from trade in the comparative advantage industry. Since industrialized countries have comparative advantage in skill-intensive industries, both channels act in the same direction and their results are consistent with predictions of both strands of literature. However, the conclusions are inconsistent for emerging economies because the advantage sector in these countries tends to be low-skill intensive. Therefore, the effect of competitive advantage of most productive firms in an industry is dampened.

1 See Romalis (2004); Gonzaga et al. (2006); Dix-Carneiro and Kovak (2015).
2 See Attanasio et al. (2004); Caselli (2014); Burstein and Vogel (2017) for arguments of why more productive firms are more skill-intensive.
3 See Verhoogen (2008); Lileeva and Treffer (2010); Kugler and Verhoogen (2012); Eslava et al. (2015) for quality upgrading, Yeaple (2005); Bustos (2011) for technology upgrading, and Grossman and Helpman (1991) for spillovers. See also Goldberg and Pavcnik (2004) and Goldberg and Pavcnik (2007) for a review about how trade has increased skill premium across emerging economies.
I use the case of Mexico as an example of an emerging economy to show that both channels are operating. Data from the Mexican Economic Census shows that within industries, firms that export have on average larger domestic sales and larger value added per worker than do non-exporters (Fact 1). Exporters are more skill-intensive compared to non-exporters (Fact 2). The correlation between value added per worker and skill-intensity of firms is positive (Fact 3); and conditional on exporting, export intensity is negatively correlated with skill intensity even after controlling for other characteristics of the firm (Fact 4).

Literature on firm heterogeneity with skill-biased productivity may account for facts 1-3 if trade is costly. However, since this literature considers a single industry, it cannot explain fact 4. Instead, Bernard et al. (2007b)'s framework may explain facts 1 and 4 if applied to a relatively unskilled-abundant country. However, it still cannot explain facts 2 and 3 because their model does not incorporate any mechanism that makes the most productive firms in an industry more skill intensive. In other words, their framework considers the choice of factor intensity as constant for every firm in the industry.

In this paper I address this inconsistency through a model that may explain the four facts above. The model consists of a small open economy where firms are heterogeneous in productivity and productivity is skilled biased (as in Burstein and Vogel (2017)). There are two industries that differ from each other because one of them is export-oriented (faces relatively high exogenous foreign demand) and the other is domestic-oriented. There are two factors of production, skilled and unskilled workers, and two tasks within each industry which differ in skill-intensity. Trade is costly so only the most productive firms export. There is a fixed cost of producing the skill-intensive task so there is also selection into producing this task.

---

4 Processing firms (maquiladoras) are excluded from the sample for all results presented in this paper. Skill intensity is defined as the fraction of payments to non-production workers, but the observations are consistent for other measures of skill (fraction of workers with high school, fraction of workers with university). Export-intensity is defined as \( \frac{\text{Exports}}{\text{Total sales}} \).

5 Burstein and Vogel (2017) explore the effects of trade on skill premium by exploring the interaction of comparative advantage and firm productivity in a framework similar to Eaton and Kortum (2002)'s. This paper instead embeds these mechanisms in a Melitz-style framework.
This model summarizes the channels through which two opposing forces – comparative and competitive advantage – interact in equilibrium to explain the four facts described above. In the model, the fraction of skilled workers differs between firms within the same industry because more productive firms choose a larger fraction of skilled labor for each task, and because the skill-intensive tasks represent a larger fraction of their total production. Additionally, selection into exporting makes exporters more skill-intensive. In a relatively unskilled-abundant country that has comparative advantage in unskilled-intensive tasks, these tasks face a relatively larger exogenous foreign demand. Therefore, firms that specialize on the unskilled-intensive tasks, which correspond to the least productive exporters, have larger export shares.

This framework is useful to study the effect of trade in demand for skilled labor because it incorporates several mechanisms. The first refers to resources being reallocated to the export-oriented industry that is also more skill-intensive (both in the model and in the data). The second is comparative advantage: foreign sales of unskilled-intensive tasks in the relatively export-oriented industries are disproportionately affected. The third is skill-biased productivity that has two effects. Following trade liberalization, more productive and skill-intensive firms grow more. Additionally, skill-bias magnifies productivity advantage in skill-intensive tasks, so trade will disproportionately benefit the relatively low productivity-low skilled exporters that specialize in the unskilled-intensive task. The fourth is the extensive margin of producing skill-intensive tasks. Since trade provides access to an additional market, the fraction of firms that may produce the costly skill-intensive task increases. This increases average skill-intensity in the industry because more firms use a more skill-intensive technology, but decreases average skill-intensity of firms performing skill-intensive tasks.

I structurally estimate the model to study how these mechanisms interact. The estimation is done for two manufacturing industries in Mexico that differ in their exporting patterns and skill intensity: the transportation equipment industry and the metal products industry.
I use the estimated model to understand the effects of changes in trade costs on demand for skill. The main result is that when trade costs are high enough, a decrease in trade costs increases the skill premium because the skill-biased productivity mechanism dominates. However, as trade costs decrease, the comparative advantage effect dominates and skill premium falls. This behavior is consistent with the observed evolution of skill premium in Mexican manufacturing following the liberalization reforms in the late 1980s and 1990s.\footnote{Trade liberalization reforms in Mexico can be traced back to 1986 when Mexico joined the General Agreement on Trade and Tariffs (GATT) and agreed to set a 50% ceiling on tariffs. There were subsequent waves of tariff reductions, and some changes took some time to be fully implemented. Since then, apart from joining NAFTA, Mexico joined OECD, WTO and has signed several free trade agreements.}

Understanding the interaction of comparative and competitive advantages in an unskilled-abundant country has long been a topic of interest for economists. The framework in this paper allows to study reallocations simultaneously across industries, across tasks within industries, and across firms. Results highlight that as exporting becomes more attractive, firms in an unskilled labor abundant country face a disproportional increase in demand for unskilled-intensive tasks. This may dampen productivity gains from trade because on one hand it induces all firms to specialize in these tasks and on the other hand it disproportionally affects relatively more unproductive exporters. These incentives might discourage skill accumulation across industries.

The rest of this paper is organized as follows. Section 1.2 shows empirical evidence of the mechanisms detailed above for the case of Mexico. Section 1.3 presents the model and discusses the characteristics of equilibrium. Section 1.4 informs the model with data from Mexican manufacturing sector, and Section 1.5 studies the effect of trade on demand for skill as informed by the model. Section 1.6 concludes.
1.2. Empirical Evidence

This section presents evidence of the exporting patterns of manufacturing firms in Mexico as an example of an emerging economy. I show that comparative and competitive advantage are operating in the sector. Concretely, I present evidence that exporters are larger, more productive and more capital and skill-intensive than non exporters, but conditional on being an exporter, it is the least skill-intensive firms that have larger export shares. Additionally, skill-intensity is positively correlated to value added per worker and sales in the domestic market. This is also true for exporting firms. However, foreign sales are negatively correlated with skill-intensity, leading to the negative relationship observed between export shares and skill. I also argue that the link between skill and firm size is driven by the interaction of a positive productivity effect and a negative comparative advantage effect.

Mexico is an appropriate country to study these mechanisms because exports are an important component of GDP, exports consist mainly of manufacturing goods, and more than 80% of manufacturing exports of the country go to the United States. Therefore, Mexico is arguably abundant in unskilled labor relative to its main trading partner.\(^7\).

1.2.1. Data

I use confidential firm level data for manufacturing sector from the Mexican Economic Census. The advantage of this database is that it includes all establishments that operate in the year of the census. The disadvantage is that there is no information on the education of workers, so the measure of skill used is the fraction of payments to white collar workers. Data from the National Survey of Employment, Wages, Technology and Training (ENESTyC) is used to show that the evidence presented is robust to more accurate measures of skill. I restrict the sample to non-processing (non maquiladora) firms that reported

\(^7\) In 2004 Mexican exports represented 20% of GDP, 84% of total exports were from the manufacturing sector, and 88.6% of non-oil exports went to the United States. In the same year, 36.1% of the population older than 25 in United States had finished post-secondary education; the fraction in Mexico was 22.4% (World Development Indicators, World Bank). Similarly, according to BLS the fraction of non-production workers to production workers in the manufacturing sector in United States in 2003 was 0.416 (https://factfinder.census.gov), while the number is 0.216 for Mexico (Economic Census 2004, INEGI).
positive production in the year of the survey. More details about the data can be found in the Data Appendix. The results in this section should be interpreted only as correlations, not as evidence of a causal relationship between the variables.

1.2.2. Evidence in Mexican Manufacturing Sector

Exporters’ Advantage

Evidence in the cross section of Mexican firms is consistent with the predictions of Melitz (2003) and with empirical literature that has documented that exporters are larger and more productive (Bernard et al. (2007a); Bernard et al. (2003)). Concretely, Mexican exporters have systematically larger employment and total sales, higher value added per worker, pay higher wages, and are more capital and skill intensive. This is still true after controlling for industry and foreign capital participation (see Tables 6 and 7).

Productivity and Skill-intensity

Columns 1-2 in Table 7 show that skill intensity is positively correlated with value added per worker. From the lens of this paper, this observation is interpreted as evidence that productivity is skill-biased.

Skill Intensity, Export Participation and Export Share

There is a positive correlation between skill-intensity and export participation both between and within industries. Figure 8 shows that industries with higher export participation are also more skill-intensive on average. This explains why firms in industries like cars, machinery, and computers are more likely to export. A plausible explanation for this trend is that preferences are non-homothetic so demand in higher income countries is biased towards higher skilled industries. If more skill-intensive goods are more expensive, another explanation is that trade costs represent a lower fraction of the value of goods. Therefore, lower production costs in lower-income countries represent a higher advantage for high-skilled high-value industries. Thirdly, it is possible that goods produced with higher skill are more difficult to replicate, so have less substitutes and will be more likely to be traded internationally.

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8 Skill intensity is measured as the fraction of payments to non-production (white collar) workers. Capital intensity is measured as capital stock per worker.

9 This explains why firms in industries like cars, machinery, and computers are more likely to export. A plausible explanation for this trend is that preferences are non-homothetic so demand in higher income countries is biased towards higher skilled industries. If more skill-intensive goods are more expensive, another explanation is that trade costs represent a lower fraction of the value of goods. Therefore, lower production costs in lower-income countries represent a higher advantage for high-skilled high-value industries. Thirdly, it is possible that goods produced with higher skill are more difficult to replicate, so have less substitutes and will be more likely to be traded internationally.
skill intensity of firms is also positively correlated with the probability of exporting (extensive margin). This observation is consistent with previous literature (Burstein and Vogel (2017)).

Conditional on exporting, skill-intensity is negatively correlated with export share (intensive margin). Columns 5-6 in Table 7 show that the negative relationship of skill and export intensity is large, significant, and robust to firm characteristics and industry fixed-effects. Additionally, although exporters are more productive and larger compared to non-exporters, more productive exporters are not more export intensive on average.10 These patterns are robust to different measures of skill (Table 8 and Figure 10).

The contrast between the extensive and intensive margin of exporting is illustrated in Figure 9. The figure shows that the lowest skill deciles of firms have on average lower export participation, but the lowest skill deciles of exporters have higher export shares.

The evidence presented above reflects that firms that participate in international trade are the most productive and skill-intensive within each industry and that trade happens mainly in skill-intensive industries. However, conditional on exporting, the firms with lower skill intensity have higher export intensity. I interpret this as evidence that the Mexican exporting sector has specialized in the relatively low-skill tasks within industries that are export-oriented. I argue that this pattern of specialization has occurred because Mexico has comparative advantage in these activities.

**Skill-Intensity and Firm Size**

Figure 11 illustrates exporters’ productivity advantage clearly: exporters are larger and more productive than non-exporters. In a plot of log employment versus value added per worker, exporters are concentrated on the top right corner of the figure. These relations are significant and robust to other controls, and exist both in the domestic and foreign

---

10 Recent literature has suggested that the role of productivity as the determinant of firm size has been overstated. Holmes and Stevens (2014) argue that size is determined by the nature of goods; Armenter and Koren (2015) instead emphasize exporting costs are firm-specific.
market (Table 9). If domestic and foreign sales are determined only by productivity and under the assumption that skill-intensity is correlated with productivity, then the relation between skill-intensity and size should be similar. However, Figure 12 shows a different story: average firm size is increasing in average skill intensity for domestic firms, but the relationship between skill-intensity and size is flat for exporters. Table 9 shows that the unconditional correlation between skill intensity and sales of exporters in the national and foreign market is positive and significant (panel C of Table 9). However, controlling for value added per worker the correlation between skill intensity and domestic sales remains positive and significant, but the correlation between skill intensity and foreign sales becomes negative and significant. In consequence, the correlation between skill and size is not statistically different from zero. This explains the positive relationship between skill intensity and size for domestic firms and the flat relationship for exporters that is observed in Figure 12.

I interpret the positive coefficient of skill and domestic sales as driven by the positive correlation between skill and productivity. Since firms in every regression in panel C of Table 9 are the same, to make sense of a positive correlation of skill intensity and domestic sales but a negative correlation with exports, there should be a mechanism, correlated with skill-intensity, that is acting only for foreign sales. I propose that this mechanism is comparative advantage.

Given the evidence in this section, the relationship between skill intensity and size of Mexican manufacturing firms can be explained by the interaction between two competing forces: a positive productivity effect and a negative comparative advantage effect. The former corresponds to the standard Melitz productivity effect, which implies that more productive firms are larger. If skill intensity is positively correlated with productivity, then more skill-intensive firms are also larger. The second mechanism is negative for emerging economies that have comparative advantage in unskilled-intensive activities. Only the first effect exists for domestic firms so the relationship between skill intensity and size is positive. However,

---

11 This relationship is robust to measuring skill intensity as the fraction of payments to non-production workers, or by average labor payments.
the second mechanism counteracts productivity as a determinant of firm size of exporters, flattening the relation. While productivity drives domestic sales and the probability of exporting, comparative advantage drives export intensity conditional on being an exporter.
1.3. Model

In this section I present a model that incorporates the mechanisms documented above and explain how these channels operate in the model.

1.3.1. Setup

Consider a small open economy with two factors of production, skilled and unskilled workers \((s\text{ and } u)\), and \(k = 1, ..., K\) industries. In each industry there are two tasks, \(\{k_l, k_h\}\). Production of task \(k_h\) requires a more skill-intensive technology than task \(k_l\). Firms are heterogeneous in idiosyncratic productivity and industry where they operate. Each firm is born in an industry able to perform task \(k_l\). It may pay a fixed cost to have access to a skill-intensive technology and perform task \(k_h\). If it does so, the firm performs the two tasks simultaneously. There is a continuum of firms in each industry, and monopolistic competition in the production of each task. There is a mass of entrepreneurs that draw a productivity and decide whether to produce or not. Firms enter and exit endogenously and there is no exogenous exit. The factors of production move freely between firms and industries, but cannot leave the country. The domestic economy is relatively abundant in unskilled labor, and may access the foreign market with exogenous demand for exports and price of imports.\(^{12}\) World variables will be denoted by an asterisk and are exogenous. In the following, I denote domestic prices, quantities, revenues and profits with a superscript \(d\), and those for exports with a superscript \(x\).

**Consumption:** Representative consumers maximize utility that depends on consumption of a CES aggregate of differentiated varieties of each task \(k_j\) from \(K\) industries. The set of available varieties of task \(k_j\), is denoted by \(\Omega_{k_j}\). Consumers choose quantities \(\{q(\omega)\}_{\omega \in \Omega_{k_j}}\).  

\(^{12}\) Under the assumption of a small open economy, aggregate variables in the world (zero-productivity cutoffs, mass of firms, total expenditure and price index) are unaffected by the domestic economy.
to maximize utility function:

\[
U = \prod_{k=\{1,...,K\}, j \in \{l,h\}} (Q_{kj})^{\alpha_{kj}}
\]

where \(Q_{kj}\) is a consumption index with price index \(P_{kj}\). If \(\sigma = \frac{1}{1-\rho} > 1\) is the constant elasticity of substitution across varieties, the aggregate of consumption and price index are given by

\[
Q_{kj} = \left( \int_{\omega \in \Omega_{kj}} q(\omega) \rho \partial \omega \right)^{\frac{1}{\rho}}, \quad P_{kj}^c = \left( \int_{\omega \in \Omega_{kj}} p(\omega)^{1-\sigma} \partial \omega \right)^{\frac{1}{1-\sigma}} \tag{1.1}
\]

**Production:** Heterogeneous firms produce differentiated varieties of tasks \((\omega)\) within industries. Skill and productivity complementarity is introduced as in Burstein and Vogel (2017). If a firm uses \(s\) skilled workers and \(u\) unskilled workers to produce task \(k_j\), its output is given by

\[
y(\beta_{kj}, \varphi) = \varphi \left[ \beta_{kj}^{\frac{1}{\eta}} (\varphi^s s)^{\frac{u-1}{\eta}} + (1 - \beta_{kj})^{\frac{1}{\eta}} u^{\frac{u-1}{\eta}} \right]^\eta \tag{1.2}
\]

where \(\eta > 1\) is the elasticity of substitution between skilled and unskilled workers and \(\varsigma\) controls the skill bias of productivity. Tasks in each industry differ only in their skill-intensity parameter. A firm is completely characterized by the industry it operates in and productivity, so I denote each firm by the pair \((k, \varphi)\).

**Labor demand:** Given wages to unskilled and skilled workers \((w_u\) and \(w_s\)), the decision about the fraction of skilled workers used for each task is static and given by:

\[
\frac{s(\beta_{kj}, \varphi)}{u(\beta_{kj}, \varphi)} = \frac{\beta_{kj}}{1 - \beta_{kj}} \left( \frac{w_u}{w_s} \right)^\eta \varphi^{\varsigma(\eta-1)} \tag{1.3}
\]

Using (1.2) and (1.3), the marginal cost of performing task \(k_j\) for a firm with productivity
\[ c(\beta_{kj}, \varphi) = \frac{1}{\varphi} \left( \beta_{kj} \left( \varphi^{-\varsigma} w_s \right)^{1-\eta} + (1 - \beta_{kj}) w_u^{1-\eta} \right)^{\frac{1}{1-\eta}} \] (1.4)

1.3.2. Equilibrium in a small open economy with costly trade

**Prices:** Profit maximization implies a constant markup over marginal cost in each task, and each market, so domestic price is:

\[ p^d(\beta_{kj}, \varphi) = \frac{c(\beta_{kj}, \varphi)}{\rho} \] (1.5)

Firms face iceberg variable trade costs \( \tau_{kj} > 1 \) to sell in foreign market. Therefore, export price of task \((\beta_{kj}, \varphi)\) is

\[ p^x(\beta_{kj}, \varphi) = \frac{\tau_{kj} c(\beta_{kj}, \varphi)}{\rho} \] (1.6)

**Domestic sales:** \( R \) is total revenue in the economy, so quantity demanded and revenue for task \( k_j \) in the domestic market is:

\[ q^d(\beta_{kj}, \varphi) = \frac{\alpha_{kj} R P^\sigma_k}{p^d(\beta_{kj}, \varphi)^\sigma} \quad r^d(\beta_{kj}, \varphi) = \alpha_{kj} R \left( \frac{P_{kj}}{c(\beta_{kj}, \varphi)} \right)^{\sigma-1} \] (1.7)

**Foreign sales:** Task \( k_j \) faces exogenous foreign demand

\[ q^x(\beta_{kj}, \varphi) = p(\beta_{kj}, \varphi)^{-\sigma} D^*_{kj} \] (1.8)

Therefore, exports are:

\[ r^x(\beta_{kj}, \varphi) = D^*_{kj} \left( \frac{\rho}{\tau_{kj} c(\beta_{kj}, \varphi)} \right)^{\sigma-1} \] (1.9)

**Cutoffs to enter, export, and produce skill-intensive task:** There is an exogenous
mass of entrants each period.\textsuperscript{13} Each entering firm draws a productivity $\varphi$ from a distribution with density $g_k(\varphi)$ and cumulative distribution $G_k(\varphi)$. Selling domestically incurs in fixed costs of $f_k^d > 0$ per period, paid using a separate factor of production whose supply is perfectly elastic.\textsuperscript{14} Paying this cost allows the firm to perform task $k_l$ using technology $\beta_{k_l}$. Selling in the foreign market incurs in fixed costs $f_k^x$ per period, paid using the separate factor of production. A firm in industry $k$ may additionally pay fixed cost $f_k^h$ to perform task $k_h$ using technology $\beta_{k_h} > \beta_{k_l}$.

Zero profits for the marginal firm in the domestic market pins down the cutoff productivity to produce in the market, $\varphi_k^l$.

$$f_k^d = \frac{r^d(\beta_{k_l}, \varphi_k^l)}{\sigma}$$

The cutoffs to export and perform task $k_h$ are denoted $\varphi_k^x$ and $\varphi_k^h$ respectively. Zero profits for the marginal firm in the foreign market and that produces the skill-intensive task pin down cutoff productivities. These are defined as follows:

\[
\begin{align*}
\text{if } & \varphi_k^h < \varphi_k^x & \frac{r^d(\beta_{k_h}, \varphi_k^h)}{\sigma} = f_k^h & \text{and } \frac{r^x(\beta_{k_l}, \varphi_k^x) + r^x(\beta_{k_h}, \varphi_k^h)}{\sigma} = f_k^x \\
\text{if } & \varphi_k^h > \varphi_k^x & \frac{r^x(\beta_{k_l}, \varphi_k^x)}{\sigma} = f_k^x & \text{and } \frac{r^d(\beta_{k_h}, \varphi_k^h) + r^x(\beta_{k_h}, \varphi_k^h)}{\sigma} = f_k^h \\
\text{if } & \varphi_k^h = \varphi_k^x & \frac{r^d(\beta_{k_h}, \varphi_k^h) + r^x(\beta_{k_l}, \varphi_k^x) + r^x(\beta_{k_h}, \varphi_k^h)}{\sigma} = f_k^x + f_k^h
\end{align*}
\]

This determines the mass of domestic varieties ($N_k^l$) where $1 - G_k(\varphi_k^l) = \frac{N_k^l}{M_k}$ the mass

\textsuperscript{13} No free entry so there are profits in equilibrium. See Appendix A for a definition of equilibrium with free entry, and for an analysis of the effects of trade. The conclusions are consistent with the results of this version of the model that are presented in the next section.

\textsuperscript{14} This is done following Eslava et al. (2015), and this way the skill intensity of the firm is given by $\mathbf{s} = \frac{s}{s + n}$ and the fixed costs do not affect this ratio.
of exporting firms \( (N^x_k) \) where \( 1 - \frac{\partial G_k(\varphi^x_k)}{M_k} = \frac{N^x_k}{M_k} \), and the mass of firms performing skill-intensive task \( (N^h_k) \) where \( 1 - \frac{\partial G_k(\varphi^h_k)}{M_k} = \frac{N^h_k}{M_k} \).

Define

\[
\mathbb{I}_l = \begin{cases} 
0 & \text{if } \varphi < \varphi^l_k \\
1 & \text{if } \varphi \geq \varphi^l_k
\end{cases}
\]

\[
\mathbb{I}_x^l = \begin{cases} 
0 & \text{if } \varphi < \varphi^x_k \\
1 & \text{if } \varphi \geq \varphi^x_k
\end{cases}
\]

\[
\mathbb{I}_h = \begin{cases} 
0 & \text{if } \varphi < \varphi^h_k \\
1 & \text{if } \varphi \geq \varphi^h_k
\end{cases}
\]

\[
\mathbb{I}_x^h = \begin{cases} 
0 & \text{if } \varphi < \max\{\varphi^h_k, \varphi^x_k\} \\
1 & \varphi \geq \max\{\varphi^h_k, \varphi^x_k\}
\end{cases}
\]

Then, total revenue of firm \( (k, \varphi) \) is:

\[
 r(k, \varphi) = \left[ \alpha_{k_l} R \left( \frac{\rho P_{k_l}}{c(\beta_{k_l}, \varphi)} \right)^{\sigma - 1} \right] \mathbb{I}_l + \left[ \alpha_{k_h} R \left( \frac{\rho P_{k_h}}{c(\beta_{k_h}, \varphi)} \right)^{\sigma - 1} \right] \mathbb{I}_h \\
+ \left[ D_{k_l}^* \left( \frac{\rho}{\tau_k c(\beta_{k_l}, \varphi)} \right)^{\sigma - 1} \right] \mathbb{I}_x^l + \left[ D_{k_h}^* \left( \frac{\rho}{\tau_k c(\beta_{k_h}, \varphi)} \right)^{\sigma - 1} \right] \mathbb{I}_x^h
\]

\[ (1.12) \]

**Consumer’s income:** The total revenue in both markets for all sectors should equal consumer’s income (earned as profit, wages, and payments to the additional factor of production).

\[
\sum_k M_k \left[ \int \left( r^d(\beta_{k_l}, \varphi) \mathbb{I}_l + r^x(\beta_{k_l}, \varphi) \mathbb{I}_x^l + r^d(\beta_{k_h}, \varphi) \mathbb{I}_h + r^x(\beta_{k_h}, \varphi) \mathbb{I}_x^h \right) \partial G_k(\varphi) \right] = R \quad (1.13)
\]
The number of skilled and unskilled workers to perform each task \( k_j \) sold in the domestic and foreign markets respectively are denoted as \( s^d(\beta_{kj}, \varphi), u^d(\beta_{kj}, \varphi), s^x(\beta_{kj}, \varphi), \) and \( u^x(\beta_{kj}, \varphi) \).

Using equations (1.2) and (1.3), there is a linear relationship between unskilled labor and output for market \( i \) given by:

\[
q^i(\beta_{kj}, \varphi) = u^i(\beta_{kj}, \varphi) \left[ (1 - \beta_{kj}) \frac{1}{\eta} \left( \frac{\beta_{kj}}{1 - \beta_{kj}} \varphi^{(\eta-1)} \left( \frac{w_u}{w_s} \right)^{\eta-1} + 1 \right) \right]^{\frac{\eta}{\eta-1}} \tag{1.14}
\]

Then \( s(\beta_{kj}, \varphi) \) is pinned down by (1.3).

The mass of unskilled and skilled workers are \( \bar{U} \) and \( \bar{S} \). Aggregate labor market clearing conditions are:

\[
\bar{U} = \sum_k M_k \left[ \int \left( u^d(\beta_{ki}, \varphi) \bar{I}_l + u^x(\beta_{ki}, \varphi) \bar{I}_x^f + u^d(\beta_{kh}, \varphi) \bar{I}_h + u^x(\beta_{kh}, \varphi) \bar{I}_x^h \right) \partial G_k(\varphi) \right] \tag{1.15}
\]

\[
\bar{S} = \sum_k M_k \left[ \int \left( s^d(\beta_{ki}, \varphi) \bar{I}_l + s^x(\beta_{ki}, \varphi) \bar{I}_x^f + s^d(\beta_{kh}, \varphi) \bar{I}_h + s^x(\beta_{kh}, \varphi) \bar{I}_x^h \right) \partial G_k(\varphi) \right] \tag{1.16}
\]

**Aggregation of prices:** Domestic price index of task \( k \) is:

\[
P_{k_j}^{1-\sigma} = N_{k_j}^d \int_{\varphi_k^d}^{\infty} p^d(\beta_{kj}, \varphi)^{1-\sigma} \partial G_k(\varphi) + \left( \tau_{kj} P_{kj}^* \right)^{1-\sigma} \tag{1.17}
\]

Where \( P_{kj}^* \) is the price index of task \( k_j \) in the foreign market.

An equilibrium with trade consists on a vector

\[
\{ p^d(\beta_{kj}, \varphi), p^x(\beta_{kj}, \varphi), P_{kj}, \varphi_k, \varphi_k^d, \varphi_k^x, w_u, w_s, R \}
\]

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Given $D_{k_j}$, $M_k$, $\tau_{k_j}$ and the parameters of the model, the conditions that determine the equilibrium are, for each task $k_j$, firms’ pricing rules in each market (equations 1.5 and 1.6), and aggregation of prices (equation 1.17); for each industry $k$, and zero-profit for marginal firm in each market (equations 1.10 and 1.11); for the aggregate economy, labor market clearing (equations 1.15 and 1.16), and consumer’s income aggregation (equation 1.13).

**Characteristics of costly trade equilibrium**

This framework is suitable to explain the observations in Mexican manufacturing industry that were documented in section 1.2.

**Skill choice of firms:** The fraction of skilled labor used in each task is decreasing in the skill premium ($\frac{w_s}{w_u}$), increasing in $\beta_{k_l}$ and increasing in $\varphi$ (equation 1.3). Firm skill-intensity within industries is increasing in $\varphi$. This is because a more productive firm uses a larger fraction of skilled labor to perform any task, only the highest productivity firms select into producing the skill-intensive task, and because the fraction of skill-intensive task in total production of a firm is increasing in $\varphi$. The parameter $\varsigma$ governs the correlation between productivity and skill intensity choice. As long as $\varsigma(\eta - 1) > 0$, this correlation is positive.

**Size, skill-intensity of exporters:** Total sales and skill-intensity are strictly increasing in productivity within an industry (equations 1.3 and 1.7) and employment is increasing in sales (equation 1.14). Therefore, firms with highest $\varphi$ in an industry are larger and more skill-intensive. Since there are fixed costs of exporting there is selection of most productive firms, and exporters in the model are more productive, larger, and more skill-intensive.

**Skill-biased productivity and competitive advantage:** Skill-biased productivity magnifies productivity advantage in skill-intensive tasks. To illustrate better the role that it plays, compare a scenario where $\varsigma > 0$ with one where $\varsigma = 0$. Define $\varphi_m$ as the minimum

---

15 A firm with the same productivity will choose a higher fraction of skilled workers to perform a task $k_h$ because by assumption $\beta_{k_h} > \beta_{k_l}$. Additionally, since there is a fixed cost of performing task $k_h$, $\varphi_h \geq \varphi_l$.  

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value of \( g_k(\varphi) \) and suppose that \( \varphi_m < w_s \) and \( w_s > w_u \). These assumptions imply that if \( \beta_{kh} > \beta_{kl} \), then \( c(\beta_{kh}, \varphi_m) > c(\beta_{kl}, \varphi_m) \). If \( \zeta = 0 \), this will be true for any \( \varphi \). However, if \( \zeta > 0 \) and \( \varphi \) is unbounded, there will be some \( \hat{\varphi} \) where \( \left( \frac{w_s}{\varphi} \right) = 1 \). For all \( \varphi > \hat{\varphi} \), the relationship is reversed: If \( \beta_{kh} > \beta_{kl} \), then \( c(\beta_{kh}, \varphi) < c(\beta_{kl}, \varphi) \) \( \forall \ varphi > \hat{\varphi} \). This intuitively means that while marginal costs are decreasing in productivity in all tasks, they are decreasing faster in more skill-intensive tasks. Thus, skill-biased productivity magnifies competitive advantage in skill-intensive activities. In each industry the ratio of skill-intensive to unskilled-intensive sales is increasing in productivity, so the fraction of the skill-intensive task in total production of the firm is increasing in \( \varphi \).{16}

**Export-intensity:** If firm exports, export share of task \( k_j \) is given by

\[
X_{\text{share}}(\beta_{kj}, \varphi) = \frac{1}{1 + \frac{\tau_{\sigma-1} \alpha_{kj} R P_{kj}^{\sigma-1}}{D_{kj}^{1-\sigma}}} \tag{1.18}
\]

Export share in each task is independent of idiosyncratic productivity, decreasing in iceberg trade cost, and increasing in the relative foreign demand. The assumption that home is relatively abundant in unskilled labor will imply that within industries, relatively unskilled-intensive tasks have a higher relative demand. Concretely, \( \frac{\tau_{\sigma-1} \alpha_{kj} R P_{kj}^{\sigma-1}}{D_{kj}^{1-\sigma}} \) is increasing in \( \beta_{kj} \), so that export share of task \( k_j \) is decreasing in \( \beta_{kj} \).

Although export share in each task does not depend on productivity, total export share of firm \((k, \varphi)\) will be affected by the property of skill-biased productivity. As discussed above, productivity advantage of firms in more skill-intensive tasks is magnified by this property. Therefore, sales of the skill-intensive task relative to the unskilled-intensive tasks are larger

\[16\] To see that the ratio of skill-intensive to unskilled-intensive sales is increasing in productivity:

\[
\frac{r(\varphi, \beta_{kh})}{r(\varphi, \beta_{kl})} = \left( \frac{c(\beta_{kl}, \varphi)}{c(\beta_{kh}, \varphi)} \right)^{\sigma-1} \frac{[\alpha_{kh} R P_{kh}^{\sigma-1} + D_{kh}^{1-\sigma} \tau_{\sigma-1}]}{[\alpha_{kl} R P_{kl}^{\sigma-1} + D_{kl}^{1-\sigma} \tau_{\sigma-1}]}\]

The terms in the squared brackets are common for all firms within an industry, and skill-biased productivity implies that relative marginal costs of the unskilled-intensive to the skilled-intensive task are increasing in \( \varphi \).

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for firms with higher \( \varphi \). Denoting \( \alpha_k j \sigma^{-1} = D_{kj} \), export share is given by

\[
X_{\text{share}}(k, \varphi) = \frac{\left[ D_{kl}^* \sigma_{kl}^{-1} \right] + \left[ \frac{c(\beta_{k1}, \varphi)}{c(\beta_{k1}, \varphi)} \sigma_{kl}^{-1} D_{kl}^* \right] + \left[ \frac{c(\beta_{k1}, \varphi)}{c(\beta_{k1}, \varphi)} \sigma_{kl}^{-1} D_{kl}^* \right]}{1 + \left[ \frac{D_{il}^*}{D_{kl}} \left( \frac{c(\beta_{k1}, \varphi)}{c(\beta_{k1}, \varphi)} \right) \sigma_{kl}^{-1} \right] + \left[ \frac{c(\beta_{k1}, \varphi)}{c(\beta_{k1}, \varphi)} \sigma_{kl}^{-1} D_{kl}^* \right] + \left[ \frac{c(\beta_{k1}, \varphi)}{c(\beta_{k1}, \varphi)} \sigma_{kl}^{-1} D_{kl}^* \right]} \tag{1.19}
\]

which is not independent of idiosyncratic productivity. More productive firms produce relatively more of the high skill-intensive task in both markets.

**Effect of Trade on Demand for Skill**

A decrease in trade costs affects the demand for skill through several channels. First, trade will reallocate resources towards the export-oriented industry. Since this industry is also more skill-intensive, this channel will increase relative demand for skill. I refer to this as the *relative skill between industries* mechanism. Second, within industries comparative advantage increases sales of unskilled task relatively more than those of the skilled task. This mechanism acts between tasks, so I refer to it as the *comparative advantage between tasks* mechanism. Third, skill-biased productivity makes the most productive firms use relatively more skilled labor to perform each task. Since trade induces a reallocation of resources towards more productive firms, this mechanism will increase demand for skill. This is the *skill-biased productivity within firms* mechanism. The fourth, mechanism is the interaction between skill-bias and comparative advantage. This mechanism counteracts the third because comparative advantage disproportionately affects relatively unproductive exporters that produce both tasks. This is because the share of the unskilled-intensive task in their total production is larger because competitive advantage of most productive firms in skill-intensive activities is magnified. Fifth, the *extensive margin of skill intensive task* channel refers to the increase in the fraction of firms that perform the skill intensive task. As trade costs decrease, access to an additional market allows a larger fraction of firms to pay the fixed cost of producing the skill-intensive task. This will increase average demand.
for skill at the industry level because more firms use technology $\beta_{kh} > \beta_{ki}$. However, this mechanism decreases average productivity of the skill intensive task because lower productivity firms will perform it. Finally, the extensive margin of unskilled-intensive task will increase demand for skill because trade increases productivity cutoff to produce (induces creative-destruction). This increases average productivity and skill-intensity of operating firms. The following table summarizes the mechanisms through which trade affects demand for skill.

<table>
<thead>
<tr>
<th>Summary of mechanisms</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative skill intensity between industries</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Comparative advantage between tasks</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Skill biased productivity within firms</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Interaction of skill bias and comparative advantage</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Extensive margin of skill intensive task</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>(average industry skill-intensity)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extensive margin of skill intensive task</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>(average skill-intensity of task $k_h$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extensive margin unskilled-intensive task</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

The mechanisms described above illustrate the interaction of competing forces in the demand for skill: for the most productive firms in an industry, relative foreign demand for low skilled task is higher (comparative advantage), but advantage in productivity is stronger in the high skilled task (competitive advantage). Since different mechanisms act in opposite directions, the net effect on relative wage of skilled workers to unskilled workers is ambiguous.

In the next section I estimate the model to evaluate the effects of trade on the skill premium and productivity.
1.4. Estimation

I structurally estimate the model to be able to contrast the effects of trade in an industry that is export-oriented with one that is not, and to study the reallocation of labor across these industries and across firms within industries when variable trade costs change. Estimation is done by minimizing the distance between the moments generated in a simulated model and those observed in data. The parameters are estimated simultaneously for two manufacturing industries: transportation equipment manufacturing and metal product manufacturing. Table 1 shows summary statistics for the two industries. I choose the transportation equipment industry because it includes the automobile industry, which is of great importance in Mexican exporting activity.\textsuperscript{17} I consider this industry is the “export-oriented” industry. Metal products industry was chosen given three considerations. In first place, there is a big contrast in the importance of international trade in this industry: only 0.46% of firms in this industry are exporters, in contrast to 15.4% in the transportation equipment industry. This contrast will be useful to understand how trade affects the reallocation of labor between industries with different export orientation. Second, these industries differ in terms of their skill-intensity: skill-intensity of firms in the metal products industry is on average 0.076, while the average in transportation equipment industry is 0.224. Third, metal products represents an important fraction of manufacturing firms, so the conclusions about what happens in this industry are economically relevant. Together, these two industries represent 17.1% of establishments and 15.9% of workers in the sample, which consists of non-processing manufacturing establishments that produced goods in 2003.

1.4.1. Estimation Procedure

Identification

I assume productivity of firms is distributed Pareto with shape parameter $a$ and minimum parameter $b$. For identification purposes, all non-exporters in an industry are assumed

\textsuperscript{17} The automobile industry only represented 27.4% of total Mexican exports in 2003 (BIE, INEGI).
Table 1: Summary Statistics by Industry, 2003

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Metal Products</th>
<th>Transportation Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of establishments</td>
<td>47,601</td>
<td>1,481</td>
</tr>
<tr>
<td>(fraction of total manufacturing)</td>
<td>16.6%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Total employment in industry</td>
<td>216,237</td>
<td>186,618</td>
</tr>
<tr>
<td>Export participation in industry</td>
<td>0.46%</td>
<td>15.4%</td>
</tr>
<tr>
<td>Fraction of non-production workers (average)</td>
<td>0.055</td>
<td>0.143</td>
</tr>
<tr>
<td>Export share (average)</td>
<td>0.291</td>
<td>0.405</td>
</tr>
</tbody>
</table>

**Sales to domestic market (2013 pesos)**

| Average all establishments | 1,920         | 174,686             |
| Standard deviation all establishments | 28,162 | 1,297,566 |
| Average non-exporters       | 1,260         | 37,374              |
| Average exporters           | 144,057       | 929,300             |

**Skill-intensity**

| Total                  | 0.076        | 0.224                |
| Non-exporters          | 0.072        | 0.181                |
| Exporters              | 0.402        | 0.447                |

* Fraction of establishments (employment) in industry out of total sample.
* Source: Mexican Economic Census 2004. Use of microdata through INEGI’s Microdata Processing Laboratory. Sample restricted to non-processing establishment with positive production in 2003. Skill-intensity is measured as the fraction of payments to non-production workers.
to produce with the same technology, $\beta_k$, so that non-exporters do not perform the high skill task (assumption that $\varphi_k^x < \varphi_k^h$). This is a reasonable assumption given that when asked whether the establishment invests in creating new products or not, only 1.2% of non-exporters in the sample report having invested in the creation of new products, while 54.3% of exporters report doing so. Given this assumption, average skill-intensity of non-exporters in data informs $\beta_k$. Since I assume that the cutoff to use the high skill-intensity technology is above the cutoff to export, I target the observed fraction of exporters with positive investment in the creation of new products in each industry. This fraction of exporters are assumed to perform the high skill task, and average skill intensity of exporters informs $\beta_h$. Differences in technologies induce different average skill-intensity, so I infer $\frac{D_{kj}^*}{\alpha_{kj}} R_{kj} \sigma_{kj}-1$ to match the negative correlation of skill intensity and export share. The correlation between domestic sales and skill intensity in both industries informs $\varsigma$. Table 2 presents the parameters and the moments that help identify them.

I arbitrarily set iceberg trade cost to 1.2 and the minimum of the Pareto distribution to 1.5 so that skilled labor is at least 1.5 times as productive as unskilled. The elasticity of substitution is taken from Broda and Weinstein (2006) and set to 5, and the elasticity of substitution between skilled and unskilled labor is taken from Acemoglu and Autor (2011) and set to 1.6. To calculate absorption ($\alpha_k$), I use publicly available data of domestic sales from Economic Census from INEGI, and the number corresponds to total production in the industry minus exports plus imports. Non-production workers are taken as proxy of skilled labor. The ratio of non-production workers to production workers in manufacturing industry in Mexico is 0.216. I normalize wage of unskilled labor and total mass of workers ($S + U$) to 1, and this pins down the exogenous mass of entrants in the benchmark.

---

18 INEGI, Mexican Economic Census, 2004. Manufacturing industry. This number corresponds to all establishments surveyed.
Table 2: List of parameters and moments that help identify them

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\zeta$</td>
<td>Skill bias of productivity</td>
<td>Correlation of domestic sales &amp; skill intensity</td>
</tr>
<tr>
<td>$\beta_{k_l}$</td>
<td>Skill-intensity of low technology</td>
<td>$\frac{w_s}{w_s+w_u} \text{ of non exporters}$</td>
</tr>
<tr>
<td>$\beta_{k_h}$</td>
<td>Skill-intensity of high technology</td>
<td>$\frac{w_h}{w_h+w_u} \text{ of exporters}$</td>
</tr>
<tr>
<td>$a_k$</td>
<td>Shape of Pareto</td>
<td>Average export share in the industry</td>
</tr>
<tr>
<td>$Q^<em>_l$, $Q^</em>_h$</td>
<td>Exogenous foreign demand</td>
<td>Correlation of export share and skill intensity</td>
</tr>
<tr>
<td>$\alpha_h$</td>
<td>Fract income spent in agg skill int goods</td>
<td>Average domestic sales domestic</td>
</tr>
<tr>
<td>$f^d_k$</td>
<td>Fixed cost of domestic market</td>
<td>Average domestic sales exporters</td>
</tr>
<tr>
<td>$f^x_k$</td>
<td>Fixed cost of foreign market</td>
<td>Survival rate of 90%</td>
</tr>
<tr>
<td>$f^*_k$</td>
<td>Fixed cost of using high skill technology</td>
<td>Fraction of exporters</td>
</tr>
<tr>
<td>$f_k$</td>
<td>Fixed cost of using high skill technology</td>
<td>Fraction exporters invest in creating new products</td>
</tr>
</tbody>
</table>
Table 3: Parameters not Estimated

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Source/Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau$</td>
<td>Iceberg trade cost</td>
<td>1.2</td>
<td>Arbitrary</td>
</tr>
<tr>
<td>$\alpha_1$</td>
<td>Absorption in transport equipment industry</td>
<td>0.815</td>
<td>BIE, INEGI</td>
</tr>
<tr>
<td>$\alpha_2$</td>
<td>Absorption in metal products industry</td>
<td>0.185</td>
<td>BIE, INEGI</td>
</tr>
<tr>
<td>$b$</td>
<td>Minimum parameter of Pareto distribution</td>
<td>1.5</td>
<td>Arbitrary</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Elasticity of substitution btw varieties</td>
<td>5</td>
<td>Broda and Weinstein (2006)</td>
</tr>
<tr>
<td>$\eta$</td>
<td>Elasticity of substitution skilled/unskilled workers</td>
<td>1.6</td>
<td>Acemoglu and Autor (2011)</td>
</tr>
<tr>
<td>$w_u$</td>
<td>Wage of unskilled labor</td>
<td>1</td>
<td>Normalization</td>
</tr>
<tr>
<td>$S$</td>
<td>Mass of skilled labor</td>
<td>0.1776</td>
<td>Mexican Economic Census 2004</td>
</tr>
<tr>
<td>$U$</td>
<td>Mass of unskilled labor</td>
<td>0.8224</td>
<td>Mexican Economic Census 2004</td>
</tr>
</tbody>
</table>
Method

Enter iteration with parameters $\varsigma, \beta_{k_1}, \beta_{k_h}, a_k, \alpha_{k_h}$, initial $D^*_{k_1}, D^*_{k_h}$ for $k = 1, 2$ and with a guess of participation rate, export participation and fraction of firms that use the high skill technology in each sector. I simulate an economy consisting on 2 industries each with 50,000 firms that correspond to random draws from a Pareto distribution with minimum parameter 1.5 and shape $a_k$ respectively. For each simulated economy, solve the domestic equilibrium given \{ $\beta_{k_1}, \beta_{k_h}, \eta, \varsigma, \varsigma, \alpha_{k_1}, \alpha_{k_h}, D^*_{k_1}, D^*_{k_h}, \tau$ \} and fraction of firms in each market for each task. Domestic equilibrium consists on $w_s, P_k, Y$, and equilibrium export share.\textsuperscript{19} For each economy and given the rest of parameters, iterate over the pair \{ $D^*_{k_1}, D^*_{k_h}$ \} to minimize the difference between the average export share and the correlation between export share and skill. When convergence is reached, calculate remaining moments. Given \{ $D^*_{k_1}, D^*_{k_h}$ \} and equilibrium outcomes, estimated parameters minimize the distance between the remaining moments in data and the model. Fixed costs, $f_k^d, f_k^z, f_k^e$ are chosen so that marginal firm in each industry and market makes zero profit.

The following table lists the parameters and the moments that will help identify them. All moments are gotten directly from data except the survival rate that I target to be 90 \%.\textsuperscript{20}

1.4.2. Estimation Results

Results are presented in Table 4, and the model fit is presented in Table 5.

Figure 1 shows that the model captures the negative correlation between export share and

\textsuperscript{19} I solve the domestic equilibrium by 1) finding prices for each industry (fixed point given income and wages). I adjust the exogenous mass of firms $M$ so that $S + U = 1$; 2) Given wages, use market clearing condition to find total revenue; 3) Find $w_s$ by using $\frac{S}{U} = 0.216$. Given equilibrium aggregate variables ($P_{k_1}, R, w_s$ and $w_u$), firms’ choices of each type of labor and total sales in each market are given by the equations in the model. Additionally, given aggregate variables and exogenous foreign variables, the solution of a domestic equilibrium gives average export shares per sector.

I do not have data to separately identify $P^*_{k_1}$, which enters the price index of task $k_1$ as a shifter (equation 1.17). Since the effect on price index is proportional to $\tau$, which I assume to be common across tasks, all prices will change in the same proportion. Only relative prices matter, so I assume that all price indexes are affected by $\tau^{1-\sigma}$.

\textsuperscript{20} For this version of the paper I target a survival rate of 90\%, but I plan to experiment with other values in the future. In particular, I will use data on the probability that the firm does not exit in the first year.
Table 4: Estimated Parameters

<table>
<thead>
<tr>
<th></th>
<th>Transportation equipment</th>
<th>Metal Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAICS 336</td>
<td>NAICS 332</td>
<td></td>
</tr>
<tr>
<td>$\xi$</td>
<td>1.138</td>
<td></td>
</tr>
<tr>
<td>$\beta_l$</td>
<td>0.205</td>
<td>0.0997</td>
</tr>
<tr>
<td>$\beta_h$</td>
<td>0.633</td>
<td>0.701</td>
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<tr>
<td>$a$</td>
<td>8.02</td>
<td>7.99</td>
</tr>
<tr>
<td>$\alpha_2$</td>
<td>0.348</td>
<td>0.367</td>
</tr>
<tr>
<td>$D^*_l$</td>
<td>0.641</td>
<td>0.083</td>
</tr>
<tr>
<td>$D^*_h$</td>
<td>0.356</td>
<td>0.084</td>
</tr>
<tr>
<td>$f^d$</td>
<td>0.128</td>
<td>0.033</td>
</tr>
<tr>
<td>$f^x$</td>
<td>0.293</td>
<td>0.290</td>
</tr>
<tr>
<td>$f^h$</td>
<td>0.433</td>
<td>4.82</td>
</tr>
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</table>

Table 5: Model Fit

<table>
<thead>
<tr>
<th></th>
<th>Transport Equip.</th>
<th>Metal Products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NAICS 336</td>
<td>NAICS 332</td>
</tr>
<tr>
<td>Data Model</td>
<td>Data Model</td>
<td></td>
</tr>
<tr>
<td>Skill intensity non exporters</td>
<td>0.181</td>
<td>0.170</td>
</tr>
<tr>
<td>Skill intensity exporters</td>
<td>0.447</td>
<td>0.320</td>
</tr>
<tr>
<td>$sd sales / average sales$</td>
<td>7.43</td>
<td>7.43</td>
</tr>
<tr>
<td>$avg dom sales non exporters / avg dom sales exporters$</td>
<td>0.040</td>
<td>0.101</td>
</tr>
<tr>
<td>Average export share</td>
<td>0.405</td>
<td>0.408</td>
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<tr>
<td>Correlation skill, export share †</td>
<td>-0.143</td>
<td>-0.143</td>
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<tr>
<td>Successful entry (target)</td>
<td>90%</td>
<td>91.0%</td>
</tr>
<tr>
<td>Export participation</td>
<td>15.4%</td>
<td>15.3%</td>
</tr>
<tr>
<td>Fraction of exporters with high technology</td>
<td>71.5%</td>
<td>70.7%</td>
</tr>
</tbody>
</table>

|                  | Data | Model |
| corr(dom sales, skill intensity) | 0.1917 | 0.316 |

† Coefficient on skill-intensity (measured as the fraction of payments to non-production workers) in an OLS regression with fraction of exports over total sales as dependent variable. The regression includes a constant term.
skill-intensity, although the magnitude is smaller than in data. This is because in the model there are only two tasks, so the model is not so flexible to be able to match this correlation.

Figure 1: Model Results: Export Share and Skill Intensity

Source: Mexican Economic Census, 2004. Use of INEGI’s Microdata Processing Laboratory. Sample limited to non-processing exporters. Firms are sorted by skill intensity and divided in 10 equally-sized bins. Each bar represents the export share in total sales of firms in that quantile of skill intensity.
1.5. The Effect of Trade in Demand for Skill

This section uses the estimated model to run a counterfactual experiment of changing trade costs (τ) while leaving all the other parameters constant. In the benchmark estimation (τ = 1.2), 84% of total labor is employed in the transportation equipment industry.

The effect of trade on skill premium is illustrated in Figure 2. Skill premium increases when trade costs decreases when τ is initially high, but it declines with additional fall in costs after τ is sufficiently low. This result is consistent with the behavior of skill premium in Mexico following liberalization reforms: an increase after the first wave of reforms between 1987-1994, but a decrease following the enactment of NAFTA in 1994 (Chiquiar (2008); Robertson (2004)). In the model, the reason for an initially increasing skill premium is that at high trade costs, the productivity threshold to export is too high, so only those firms at the very top of the productivity distribution may export. Labor is reallocated to these exceptional firms that use a large fraction of skilled labor for both tasks, and they perform both tasks even in the absence of trade. Since these firms grow disproportionately, relative demand for skilled labor increases. However, additional decreases in trade costs will allow some lower productivity firms to export. This increases relative demand for unskilled labor because these firms specialize in the production of the comparative advantage tasks. Thus the negative effects on relative skilled labor demand dominate and skill premium decreases.

Reallocation occurs both between industries and between tasks within industries. The left panel of Figure 3 shows that labor is reallocated towards the export-oriented industry because foreign demand is higher for these goods. Since this industry is more skill-intensive on average, this result mimics the observation that more skill-intensive industries tend to have higher export participation. The right panel shows the changes in relative demand of skilled labor in each industry. The fraction of skilled labor in the export-oriented industry increases. This is consequence of three mechanisms. First, resources within the industry are used in the most productive firms which are also the more skill intensive for any given task. Second, the firms that grow most are the most productive, which coincide with the
firms that perform the skill intensive task. Third, a larger fraction of firms in the industry use the skill intensive technology (Figure 4). Because the mass of skilled labor is fixed in these experiments, the fraction of skilled labor in the domestic-oriented industry decreases.

Figure 4 illustrates the extensive margin of production of the skill-intensive task. At high $\tau$, a decrease in trade cost does not change the equilibrium fraction of firms performing the skill intensive task. As trade cost decreases further, lower productivity firms in the export-oriented industry may become exporters. Having access to an additional market allows a fraction of these firms to pay the fixed cost of producing the skill-intensive task. The opposite is true in the domestic oriented industry, where the production of the skill-intensive task is discouraged as exporters specialize in the comparative advantage task.\(^{21}\)

Finally, average productivity in both industries increases with trade liberalization (Figure 5). The mechanisms driving these are consistent with Melitz (2003) because trade induces creative destruction and forces the least productive firms in an industry to exit. This decreases the mass of domestic varieties.

Although average productivity in the industry increases, Figure 6 shows that productivity of the skill-intensive task decreases in the export-oriented industry. This is driven by the extensive margin of participation in this task, because firms that are relatively unproductive may select into producing it. Productivity gains of the comparative advantage task are larger in both industries.

\(^{21}\) In this exercise the mass of firms that perform high skilled task in metal industry is really low, so this effect may be negligible.
The graph in the left (right) plots the fraction of total skilled (unskilled) labor that is employed in the industry.
Figure 4: Export and High Skill Task Participation

Transportation equipment

Metal products

The graphs show the fraction of active firms that are exporters and produce the high skill tasks in each industry.

Figure 5: Domestic Varieties Mass of active firms producing unskilled-intensive task in an industry

domestic.png
1.6. Conclusion

The model presented allows to study how skill-biased productivity and comparative advantage interact in a relatively skill-scarce country when trade costs decrease. In the model, factor intensities differ between firms, industries, and tasks, which allows to simultaneously account for an increase in weighted average productivity, the growth of skill-intensive industries, and the existence of a negative correlation between export intensity and skill intensity. As trade costs decrease, the reallocation of labor across industries and tasks translates into a non-monotonic effect on skill-premium. When trade costs are high, the reallocation of resources within industries towards more productive firms increases relative demand for skill, but as trade becomes more attractive, the reallocation of resources to unskilled-intensive tasks dominates.

This paper highlights a contrast between emerging economies, that tend to be unskilled labor-abundant, and their industrialized counterparts. While comparative advantage magnifies gains from trade in the advantage sector of industrialized countries, productivity gains are dampened in the skill-intensive tasks of emerging economies. This shows that trade may induce higher growth of skill-intensive broadly defined industries, while at the same time a larger expansion of unskilled-intensive tasks within those industries. The results presented
raise the question of whether trade is weakening incentives for skill accumulation by inducing specialization in the unskilled intensive tasks. This calls for future research on what effects this may have in the long run.
Figure 7: White collar/ Blue collar wage ratio

Source: Own elaboration with data from Monthly Industrial Survey 1987-2004, BIE-INEGI.
Figure 8: Fraction of Exporters by Skill Intensity: 3-digit NAICS Industry Average

Source: Mexican Economic Census 2004. Use of microdata through INEGI’s Microdata Processing Laboratory. Each observation corresponds to the average in a 4 digit industry. Skill intensity is measured as the wage bill to non production workers relative to the total wage bill. “Relative Foreign appeal” refers to the relative higher foreign demand of the good relative to domestic demand.

Figure 9: Export Participation and Export Intensity by Skill Intensity Bins, 2003

Source: Mexican Economic Census 2004. Use of microdata through INEGI’s Microdata Processing Laboratory. Sample limited to non-processing exporters. Firms are sorted by skill intensity and divided in 10 equally-sized bins. Each bar on the left panel corresponds to the fraction of firms in that decile of skill-intensity that export. Each bar on the right panel represents the export share of firms in that quantile of skill intensity. Skill-intensity is measured as the fraction of payments to non-production workers.
Figure 10: Export Intensity by Skill-Intensity Bins, 2004

Fraction of workers with high school

Average education of workers

Source: ENESTyC 2005. Use of microdata through INEGI’s Microdata Processing Laboratory. Sample limited to non-processing exporters. Firms are sorted by the skill intensity measure used in each panel and divided in 10 equally-sized bins. Each bar represents the export share in total sales of firms in that quantile of skill intensity.

Figure 11: Firm Productivity and Size, 2003

Source: Mexican Economic Census 2004. Use of microdata through INEGI’s Microdata Processing Laboratory. Productivity is measured as value added per worker. Size is measured by total sales. Each point in the graph on the left refers to one exporting or non exporting establishment. Each point in graph on the right refers to the average of exporters or non-exporters in one 6-digit industry.
Figure 12: Firm Skill Intensity and Size, 2003
Frac Payments to Non-production Workers Average Total Payments to Labor

Source: Mexican Economic Census 2004. Use of microdata through INEGI’s Microdata Processing Laboratory. Skill Intensity is measured by the fraction of Payments to Non Production Workers. Size is measured by total sales. Each point in the graphs refers to the average of exporters or non-exporters in one 6-digit industry.

Tables

<table>
<thead>
<tr>
<th>Exporter Premia</th>
<th>Exporter Premia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log employment</td>
<td>3.90</td>
</tr>
<tr>
<td></td>
<td>2.76</td>
</tr>
<tr>
<td>Log sales</td>
<td>6.12</td>
</tr>
<tr>
<td></td>
<td>4.20</td>
</tr>
<tr>
<td></td>
<td>0.63</td>
</tr>
<tr>
<td>Log value added per worker</td>
<td>2.03</td>
</tr>
<tr>
<td></td>
<td>1.24</td>
</tr>
<tr>
<td></td>
<td>0.34</td>
</tr>
<tr>
<td>Log average wage</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>0.28</td>
</tr>
<tr>
<td>Log capital intensity</td>
<td>1.82</td>
</tr>
<tr>
<td></td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>Log skill per worker</td>
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<tr>
<td></td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>0.37</td>
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<tr>
<td>Log employment control</td>
<td>X</td>
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<tr>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>6 digit industry FE</td>
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</tr>
<tr>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Source: Mexican Economic Census 2004. Use of microdata through INEGI’s Microdata Processing Laboratory. The table shows the coefficient of OLS regressions of firm characteristics on a dummy indicating firm’s exporting status. Regressions in second column include industry fixed effects and in the third column include industry fixed effects and log firm employment as controls. Capital intensity refers to capital stock per worker and skill intensity is the payment to non production workers over total wage bill. All results are significant at 1 percent level.
Table 7: Productivity, Export Participation and Export Intensity, 2003

<table>
<thead>
<tr>
<th></th>
<th>Value added per worker</th>
<th>Export participation</th>
<th>Export share</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Value added/ worker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Log)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment</td>
<td>0.059***</td>
<td>0.054***</td>
<td>0.378***</td>
</tr>
<tr>
<td>(Log)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.028)</td>
</tr>
<tr>
<td>Skill intensity</td>
<td>0.710***</td>
<td>0.627***</td>
<td>0.275***</td>
</tr>
<tr>
<td>(Log)</td>
<td>(0.016)</td>
<td>(0.016)</td>
<td>(0.071)</td>
</tr>
<tr>
<td>Capital intensity</td>
<td>0.229***</td>
<td>0.229***</td>
<td>0.041***</td>
</tr>
<tr>
<td>(Log)</td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.012)</td>
</tr>
</tbody>
</table>

Observations 131,598 131,598 25,687 25,687 2,948 2,948
Industry Fixed Effects No 3 digit No 3 digit No 3 digit

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: Mexican Economic Census, 2004. Use of microdata through INEGI’s Microdata Processing Laboratory. Sample restricted to non-processing firms. All regressions include an unreported constant term. Columns (1) and (2) show coefficient of an OLS regression of log value added per worker as dependent variable. Columns (3) and (4) show coefficient of a probit regression of a dummy of exporter as dependent variable. Columns (5) and (6) show coefficient of OLS regression of exports over total sales as dependent variable. Skill intensity is measured as the wage bill to non production workers relative to the total wage bill. Capital intensity is measured as capital stock per worker. All regressions include a dummy indicating that the firm received foreign capital and one indicating whether it belongs to a corporation as additional control variables.
Table 8: Export Share and Skill intensity, 2005

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<th>All Controls</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Fraction wkrs high school education</td>
<td>-5.46**</td>
<td>-10.59***</td>
<td>-6.85*</td>
<td>-4.18</td>
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<tr>
<td></td>
<td>(3.14)</td>
<td>(3.46)</td>
<td>(3.51)</td>
<td>(3.50)</td>
</tr>
<tr>
<td>Fraction wkrs professional education</td>
<td>-16.08***</td>
<td>-23.41***</td>
<td>-15.96**</td>
<td>-14.48**</td>
</tr>
<tr>
<td></td>
<td>(5.34)</td>
<td>(6.19)</td>
<td>(6.20)</td>
<td>(6.16)</td>
</tr>
<tr>
<td>Average education of workers</td>
<td>-3.96***</td>
<td>-6.98***</td>
<td>-5.13***</td>
<td>-3.54**</td>
</tr>
<tr>
<td></td>
<td>(1.24)</td>
<td>(1.40)</td>
<td>(1.44)</td>
<td>(1.45)</td>
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<tr>
<td>Log average wages</td>
<td>-3.32***</td>
<td>-7.80***</td>
<td>-6.08***</td>
<td>-5.93***</td>
</tr>
<tr>
<td></td>
<td>(1.16)</td>
<td>(1.60)</td>
<td>(1.62)</td>
<td>(1.62)</td>
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</tbody>
</table>

3-digit industry fixed effects: \( \times \) \( \checkmark \) \( \times \) \( \checkmark \)

4-digit industry fixed effects: \( \times \) \( \checkmark \) \( \times \) \( \checkmark \)

Source: ENESTyC 2005. Use of microdata through INEGI's Microdata Processing Laboratory. \(* * * p<0.01, ** p<0.05, * p<0.1. Each row in the tables show the coefficient of an independent OLS regression with export share as dependent variable and each measure of skill as independent variable. Column 1 does not include any additional control. Columns 2 includes log value added per worker, log employment, log total sales, log capital stock per worker, a dummy indicating that the establishment receives foreign capital, and the fraction of foreign capital as additional controls. Columns 3 and 4 include all controls in column 2 plus 3-digit and 4-digit industry fixed effects respectively. Sample restricted to non-processing firms."
Table 9: Firm Size, 2003

**Panel A: Domestic Firms**

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Log Domestic Sales</th>
<th>Log employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log VA per worker</td>
<td>0.98***</td>
<td>0.11***</td>
</tr>
<tr>
<td></td>
<td>0.88***</td>
<td>0.04***</td>
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<td></td>
<td>0.74***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.21***</td>
<td></td>
</tr>
<tr>
<td>Skill intensity</td>
<td>4.19***</td>
<td>2.72***</td>
</tr>
<tr>
<td></td>
<td>3.03***</td>
<td>2.57***</td>
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<tr>
<td></td>
<td>1.30***</td>
<td>1.09***</td>
</tr>
<tr>
<td>Additional controls</td>
<td>×</td>
<td>×</td>
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**Panel B: Exporters**

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Log Total Sales</th>
<th>Log Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log VA per worker</td>
<td>1.00***</td>
<td>0.30***</td>
</tr>
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<td></td>
<td>1.08***</td>
<td>0.12***</td>
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<td></td>
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<tr>
<td></td>
<td>0.217***</td>
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</tr>
<tr>
<td>Skill intensity</td>
<td>2.06***</td>
<td>0.399***</td>
</tr>
<tr>
<td></td>
<td>0.23</td>
<td>−0.12</td>
</tr>
<tr>
<td></td>
<td>0.08</td>
<td>−0.17</td>
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<tr>
<td>Additional controls</td>
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</table>

**Panel C: Exporters**

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Log Domestic Sales</th>
<th>Log Foreign Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log VA per worker</td>
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<td>1.14***</td>
</tr>
<tr>
<td></td>
<td>1.10***</td>
<td>0.68***</td>
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<td></td>
<td>0.79***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.96***</td>
<td></td>
</tr>
<tr>
<td>Skill intensity</td>
<td>2.48***</td>
<td>1.14***</td>
</tr>
<tr>
<td></td>
<td>0.67***</td>
<td>−0.78***</td>
</tr>
<tr>
<td></td>
<td>0.58***</td>
<td>−0.9***</td>
</tr>
<tr>
<td>Additional controls</td>
<td>×</td>
<td>×</td>
</tr>
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</table>

Standard errors in parentheses. ** ** ** p<0.01, ** p<0.05, * p<0.1. Source: Mexican Economic Census, 2004. Use of microdata through INEGI’s Microdata Processing Laboratory. Sample restricted to non-processing firms. Tables show coefficient in OLS regression. Skill measured as wage bill to non production workers relative to total wage bill. Additional controls: log capital per worker, indicators of foreign capital participation and firm belonging to a corporation, and 4 digit NAICS fixed effects.
APPENDICES

Data Appendix

*Mexican Economic Census*

The Mexican Economic Census is carried out every five years and it provides information for all establishments which operated in Mexico during the year previous to the census. The unit of analysis for the data is an establishment, so all street vendors and economic activities that do not have a fixed location are excluded. Also excluded are home units that perform productive activities. The topics covered include date of initiation of activities, foreign capital participation, total number of days worked, employment, labor compensations, inputs, expenses, income, fixed assets, inventories, transport equipment, characteristics of physical capital, and investment. Industries are classified with the Mexican North America Industry Classification System (NAICS). The manufacturing sample consists on all establishments in urban locations, industrial parks and corridors, but only a sample of establishments in rural communities.

I have access to confidential firm level data corresponding to the years 1993, 1998, 2003, 2008, and 2013. In all results I present, I use information for manufacturing activities for the year 2003, although I obtain the same qualitative results when I do the analysis with data for other years.

*National Survey of Employment, Wages, Technology and Training (ENESTyC)*

ENESTyC is an industrial survey at the manufacturing establishment level carried out in 1992, 1995, 1999, 2001, and 2005. It covers topics of employment, wages, expenditures, income, value of production, fixed assets, characteristics of the establishment, data on organization of the firm, the market, technology and machinery, training, security and hygiene, and more detailed data on the employment.
I have access to data from 1992 and 2005. The caveat from this data is that it is not representative at the 6-digit industry level, but only at the 4-digit. In 1992 the survey covered 8,733 establishments, and in 2005 9,920. The advantage of this survey is that it is the only one that includes detailed data about the education and occupation position of workers.
Free Entry

This section presents the specification of the model with free entry.

There is an unbounded mass of potential entrants in each sector. To produce in a sector, firms must pay a sunk fixed entry cost $f^e_k > 0$. Each entering firm draws a productivity $\varphi$ from a distribution with density $g_k(\varphi)$ and cumulative distribution $G_k(\varphi)$. Selling domestically incurs in fixed costs of $f^d_k > 0$ per period, paid using a separate factor of production whose supply is perfectly elastic. Paying this cost allows the firm to perform task $k_l$ using technology $\beta_{k_l}$. Selling in the foreign market incurs in fixed costs $f^x_k$ per period, paid using the separate factor of production. A firm in industry $k$ may additionally pay fixed cost $f^h_k$ to perform task $k_h$ using technology $\beta_{k_h} > \beta_{k_l}$. Assume for this part that $\varphi^x_k < \varphi^h_k$.

From the analysis in Section 1.3, profit of unskilled-intensive task (if produce) in each market is:

$$\pi^d(\beta_{k_l}, \varphi) = \frac{r^d(\beta_{k_l}, \varphi)}{\sigma} - f^d_k$$

Profit of skill-intensive task (if produce) is:

$$\pi^x(\beta_{k_l}, \varphi) = \frac{r^x(\beta_{k_l}, \varphi)}{\sigma} - f^x_k$$

There is no exogenous exit, so free entry condition is given by:

$$\left[1 - G(\varphi^l_k)\right] \mathbb{E}[\pi^d(\beta_{k_l}, \varphi)|\varphi > \varphi^l_k] + \left[1 - G(\varphi^x_k)\right] \mathbb{E}[\pi^x(\beta_{k_l}, \varphi)|\varphi > \varphi^x_k] + \left[1 - G(\varphi^h_k)\right] \mathbb{E}[\pi^d(\beta_{k_l}, \varphi + \pi^x(\beta_{k_h}, \varphi)|\varphi > \varphi^h_k] = f^e_k$$

Using the conditions that $\pi^d(\beta_{k_l}, \varphi^l_k) = 0$, $\pi^x(\beta_{k_l}, \varphi^x_k) = 0$, and $\pi(\beta_{k_h}, \varphi^h_k) = 0$ the previous equation can be written as
An equilibrium with trade consists on a vector:

$$\{p^d(\beta_{kj}, \varphi), p^x(\beta_{kj}, \varphi), P_{kj}, \varphi^d_{kj}, \varphi^x_{kj}, \varphi^h_{kj}, M_k, w_u, w_s, R}\$$

. Given $$D^*_{kj}, \tau_{kj}$$ and the parameters of the model, the conditions that determine the equilibrium are, for each task $$k_j$$, firms’ pricing rules in each market (equations 1.5 and 1.6), and aggregation of prices (equation 1.17); for each industry $$k$$, free entry (equation A.1), and zero-profit for marginal firm in each market (equations 1.10 and 1.11); for the aggregate economy, labor market clearing (equations 1.15 and 1.16), and consumer’s income aggregation (equation 1.13).

**Productivity gains from trade:** To illustrate the effects of trade on productivity I restrict to the case where $$\varphi^l_{kj} \geq \varphi^x_{kj}$$. Each of the three terms in equation A.1 are decreasing in $$\varphi^l_{kj}, \varphi^x_{kj}, \varphi^h_{kj}$$ respectively. Opening to trade increases $$\varphi^l_{kj}$$ in both industries, because $$\varphi^x_{kj}$$ decreases with trade costs, so the second term in equation (A.1) increases. If $$f_{ek}$$ doesn’t change, then decreases in trade costs should increase $$\varphi^l_{kj}$$ since the first term is decreasing in the productivity threshold. The increase in the productivity cutoff will increase average productivity in the industry. However, because relative demand of the unskilled task in-

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\begin{align*}
\begin{cases}
\text{if } \varphi^h_{kj} < \varphi^x_{kj} & f_k^d \int_{\varphi^l_{kj}}^{\infty} \left[ \frac{c(\beta_{kj}, \varphi)}{c(\beta_{kj}, \varphi^l_{kj})} \right]^{1-\sigma} - 1 \partial G_k(\varphi) + f_k^x \int_{\varphi^l_{kj}}^{\infty} \left[ \frac{c(\beta_{kj}, \varphi)}{c(\beta_{kj}, \varphi^x_{kj})} \right]^{1-\sigma} - 1 \partial G_k(\varphi) \\
\text{if } \varphi^h_{kj} \geq \varphi^x_{kj} & f_k^d \int_{\varphi^l_{kj}}^{\infty} \left[ \frac{c(\beta_{kj}, \varphi)}{c(\beta_{kj}, \varphi^l_{kj})} \right]^{1-\sigma} - 1 \partial G_k(\varphi) + f_k^x \int_{\varphi^l_{kj}}^{\infty} \left[ \frac{c(\beta_{kj}, \varphi)}{c(\beta_{kj}, \varphi^x_{kj})} \right]^{1-\sigma} - 1 \partial G_k(\varphi) \
\end{cases}
\end{align*}
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(A.1)
creases most, the firms that will grow most are those that have a larger fraction of sales of the unskilled-intensive task, so not the most productive in the industry.
BIBLIOGRAPHY


