Firm Heterogeneity and Ricardian Trade: The Impact of Domestic Competition on Export Performance

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Abstract

High productivity promotes exports at both the sector and firm level. This is the primary prediction of models of Ricardian comparative advantage and firm heterogeneity, respectively. We integrate these two models to investigate how sector-level productivity affects firms' export performance. Using data for Chilean and Colombian plants, we find that, conditioning on own-plant productivity, sector-level productivity *reduces* the propensity to export and the volume of exports. This contradicts the canonical model of firm heterogeneity. We rationalize the evidence through a model with sector-specific factors of production. Productive sectors bid up the return to their specific factor making firms less likely to cover the fixed costs of exporting. We find evidence of this mechanism looking at sector-level relative wages and relative productivity.

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1 Introduction

The link between productivity and output is among the most robust of all economic relationships. Extremely productive individuals, firms, and industries thrive in nearly every market structure. With regard to firms, productivity differences can come from a variety of sources. When discussing the origins of these productivity differences, it is natural to ask if a firm's performance is due to its own productivity or due to the productivity of the industry in which it resides.

Two common models of international trade provide strikingly different answers to this question. First, a venerable literature on Ricardian comparative advantage emphasizes differences in productivity at the industry level across countries and examines its implications for the structure of a nation's exports, e.g. Dornbusch, Fischer, and Samuelson (1977) (henceforth DFS). In this model, all firms in an industry possess the same productivity level and all that matters for export performance is comparative advantage across industries. Alternately, a more recent literature examines firms that possess heterogeneous productivity levels within an industry and models how this affects a firm's ability to export relative to other firms in the industry. In this class of models, productivity is an attribute of the firm itself and industry productivity is merely an aggregate construct. Clearly, reality lies someplace between, with a firm's productivity level determined both by the industry and country in which it resides and as well as at the firm-level. This paper constructs a bridge between the two literatures by asking how the productivity of peer firms affects both domestic and external outcomes, such as export probability, exports, sales, and value added, through the lens of the firm heterogeneity literature (e.g. Melitz, 2003). Because we study this question in the context of the canonical firm heterogeneity literature, we do not consider technology "spillovers" nor any technology transfer.[1]

Specifically, we construct a model with three countries in which there are two small open economies that export to a common world market in two different industries. Firms are heterogeneous within each industry as in Melitz (2003). We summarize the question and the identification strategy with a simple thought experiment. Assume that comparative advantage is defined by average productivity across sectors. More precisely, suppose that when comparing productivity across countries and industries, one country possesses a larger advantage in average productivity in one sector relative to another sector. This is the comparative advantage industry and the other is the comparative disadvantage industry. If we consider two firms *with the same level of productivity*, one

[1]e.g. Keller (2002).

residing in each sector, will the firm residing in the comparative advantage industry have superior, equal, or inferior outcomes to the firm residing in the comparative disadvantage sector?

Using plant level data for Chile and Colombia for 1990 and 1991, we find that, conditional on own productivity, plants with relatively more productive domestic peer firms sell less at home and abroad and have a lower propensity to export. This result can come from a variety of reasons including, but not restricted to, product market competition, and factor market competition. We focus on factor market competition as a channel explaining our results. We argue that inclusion of sector-specific inputs is an intuitively appealing way of amending the canonical model to be consistent with the data. As average productivity in the industry rises, the wage of the specific factor associated with that industry increases leading to a higher average wage bill for a firm of a given productivity level in that industry.

In theory, sector-specific inputs can be thought of as factors of production that cannot easily be moved from industry to industry. These can be industry-specific knowledge of workers or physical capital that diminishes in capacity if moved from one industry to another. Ramey and Shapiro (2001) and Neal (1995) explore the specificity of capital and labor, respectively, and find such specificity to be important. In addition, Heckman and Pages (2000) look at labor market regulations in Latin America. They find that labor market regulations in Chile and Colombia make labor quite immobile due to extensive hiring and firing costs based on seniority. While our model does not assume which factor of production is specific and to what degree, we examine the specificity of different types of labor as a channel for our results.

To assess the role of factor market competition, we use a difference-in-difference strategy to examine the relationship between industry wages and average productivity across countries and industries. Our results indicate that industries with higher relative average productivity tend to pay higher relative average wages, and higher relative wages for both skilled and unskilled workers. Looking at the relationship between industry-level productivity and firm-level outcomes along with the relationship between industry-level productivity and wages, we estimate that if the relative average productivity of firms in an industry doubles, relative factor prices will increase by approximately 21.9%. For a firm of a given productivity level, this will lead to the probability of exporting falling by 6.3% and the level of exports falling by 17.7%.

Examining and comparing productivity and export performance in these two countries is appropriate for three reasons. First, because of the myriad of labor market restrictions in both countries discussed in Heckman and Pages (2000), the existence of specific factors is more reasonable than in countries where labor markets are less restricted. Second, because we are working with detailed plant level data, we can verify that definitions of output, employment, and capital stock are reasonably comparable across countries. This will assist in the development of measures of productivity that are comparable across countries. Third, these two countries export in similar industries to similar markets and are likely to face similar competitive conditions in world markets based on their geographic location and level of development.

Given our data, our model of small open economies exporting to the rest of the world is appropriate as trade between Chile and Colombia is negligible. Colombian exports to Chile comprise less than 1% of its total exports and Chilean exports to Colombia comprise less than 3% of its total exports. In contrast, exports to G7 countries, Brazil, and Argentina combined comprise 71.3% of Chilean exports and 63.4% of Colombian exports for 1990-1991.[2]

Figure 1 plots Chilean and Colombian exports at the SITC one-digit level to their ten largest destination markets, normalized by world exports to that destination in that industry.[3] An upward sloping relationship suggests that these two countries compete in similar countries and industries. In addition, while both countries experienced substantial macro-economic turbulence associated with the Latin American debt crisis, much of this turbulence had subsided by 1990.

Section 2 briefly reviews the literature that we draw upon and derives aspects of the canonical model against which we contrast our framework. Section 3 presents the model. Section 4 describes the data and offers empirical evidence. Section 5 concludes.

2 Relation to the Literature

Early research on comparative advantage developed models of comparative advantage based on industry-level differences in productivity. Research initially prospered as empirical work validated many of its primary predictions (MacDougall, 1951,1952, and Stern, 1962) and theoretical developments smoothed some of the model's rough edges (DFS). However, work stalled as the model's basic predictions were viewed as no longer worth testing and theory ran up against intractable generalizations (Wilson, 1980). More recently, the Ricardian model has experienced a renaissance with work exploring how to integrate it with the Heckscher-Ohlin tradition (Harrigan, 1997 and

[2]IMF Direction of Trade Statistics Database (2008).

[3]A similar pattern holds without normalization.

Morrow, 2008) and how to extend it to the case of many countries (Eaton and Kortum, 2002, and Costinot and Komunjer, 2007). However, this literature maintains the representative firm assumption in which all operating firms in an industry possess the same level of productivity or in which there is only a single firm possessing a given level of productivity in an industry. Consequently, it is unable to make any predictions regarding firm variation within an industry.

In contrast, recent work on firm-level heterogeneity has instead emphasized differences in productivity across operating firms within an industry (Bernard, Eaton, Jensen, and Kortum, 2003, Melitz, 2003, and Melitz and Ottaviano, 2008). This literature and its progeny have developed a tractable framework in which firms with higher productivity levels possess higher levels of output and employment and are more likely to undertake costly, but productive, activities than their less productive peers. However, this literature has been unable to extend the model beyond two asymmetric sectors where one of the sectors is homogenous (Demidova, 2008, and Falvey, Greenaway, and Yu, 2004).[4] Consequently, while this literature makes very crisp predictions regarding firm heterogeneity within an industry, it runs into some difficulty in comparing firms across industries.

We now briefly sketch out the elements of the baseline firm heterogeneity model to illustrate its empirical predictions for small open economies exporting to a common market. Suppose that one of multiple small open economies exports to a large "world" market. Assume that any small open economy examined is small enough that it does not affect the world equilibrium. Market structure is Dixit-Stiglitz with an elasticity of substitution across varieties of $\sigma > 1$ where each firm produces a unique variety. ϕ_{fic} represents productivity for firm f in industry i in country c. w_c is a country-specific wage. A firm's revenue from exports to the World can be described using a revenue function where A_i is a demand shifter in the world market that each small open economy takes as given:[5]

$$r(\phi_{fic}) = A_i \left[\frac{\rho \phi_{fic}}{\tau w_c} \right]^{\sigma - 1}.$$

Consequently, we can express relative export revenue from the World market for two firms in different countries but the same industry as follows where we assume that countries c and c' both

[4] An exception is Bernard, Redding, and Schott (2007) in which there are two differentiated sectors but producticity draws come from completely symmetric distributions. Okubo (2007) extends the results of Demidova (2008) to a continuum of sectors.

[5] $A_i = \frac{E_i}{P_i^{1-\sigma}}$ where E_i is world expenditure in industry i and P_i is the CES price index, τ represents iceberg transportation costs, and $\rho = \frac{\sigma-1}{\sigma}$. Similar notation is used by Helpman, Melitz, and Yeaple (2004).

face the same iceberg transportation costs in servicing the world export market:

$$\frac{r(\phi_{fic})}{r(\phi_{f'ic'})} = \left[\frac{\phi_{fic} w_{c'}}{\phi_{f'ic'} w_c}\right]^{\sigma-1}.$$

In this case, industry productivity should have *zero effect* on relative export performance as demand is determined by firm- and country- but not industry-level characteristics. We refer to this as the prediction of the "baseline model" in the small open economy case.

Alternately, Demidova (2008) presents a rich two-country model that predicts that industry productivity should have a *positive* effect on exporting probability conditional on own firm productivity. Hers is a model in which there are only two countries trading with each other. The intuition of her model can be presented via a framework with a productive North and an unproductive South. If the Northern market is filled with relatively productive firms, this will dampen the incentive for Southern firms to enter the export market. This will lead to a lower rate of entry in the South and less competitive conditions for the reasons exposited in Melitz (2003). This will then provide greater incentive for Northern firms to export to the South. Hence firms in the comparative advantage industry will have a lower productivity threshold for exporting than firms in the comparative disadvantage industry. This will result in industry productivity having a *positive* effect on the probability of exporting.

The fact that we do not find this result empirically does not imply that the model of Demidova (2008) is incorrect or misleading. Rather, we believe that it is simply inappropriate in this context of two small open economies exporting to a large common market. Her model would be the correct one to reference in the case of two large countries that trade in large volumes, because the general equilibrium mechanisms in her model are more likely to be present than in the case we examine.

Bernard, Redding, and Schott (2007) present a model in which asymmetries come from differences in factor abundance and the interaction of these differences with the firm heterogeneity model. However, a small open economy version of their model would predict a positive coefficient on industry productivity. This is because average productivity is higher in the sector in which the country possesses a Heckscher-Ohlin comparative advantage. However, as long as fixed costs are in the same factor proportions as variable costs and factor price equalization fails, the comparative advantage sector will have a relatively lower export cutoff. This comes from the fact that the relative factor price of the relatively abundant factor rises with liberalization but is still less than in the country where it is a relatively scarce factor.

We now present our framework. This model is consistent with the empirical evidence presented in Section 4 that industry productivity has a *negative* effect on plant level outcomes both at home and abroad.

3 Model

Consider a small open economy, that we refer to as country c. The preferences of the representative consumer are defined over the consumption of three aggregates of differentiated goods according to a Cobb-Douglas utility function:

$$U = \prod_{i=0}^{2} Q_{ic}^{\alpha}$$

where Q_{ic} is a CES aggregator over set I_{ic} of varieties of good i consumed in country c:

$$Q_{ic} = \left[\int_{\omega \in I_{ic}} q_{ic}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}} \text{ with } \sigma > 1.$$

Demand in c for variety ω in sector i is:

$$q_{ic}(\omega) = \frac{\alpha E_c p_{ic}(\omega)^{-\sigma}}{P_{ic}^{1-\sigma}}$$

where $P_{ic} = \left[\int_{\omega \in I_i} p_{ic}(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}$, $p_{ic}(\omega)$ is the price faced by consumers in c for variety ω of good i and E_c is aggregate expenditure in country c.

Home produces, consumes and exports goods 1 and 2. Good 0 is imported from the rest of the world to balance trade.[6] Varieties in industry i are produced with labor, freely mobile across sectors, and a factor specific to sector i, that we denote by K_{ic} and earns return s_{ic}. We use the terms "sector" and "industry" interchangeably. This specific factor can be physical or human capital or any factor of production that is immobile over the time span considered. The labor endowment of the economy is equal to the population size L_c. Each worker earns a wage w_c.

The setup within each sector i is similar to Melitz (2003): there is continuum of firms, each producing a different variety, and characterized by a productivity level denoted by ϕ. A firm with

[6] This assumption aims at minimizing general equilibrium effects across sectors. Note that good 0 is not a homogenous good introduced to pin down the wage level.

productivity ϕ produces quantity q and faces the following homothetic total cost function:

$$TC_{ic}(q,\phi) = \left(f + \frac{q}{\phi}\right) w_c^{1-\eta} s_{ic}^{\eta}$$

where f is a fixed cost and η is the share of costs spent on the specific factor K_{ic}. The parameter η is restricted to be the same across sectors. We normalize w_c to one. The higher ϕ is, the lower total costs of producing quantity q. As shown by Melitz (2003) a firm with productivity ϕ charges a lower price $p_{ic}(\phi)$, has higher revenues $r_{ic}(\phi)$ and earns higher profits $\pi_{ic}(\phi)$ compared to other firms in the same sector:

$$\begin{aligned} p_{ic}(\phi) &= \frac{s_{ic}^{\eta}}{\rho\phi} \\ r_{ic}(\phi) &= \alpha E_c \left(\frac{s_{ic}^{\eta}}{P_{ic}\rho\phi}\right)^{1-\sigma} \\ \pi_{ic}(\phi) &= \frac{\alpha E_c}{\sigma}\left(\frac{s_{ic}^{\eta}}{P_{ic}\rho\phi}\right)^{1-\sigma} - f s_{ic}^{\eta} \end{aligned}$$

where $\rho = \frac{\sigma-1}{\sigma}$. We depart from Melitz in adopting, for analytical tractability, a specific distribution of the productivity parameter ϕ. The distribution can potentially vary across sectors and countries and will be the main source of asymmetry, apart from population and specific factor size. We follow a large number of papers (e.g. Chaney (2008) and Helpman, Melitz, Yeaple (2004)) in assuming that, within each sector i, the productivity parameter ϕ follows a Pareto distribution with parameters k and $\phi_{m,ic}$. The cumulative density function of parameter ϕ is therefore:

$$G_{ic}(\phi) = 1 - \left(\frac{\phi_{m,ic}}{\phi}\right)^{k}. \tag{1}$$

The parameter $\phi_{m,ic}$, which we allow to vary across sectors, represents the lower bound of the support of the distribution.[7] Therefore in a sector with higher $\phi_{m,ic}$, firms draw from a distribution with a higher average productivity. We refer to distributions of productivity as being "superior" if they possess higher minimum draws. This is the source of Ricardian differences in the model.[8]

We allow for free entry into each sector i. We follow Melitz (2003) in assuming that firms must pay a fixed cost $f_e s_{ic}^{\eta}$ to draw a level of productivity in sector i. Once firms observe their level of

[7] We restrict $k > \sigma - 1$ to ensure that all integrals converge.

[8] A higher $\phi_{m,ic}$ also implies a higher standard deviation of productivity, but the coefficient of variation, a normalized measure of dispersion, does not depend on $\phi_{m,ic}$.

productivity they can produce or, if the productivity parameter is too low, exit without producing. If they decide to produce, then each year they face an exogenous probability of exiting the market δ. We consider the steady-state equilibrium where entry is equal to exit in each sector and aggregate sector-wide variables are constant. Therefore in the steady state a prospective entrant can expect a constant profit each year, conditional on surviving.

Upon drawing a productivity level ϕ, a firm makes two decisions. First, it decides whether to produce or not for the domestic market. We indicate by $\phi_{d,ic}$ the productivity threshold for domestic production. The threshold $\phi_{d,ic}$ is such that profits in the domestic market of a firm with that level productivity, $\pi_{d,ic}(\phi_{d,ic})$ are zero. Firms with productivity below $\phi_{d,ic}$ exit immediately. Firms with productivity above $\phi_{d,ic}$ continue to operate. Second, the firm decides whether to export or not. Firms that export have to bear an additional fixed cost $f_x s_{ic}^{\eta}$ and a per-unit transport cost of the iceberg type. For each unit sold abroad, a firm must ship τ units, with $\tau > 1$. We indicate by $\phi_{x,ic}$ the threshold for exporting. The threshold $\phi_{x,ic}$ is such that profits in the foreign market for a firm with that level of productivity, $\pi_{x,ic}(\phi_{x,ic})$, are zero. Firms with productivity below $\phi_{x,ic}$ do not export. Since marginal costs are constant in the quantity produced, the two decisions are independent.

Since the focus of the empirical section is on a small open economy, we depart from Melitz (2003) in that we simplify the interaction of the country with the rest of the world. In this paper, we consider a partial equilibrium setting, where the world represents an export market for firms in the country, but the country is too small to affect aggregate variables in the world market. In Melitz (2003) the analysis considers many symmetric countries, with each country exporting to and importing from every other country. Demidova (2008) and Falvey, Greenaway and Yu (2006) consider a world consisting of two countries trading with one another. Their setup is appropriate to analyze the interaction among large countries. We also disregard imports into the country since we are not interested in differences across sectors coming from differential import penetration. The focus of the paper is on understanding exporting behavior of firms in a small open economy characterized by productivity differences across sectors and we aim to simplify the other elements of the model as much as possible. In particular we assume that the world market expenditure level and price index in a given sector i are summarized by a constant A_i. Therefore revenues in the world market for an exporting firm of productivity ϕ in sector i are:

$$r_{x,ic}(\phi) = A_i \left(\frac{\tau s_{ic}^{\eta}}{\rho \phi} \right)^{1-\sigma}. \tag{2}$$

Market conditions in the world market, A_i, are not affected by firms' export decisions in a small country c, because we assume the country is small.

The free entry condition for sector i is summarized by the following equation, which states that, conditional on producing (drawing a productivity parameter higher than $\phi_{d,ic}$), the discounted expected stream of profits is equal to the entry cost:

$$[1 - G(\phi_{d,ic})] \frac{\overline{\pi}_{ic}}{\delta} = f_e s_{ic}^{\eta}, \tag{3}$$

where $\frac{\overline{\pi}_{ic}}{\delta}$ is the discounted constant expected profit. The expected profit is comprised of sales in the domestic market, where expected profits are $\overline{\pi}_{d,ic}$, and sales in the foreign market, where expected profits are $\overline{\pi}_{x,ic}$, weighted by the probability of exporting:

$$\overline{\pi}_{ic} = \overline{\pi}_{d,ic} + \frac{1 - G(\phi_{ix})}{1 - G(\phi_{id})} \overline{\pi}_{x,ic}. \tag{4}$$

As shown in Melitz (2003) expected profits in each market coincide with the profits of a firm characterized by an average productivity level, where the average for firms producing in the domestic market, $\overline{\phi}_{d,ic}$, is defined as follows:

$$\overline{\phi}_{d,ic}^{\sigma-1} = \frac{1}{1 - G(\phi_{d,ic})} \int_{\phi_{d,ic}}^{\infty} \phi^{\sigma-1} g(\phi)\, d\phi$$

and the average productivity of exporting firms, $\overline{\phi}_{x,ic}$, is defined as:

$$\overline{\phi}_{x,ic}^{\sigma-1} = \frac{1}{1 - G(\phi_{x,ic})} \int_{\phi_{x,ic}}^{\infty} \phi^{\sigma-1} g(\phi)\, d\phi.$$

It is easy to verify that, analogously to Melitz (2003), the conditions determining the domestic and foreign cutoffs, $\pi_{d,ic}(\phi_{d,ic}) = 0$ and $\pi_{x,ic}(\phi_{x,ic}) = 0$, yield the following relationships between the cutoffs and the average profits in the domestic and foreign markets:

$$\overline{\pi}_{d,ic} = s_{ic}^{\eta} f \left[\left(\frac{\overline{\phi}_{d,ic}}{\phi_{d,ic}} \right)^{\sigma-1} - 1 \right] \tag{5}$$

$$\overline{\pi}_{x,ic} = s_{ic}^{\eta} f_x \left[\left(\frac{\overline{\phi}_{x,ic}}{\phi_{x,ic}} \right)^{\sigma-1} - 1 \right]. \tag{6}$$

In Melitz (2003) $\phi_{x,ic}$ is a simple function of the domestic cutoff $\phi_{d,ic}$, which depends only on exogenous parameters.[9] Therefore the three equations (3), (5) and (6) uniquely determine the equilibrium cutoffs and the mass of firms is determined residually in a two-step procedure.[10] In our case, because of the lack of symmetry between the domestic market and the world market, the cutoffs are determined simultaneously with the mass of firms. This is because both the mass of firms and the cutoffs are partially determined by the return to the specific factor.

To solve for the equilibrium we also employ a sector-specific factor market clearing condition. In the steady state the free-entry condition guarantees that there are no pure profits (positive profits of operating firms are equal to the total cost of entry into the market), so that firms' revenues are split between the mobile factor and the specific factor, with a share η earned by the specific factor. Aggregating up to the entire sector i, the following equation states that a share η of total revenues in sector i are paid to K_{ic}:

$$\eta M_{ic} \overline{r}_{ic} = s_{ic} K_{ic} \tag{7}$$

where $\overline{r}_{ic}$ are the expected revenues of a firm operating in sector i.

Consider now a second small open economy c' exporting to a large world market. We assume that the two countries do not export (or export a negligible amount) to each other and that they only export to a common third market, facing the same transport costs. We allow the two countries to differ in size, both in terms of population and specific factor endowments, and most importantly, we assume that the countries productivity distributions are such that country c' has a comparative advantage in sector 1 while country c has a comparative advantage in sector 2. Specifically we make the following assumption:

[9] See equation (19) on page 1711 of Melitz (2003). This condition holds only under symmetry, otherwise total expenditure and price indices are not the same across countries and the relationship between exporting and domestic cutoff depends on endogenous variables.

[10] The mass of firms is determined employing the condition that, in the absence of profits, total revenues are equal to total labor income.

Assumption 1 The distribution of productivity in sectors 1 and 2 in countries c and c' is such that $\frac{\phi_{m,1c}}{\phi_{m,2c}} < \frac{\phi_{m,1c'}}{\phi_{m,2c'}}$.

The question we address is whether, given individual productivity, firms in sector 1 in country c are more or less likely to export than firms in sector 2 in the Home country, relative to firms in the Foreign country. In this model this question is equivalent to investigating whether $\frac{\phi_{x,1c}}{\phi_{x,2c}} \gtrless \frac{\phi_{x,1c'}}{\phi_{x,2c'}}$. Since the revenues of the least productive exporting firm in c can be expressed as[11] $r_{x,ic}\left(\phi_{x,ic}\right) = \sigma f_x s_{ic}^{\eta}$ and a similar expression holds for country c', then the ratio between the revenues of two marginal exporting firms in c and c' is given by $\frac{s_{ic}^{\eta}}{s_{ic'}^{\eta} w_{c'}^{1-\eta}}$. Using the expression for export revenues in (2), the relationship between the export cutoffs in the two countries in sector i is given by the following equation:

$$\frac{\phi_{x,ic'}}{\phi_{x,ic}} = \left[\left(\frac{s_{ic'}}{s_{ic}}\right)^{\eta} \left(w_{c'}\right)^{1-\eta}\right]^{\frac{\sigma}{\sigma-1}} \tag{8}$$

Notice that, everything else equal, the larger the return to the specific factor in sector i, the higher the exporting cutoff. Because we are interested in the effect of being in the comparative advantage sector on relative export performance across industries and countries, we take the ratio of (8) across the two sectors 1 and 2 and rearrange to find the following relationship between relative export cutoffs and relative specific factor returns across:

$$\frac{\phi_{x,2c}/\phi_{x,2c'}}{\phi_{x,1c}/\phi_{x,1c'}} = \left(\frac{s_{2c}/s_{2c'}}{s_{1c}/s_{1c'}}\right)^{\frac{\eta\sigma}{\sigma-1}} \tag{9}$$

Equation (9) illustrates how export cutoffs are related across countries and sectors in the same fashion as the returns to the specific factors in those countries and sectors. The higher is the relative return to the specific factor in sector i the higher is the relative export cutoff in sector i, the lower the probability of exporting for a firm of a *given* productivity in sector i. Therefore, if comparative advantage uniquely determines the relative ranking of returns to the specific factor across countries then we have a link between aggregate sector productivity and export performance by individual firms. We establish this in the following proposition, where we make use of a restriction on sector size that we impose for the remainder of the paper.

Assumption 2 Within each country c each sector i is endowed with the same amount of specific factor: $K_{ic} = K_c \ \forall i, c$.

[11] This relationship derives from the fact that $\pi_{x,ic}\left(\phi_{x,ic}\right) = \frac{r_{x,ic}\left(\phi_{x,ic}\right)}{\sigma} - f_x s_{ic}^{\eta}$.

Proposition 1 *If firms in c draw their productivity parameter from a relatively superior distribution in sector 2 than in sector 1, compared to c', i.e.*

$$\frac{\phi_{m,1c}}{\phi_{m,1c'}} < \frac{\phi_{m,2c}}{\phi_{m,2c'}}$$

then the relative return to the specific factor in c is higher in sector 2 than in sector 1, compared to c', i.e.

$$\frac{s_{1c}}{s_{1c'}} < \frac{s_{2c}}{s_{2c'}}$$

and, given its productivity level ϕ, a firm in c is more likely to export in sector 1 than in sector 2, compared to c', i.e.

$$\frac{\phi_{x,1c}}{\phi_{x,1c'}} < \frac{\phi_{x,2c}}{\phi_{x,2c'}}$$

Proof. In Appendix. ■

The intuition for the result is simple. As firms in a sector draw from a productivity distribution with a higher average, firms in the sector are on average more productive, produce more and have a high demand for the specific factor, which is available in fixed amount. Tougher competition for this input's services drives up the return to the specific factor. Everything else equal, a firm in a relatively more productive sector faces higher costs and therefore is less likely to be able to cover the fixed cost of exporting, and reducing its probability of exporting.

The same mechanism explains why firms in comparative advantage sectors export less, for a given level of productivity. The following proposition establishes the result that, conditional on exporting, export revenues are relatively higher for Home firms in sector 1 than in sector 2, compared to Foreign, conditional on own firm productivity.

Proposition 2 *If firms in c draw their productivity parameter from a relatively better distribution in sector 2 than in sector 1, compared to c', i.e.*

$$\frac{\phi_{m,1c}}{\phi_{m,1c'}} < \frac{\phi_{m,2c}}{\phi_{m,2c'}}$$

then, given its productivity level ϕ, a firm in c has higher export revenues in sector 1 than in sector 2, compared to c', i.e.

$$\frac{r_{x,1c}(\phi)}{r_{x,1c'}(\phi)} > \frac{r_{x,2c}(\phi)}{r_{x,2c'}(\phi)}$$

Proof. We employ the definition of export revenues in (2) to find the following relative export performance measure across sectors and countries:

$$\frac{r_{x,1c}(\phi)}{r_{x,1c'}(\phi)} > \frac{r_{x,2c}(\phi)}{r_{x,2c'}(\phi)} = \left(\frac{s_{1c}}{s_{1c'}} / \frac{s_{2c}}{s_{2c'}}\right)^{\eta(1-\sigma)}.$$

Since we showed in proposition (1) that $\frac{s_{1c}}{s_{1c'}} / \frac{s_{2c}}{s_{2c'}}$ and we assumed that $\sigma > 1$, then the result follows. ■

Proposition 2 can be used to motivate a reduced form expression for export revenues. Note that (log) plant level (export) revenue in foreign markets can be written as follows:

$$\ln r(\phi_{fic}) = \ln A_i + (\sigma - 1)\ln\phi_{fic} + (1-\sigma)\left[\eta \ln s_{ic} + (1-\eta)\ln w_c\right] + \nu_{fic}, \tag{10}$$

where s_{ic} is the wage of the specific factor, w_c is the wage of the mobile factor, ν_{fic} represents a random disturbance, A_i is an industry-specific demand shifting term that plants in both countries take as given in a given industry and is controlled for by industry fixed effects.[12] Assume that Ψ represents the elasticity of the return to the specific factor to industry productivity. Therefore the elasticity of average wages with respect to industry productivity is equal to $\eta\Psi > 0$. We can then rewrite equation (10) as:

$$\ln r(\phi_{fic}) = \ln A_i + (\sigma - 1)\ln\phi_{fic} + (1-\sigma)\eta\Psi\ln\phi_{ic} + (1-\sigma)(1-\eta)\ln w_c + \nu_{fic}. \tag{11}$$

With these theoretical results in hand, we now gauge their validity using plant level data that we now describe.

4 Empirical Results

This section explores the empirical predictions of Section 3 that, controlling for own productivity, a plant in a comparative advantage industry produces and exports less. Section 4.1 describes the data employed and our measures of productivity. Section 4.2 describes the baseline results that are inconsistent with the baseline model of firm heterogeneity. Section 4.4 explores the factor market competition channel between industry productivity and plant-level outcomes: A 100% increase in peer firm productivity increases average industry wages by 21.9%. For a firm of a given productivity

[12] We also assume that this term contains industry specific mark-ups and iceberg transportation costs.

level, this leads to the probability of exporting falling by 6.3% and the level of exports falling by 17.7%.[13] In section 4.4 we also briefly discuss the role that product market competition might play in generating the results.

4.1 Data

Plant-level data come from the statistical agencies *Instituto Nacional de Estadistica* and *Departmento Administrartivo Nacional de Estadistica* for Chile and Colombia, respectively. These data have been used extensively in the trade literature.[14] Industry affiliation is at the ISIC (Rev. 2) 3-digit level. Because plant-level exports are only available for Chile *starting* in 1990 and the Colombian export data is available *until* 1991, we only use 1990 and 1991 in our analysis. All of our results are cross-sectional. Table 1 presents summary statistics for the data including the total number of observations in each year and the country composition of each industry. [15] Due to the respective sizes of the countries, approximately 70% of the observations are for Colombian plants and the remainder are Chilean.

The focus of this study is on plant and industry productivity. Because of difficulties in comparing intermediates and capital stocks across countries, we employ value added per worker as a measure of productivity.[16] Production and non-production workers are weighted by their shares in the total wage bill by country and industry. We examine value added measures of total factor productivity in the robustness section to take into account differences in capital intensities across plants and industries. In order to compare productivity differences across countries, we ensure that the data are comparable.[17] As a starting point, we must ensure that output and inputs are measured in the same units.

We also want to remove non-productivity related relative price differences in output and investment. We use 3-digit output deflators from the central bank of each country to put all output data in 1980 constant country-specific pesos for each country. We then use the average December

[13] These estimates use the average parameter values for the year 1990 and 1991.

[14] E.g. Tybout and Roberts (1996), Levinsohn (1993), Hsieh and Parker (2007), Levinsohn and Petrin (2003, 2008), Hallak and Sivadasan (2009).

[15] We drop industries related to tobacco and petroleum refining. (ISIC 314, 353, and 354).

[16] Value added is defined as the value of output minus the value of intermediates such as materials and contract work.

[17] In addition to the measures mentioned here, we have ensured that the plant level measures of output, value added, employment, and investment aggregate to virtually the same numbers as the UNIDO 3-digit data set which has been used widely to conduct cross country studies e.g. Antweiller and Trefler (2002), Hanson and Xiang (2004), and Morrow (2008).

exchange rate for 1980 in each country to transform output in each sector into non-PPP adjusted 1980 U.S. dollars. Finally, we use constructed disaggregated 1980 PPP price indexes from the Penn World Tables to transform these values into PPP adjusted 1980 U.S. dollars. We construct these PPP price indexes are at the 3-digit ISIC level. Because of our difference-in-difference strategy, all (multiplicative) country-specific and industry-specific terms in productivity (and all outcome variables) will be differenced out. See the Data Appendix for more details.

For each country, skilled and unskilled workers are proxied by similarly defined non-production and production workers. We use the procedure outlined in Bils and Klenow (2000) and Caselli (2005) to calculate effective labor input at the country level. While this will not matter for measures of value added per worker, it will affect our calculations of value added TFP in the robustness section. We estimate one physical Chilean worker to be 2.04 effective workers and one Colombian worker to be approximately 1.65 effective workers.[18] When calculating the value added measure of productivity, capital stock is calculated using the perpetual inventory method. We deflate investment using country specific investment deflators, nominal exchange rates, and the Penn World Tables country-specific PPP investment deflator in a manner similar to how we deflate output.

Because plant-level value added per worker measures contain some measurement error, we instrument for plant level value added per worker using its one year lagged value for the same plant. Industry value added per worker is measured as the weighted arithmetic average of plant level value added per worker within that ISIC 3-digit industry-country-year panel where the weights correspond to value added.[19] Because collinearity between plant and industry productivity might be a concern in industries dominated by a few large firms, we drop industries with less than 25 plants in either country.[20] An analysis of variance reveals that 16% of the overall variation in value added per worker across plants and industries is explained by differences across industries. For value added measure of TFP this share is 45%.[21]

[18]See Caselli (2005) for details. We augment skilled and unskilled labor equivalently.

[19]Results are unchanged when we take a geometric instead of an arithmetic mean.

[20]This leads to us droping ISICs 361,362, 371, and 372. Eslava et al. (2009) make an identical restriction on industry size.

[21]This suggests that there are greater differences in capital intensity across firms within an industry than across industries.

4.2 Results

We now present the empirical results that test our model and discuss how they contrast with the baseline model. In the following specifications observations are indexed by plant (f), industry (i), country (c). Equation (12) estimates production (y_{fic}) or value added (va_{fic}) as a function of plant and industry productivity:

$$q_{fic} = \beta_{plant}\phi_{fic} + \beta_{ind}\phi_{ic} + \beta_{chile}chile_c + \beta'_{ind}INDi + \epsilon_{fic} \quad q_{fic} \in \{y_{fic}, va_{fic}\}, \tag{12}$$

where ϕ_{fic} and ϕ_{ic} are plant and industry level productivity, $chile_c$ is a binary variable taking a value of 1 for Chilean plants and 0 for Colombian plants, and IND_i is a vector of industry-specific fixed effects that control for factors including but not restricted to world demand and scale at the industry level.

Equation (13) estimates a similar relationship for the probability of exporting:

$$Pr\left(EXP_{fic} > 0\right) = F\left(\beta_{plant}\phi_{fic} + \beta_{ind}\phi_{ic} + \beta_{chile}chile_c + \beta'_{ind}INDi\right) + \nu_{fic}, \tag{13}$$

where $F(\bullet)$ is the logit operator for export participation. We also estimate linear probability of exporting models for ease of interpretation.

Under the baseline model of firm heterogeneity with small open economies, the coefficient on industry productivity for exporting probability and exports should be zero as wages will be country- and not country-industry specific and all CES price indexes on world markets will be controlled for by industry-specific fixed effects. Table 2 presents results for equation (12). Table 3 results from equation (13) combined with results for a linear probability model.[22]

As expected from numerous firm/plant level studies, plant productivity is a very strong determinant of the value of production and value added at the plant level. However, conditional on plant productivity, industry productivity is estimated to have a *negative* effect on plant production where this estimate is significantly different from zero at least at the 10% level of confidence. Similar results hold for the probability of exporting.

The results for domestic performance would be expected in any closed economy model in which more productive peer firms shift in a given firm's residual demand curve. However, because small

[22] For all regressions, we have experimented with weighted least squares estimation with weights corresponding to firm and/or industry size. The point estimates and standard errors change negligibly.

open economies are likely to have little, if any, effect on the World residual demand curve, the results pertaining to exporting are less obvious.

For most specifications we can reject the null that the coefficients for ϕ_{fic} and ϕ_{ic} are equal and opposite in sign (with the exceptions of columns (4) and (8) in Table 3). If we abandon the restriction on the number of plants per industry we can reject that null at the 5% confidence level for all specifications. This indicates that if all plants in a country-industry panel share the same relative productivity level the country will have higher sales in a given industry. Consequently, familiar results based on a Ricardian model of comparative advantage continue to hold in the point estimates. A caveat is that this particular aspect of the results is less robust at the 4-digit level which we discuss below.

Figures 2, 3, and 4 present this information graphically. In each graph, we purge the left-hand side variable from Tables 2 and 3 of plant productivity and the fixed effects listed. We then purge industry-level productivity of the same variables. Finally, we collapse the left hand side variables down to their industry-year-country means and transform them into Chilean relative to Colombian values. Finally, we plot them against Chilean relative to Colombian industry productivity. Data in the figures are pooled for the years 1990 and 1991.[23]

Tables 4 and 5 decompose the value of production into domestic sales and exports where domestic sales are defined as the value of production minus exports. This allows us to see if and how superior distributions of productivity affect domestic and external performance differentially. The qualitative results from Tables 2 and 3 continue to hold for both domestic and foreign sales.[24] Own plant productivity increases sales while the productivity of other plants in the industry diminishes sales both at home and abroad. Again, this is a shortcoming of the baseline model in which industry productivity should not have any effect on export performance. For domestic sales we can reject at conventional confidence levels the null hypothesis that the coefficients on own plant productivity and industry productivity are of equal magnitude and opposite sign. For exports we reject the same null at the 3% level for 1990, and 15% for 1991. These results should be interpreted in light of the fact that a minority of firms export leading the sample size to fall by 83% for the export revenue equations.

As illustrated in the theory section, the results for export performance are inconsistent with the

[23]As a note, the outlier ISIC 312 contains miscellaneous food products which is less likely to be comparable across countries due to its "bag" nature..

[24]There are slightly fewer observations for domestic revenue than total revenue because of a small number of firms that export but do not sell domestically.

small open economy version of the firm heterogeneity model presented as well as the asymmetric two country version of firm heterogeneity model of Demidova (2008). It is consistent with our specific factors version of the firm heterogeneity model.

4.3 Robustness

This section explores the robustness of our results in three directions. First, we analyze the results at the 4-digit level. Second, we examine the possibility that industry productivity is merely picking up higher order effects in plant productivity. Third, we employ value added measures of total factor productivity instead of value added per worker.

Tables 6a and 6b present results at the 4-digit level of aggregation. A priori we believe that these results should be taken with caution because we lose 66 of 80 possible 4-digit ISIC industries by only examining industries in which both countries produce (or export in the case of export related variables) and which have at least 25 plants. Therefore the 3-digit analysis is our preferred specification.[25] Consequently, these results suggest that the general patterns hold at a finer level of disaggregation, even though the point estimates are less precise. While the general pattern of the coefficients does not change, the relative magnitudes of plant and industry productivity narrow (or reverse for export values) so that the null hypothesis that the coefficient on industry productivity measure is equal in absolute magnitude to the coefficient on plant level productivity cannot be rejected.

Table 7 presents results based on value added TFP instead of value added per worker. For brevity we present results pooled across years 1990 and 1991. The advantage of using value added TFP is that we purge differences in capital intensity across firms and industries from value added per worker. The cost is that comparing capital inputs across countries can be problematic due to measurement error (e.g. difficulties in reporting the value of capital stock). To estimate value added total factor productivity we use the estimation procedure outlined in Levinsohn and Petrin (2003) (LP).[26] Productivity estimation occurs at the 3-digit ISIC level with regressions run within and not across countries. Since there are 20 3-digit ISIC sectors and two countries, we estimate productivity separately for 40 different panels. This allows us to estimate output elasticities that are country-industry specific. Point estimates for the input elasticities are obtained from estimating these

[25] This is consistent with the preference of 3-digit specifications of Levinsohn (1993) and Fernandez (2007)

[26] Because of identification issues with the Levinsohn-Petrin procedure (e.g. Ackerberg, Caves, and Frazer, 2009. The presence of pervasive missing observations for investment precludes using the Olley-Pakes (1996) method.) we have also estimated TFP using OLS estimation. The results are virtually identical.

regressions over 1982-1996 for Chile and 1982-1991 for Colombia. We assume that the production function is as given in equation (14) where lower case letters are natural logarithms; value added (va) is a function of capital stock (k), non-production workers (npw) and production workers (pw):

$$va_{ft} = \beta_0 + \beta_{npw} npw_{ft} + \beta_{pw} pw_{ft} + \beta_k k_{ft} + \epsilon_{ft}. \quad (14)$$

We use materials as the omitted proxy variable. Because the regression is run at the industry-country level, industry and country subscripts (i and c) in equation (14) are suppressed. The results are even stronger than the results for value added per worker.

Table 8 presents specification including a quadratic term for own plant productivity to control for non-linear effects that industry productivity may be proxying for. The results show a convexity in the relationship between own plant productivity and plant-level production, value added, and exports. There is a slight concavity in the propensity to export. However the coefficient on industry productivity changes little when higher order terms for plant value added per worker are added.

4.4 Transmission and Magnitudes

The results above suggest that plants of a given productivity level attain superior economic outcomes both at home and abroad when they reside in less economically competitive industries. While both factor and product market competition are likely contributors to this result, we focus on factor market competition in this paper. This section examines the empirical link between industry productivity and industry wages to examine whether the factor market competition channel can explain the entirety of the results in section 4.2. As specified in the theory section, if factors are sector-specific, a superior distribution of productivity in an industry bids up the wages of the specific factor. Conditional on a given level of plant productivity, this leads to a lower probability of exporting and a lower level of exports conditional on exporting. This subsection presents regression and scatterplot evidence consistent with the idea of factor market competition drives a portion of the results in Tables 2 and 3.

To identify this mechanism, we estimate the regressions in equation (15) which use the same notation as equation (12).[27] These estimate plant level average wages, average wages for skilled

[27] Note testing whether the coefficient on industry TFP is positive in these regressions is equivalent to regressing the left hand side variables on plant and industry productivity and testing the linear restriction that the sum of the coefficients on ϕ_{fic} and ϕ_{ic} is positive.

workers, and average wages for unskilled workers as a function of where the firm lies in the distribution of the industry and as a function of the average productivity in the industry itself.

$$w_{k,fci} = \beta_{deviation} dev_{fic} + \beta_{ind}\phi_{ci} + \beta_{chile} chile_c + \beta'_{IND} INDi + \nu_{fci} \quad k \in \{avg, skill, unskill\} \quad (15)$$

where $dev_{fic} = \phi_{fci} - \phi_{ci}$. We show that plant level wages are increasing in industry level productivity conditioning on where the plant lies in the distribution of that industry.[28] While there is a large literature showing that more productive plants pay higher wages, we are agnostic as to why more productive *plants* pay higher wages and are more interested in whether plants in more productive *industries* pay higher wages conditional on their own characteristics relative to industry averages.[29] Table 9 presents regression results at the 3-digit level.

The results suggest that both plant and industry productivity have a positive effect on wages with the elasticity for own plant productivity (relative to industry average) much larger than that of industry productivity. Averaging the coefficients in columns (1) and (4) of Table 9, we find that a doubling of industry productivity increases average wages at the plant level by 21.9%. The regression results suggest that the marginal effect of industry productivity is stronger for skilled labor than for unskilled labor. We find this result to be reassuring based on work on Latin American and United States labor markets by Heckman and Pages (2000) and Diebold, Neumark, and Polsky (1997).

In examining Latin American labor market frictions, Heckman and Pages (2000) argue that costs of labor adjustment are based partially on tenure with labor markets being subject to a myriad of restrictions in general. They find that while Colombian labor market restrictions underwent major liberalization in 1990, labor market restrictions post-liberalization were still much higher than the industrialized country average. They also find that similar results hold for Chile. Studying labor market tenure in the United States, Diebold, Neumark, and Polsky (1997) find that skilled workers tend to have longer tenure spells than unskilled workers. If we assume that these results hold across borders, it is a reasonable assumption that skilled labor is more of a fixed factor then unskilled

[28]For original work on the link between exporting and wages see Bernard and Jensen (1995). See Brown and Medoff (1989) for a complementary study on the link between size and wages. Different models posit different reasons for the relationship between exporting and wages (e.g. Verhoogen (2008) and Amiti and Davis (2008)).

[29]Note that because we estimate the input elasticities separately across countries and industries with production and non-production workers, we can partially control for differing but time invariant skill composition within a country-industry panel as these should show up as differences in the input elasticities.

labor. Consequently, the results above are consistent with those findings. Figure 5 presents the same information via scatterplot. Based on regression results and scatterplot, there is preliminary evidence that industry productivity bids up the industry wage that plants face. We now perform a back of the envelope calculation to assess the strength of this mechanism.

4.4.1 Quantifying own and peer-firm productivity effects

The negative effect of industry productivity on plant level outcomes conditional on plant productivity is at least partially due to some combination of factor and product market competition. We can use the results from Tables 5 and 9a to provide bounds on how much of the negative coefficient on industry productivity can be due to the factor market competition. Considering equation (11) and dividing the coefficient on industry productivity by the (negative) coefficient on plant productivity yields an estimate of $\eta\Psi$. This is what the elasticity of average wages with respect to industry wages would need to be for the factor market competition channel to explain the entire magnitude of the coefficient on industry productivity. Based on our estimates in Table 5 the average value of $\sigma - 1$ is 0.826, which implies $\eta\Psi = 0.389$.[30] Because our estimates imply an elasticity of average wages to industry productivity of approximately 0.219, factor market competition is 56% of the magnitude it would need to be to be consistent with factor market competition explaining the entirety of our results.

Given our assessment of the importance of factor market competition, we now ask how own and peer-firm productivity affects external (international) outcomes through *this specific channel*. Specifically we ask three questions:

1. If a plant moves from the 25th percentile of the *within* industry productivity distribution to the 75th percentile. How will its export performance change?

2. If we move a plant of a *given productivity level* from an industry in the 25th percentile of the industry-by-industry distribution of productivity to an industry in the 75th percentile, how will this affect its export performance?

3. If a firm is a representative firm in an industry in the 75th percentile of industry-level productivity differences, how will its performance differ from a representative firm in the 25th

[30] This is calculated by dividing the average coefficient on industry TFP by the average coefficient on plant TFP in the export revenue equation.

percentile? e.g. what is the net effect on export performance of a firm being a representative firm in a (Ricardian) comparative advantage industry compared to a (Ricardian) comparative disadvantage industry?

Table 10 presents summary statistics regarding the distribution of firm and industry productivity. Column 1 reports the difference in productivity between Chile and Columbia within an industry. For example in ISIC 311 Columbia is 60% more productive than Chile. Column 2 presents that difference relative the median difference, removing absolute advantage. This column also shows that the industry at the 75th percentile is 118.5% relatively more productive than the industry at the 25th percentile.[31] For Column 3 we rank all plants within an industry according to productivity regardless of the country in which they reside. We then compute the difference in productivity between the plant at the 75th percentile and the plant at the 25th percentile. For example, in ISIC industry 311 a firm moving from the 25th percentile to the 75th percentile becomes 129.5% more productive.

Given that the average point estimate on own plant productivity is 0.826 and the median change in productivity moving through distribution of a given industry is 0.782, the answer to question 1 is that a within-sector improvement in productivity leads to exports increasing by approximately 64.6%. Answering question 2, a firm moving from a comparative advantage industry to a comparative disadvantage industry will see its sales fall by 21.4% due to factor market competition.[32] Answering question 3, if a firm moves from a comparative disadvantage industry to a comparative advantage industry as a mean firm in each industry, its productivity will increase by 118.5%. The direct effect of own firm productivity will be to increase export revenue by 97.9%. However the indirect of factor market competition will be to diminish export revenues by 21.4%. This means that the net effect of such a movement on export sales will be an increase of 76.5%.

Theory maps into export probability equation less clearly when examining the propensity to export. However, we feel that it is illustrative to perform a similar exercise as with export levels using the linear probability models. We assume that a similar proportion (56%) of the coefficient on industry productivity for the linear probability of exporting is explained by factor market competition as in the regressions explaining export levels.

The average of estimates from Table 3, Column 6 and 8 imply that if a plant moves from

[31] This is calculated as 0.631-(-0.554).

[32] This figure is derived as $\underset{1-\sigma}{-0.826} \times \underset{25-75 \text{ prod gain}}{1.185} \times \underset{\eta\Psi}{0.219}$

the 25th to the 75th percentiles of the within industry distribution, it will be 13.8% more likely to export. If a plant moves from a relatively unproductive industry in the 25th percentile to a relatively productive industry in the 75th percentile (holding its own productivity constant), it will be approximately 7.4% less likely to export. Finally if a firm moves from being a representative plant in a comparative disadvantage industry to a representative firm in a comparative advantage industry, the direct effect of own firm productivity will be to increase its propensity to export by 20.9%. However the indirect of factor market competition will be to diminish the propensity to export by 7.4%. This means that the net effect of such a movement on the probability of exporting will be 13.5%.

Clearly there is a large residual of the negative coefficient that remains unexplained. We have sought to err on the side of caution by focusing on a specific mechanism in both the theoretical and empirical work. Another very likely explanation for this is due to product market competition abroad from peer firms in the same exporting country. A common assumption of the imperfect competition and international trade literature is that the elasticity of substitution between domestic varieties is the same as between a domestic and a foreign variety. In this canonical framework, this will lead to product market competition at home but not abroad as all countries face the same CES price aggregator in foreign markets.

However, if the elasticity of substitution is different for within- and across-country varieties, this can lead to product market competition abroad as a function of country-industry productivity. We are unaware of any work calculating different elasticities of substitution across domestic and foreign varieties. It would be interesting to calculate how much of a difference must exist in these elasticities to generate the above results.

5 Conclusion

This paper provides an theoretical and empirical framework to assess how plant- and industry-level productivity differences interact in determining plant-level outcomes. Specifically, we ask how the productivity of peer firms affects outcomes related to exporting in the context of small open economies exporting to a large World market. We do this in the context of a model where productivity varies both across industries and firms within the industries as in DFS (1977) and Melitz (2003), respectively. Using plant-level data for Chile and Colombia for 1990 and 1991, we find that more productive domestic peer plants *diminish* domestic sales, exports, and the propensity to export conditional on own-plant productivity.

This result can come from a variety of reasons including, but not restricted to, product market competition and factor market competition. To discipline and identify a channel for our results, we focus on factor market competition. We argue that inclusion of sector-specific inputs is an intuitively appealing way of amending the model to be consistent with the data. As average productivity in the industry increases, the wage of the specific factor increases, raising the average wage bill for a firm of a given productivity level.

To assess the role that factor market competition may play, we examine relative wages in an industry across countries and how they relate to relative average productivity in the industry controlling for country-specific and industry-specific effects. We find that industries with higher average productivity tend to pay higher wages controlling for the proportion of skilled workers in the industry and differing labor-input elasticities across industries and countries. We estimate that if the average productivity of plants in an industry doubles, factor prices will increase by approximately 21.9%. For a firm of a given productivity level, this will lead to the probability of exporting falling by 6.3% and the level of exports falling by 17.7%.

Avenues for future research are plentiful. First, we can ask how non-conventional product market competition contributes to these results. Specifically, an elasticity of substitution between domestic varieties that is greater than between domestic and foreign varieties can contribute to generating this result. Second, we can ask how the short run specificity of factors at the sector-level can diminish the gains from trade liberalization given firm heterogeneity within those sectors.

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7 Appendix

7.1 Proof of Proposition 1

In this section we derive a number of intermediate results that will be subsequently employed in the proof of the Proposition (1).

From the definition of $\overline{\phi}_{d,ic}$ and $\overline{\phi}_{x,ic}$ it is useful to derive the following expressions:

$$\left(\frac{\overline{\phi}_{d,ic}}{\phi_{d,ic}}\right)^{\sigma-1} = \left(\frac{\overline{\phi}_{x,ic}}{\phi_{x,ic}}\right)^{\sigma-1} = \frac{k}{k+1-\sigma} \tag{16}$$

We substitute (4) in (3) and replace $\overline{\pi}_{d,ic}$ and $\overline{\pi}_{x,ic}$ with their expressions in (5) and (6). Substituting (16) and the Pareto cumulative density function (1) in the resulting expression, yields the following condition:

$$\delta f_e \frac{k+1-\sigma}{\sigma-1} = f\left(\frac{\phi_{m,ic}}{\phi_{d,ic}}\right)^k + f_x\left(\frac{\phi_{m,ic}}{\phi_{x,ic}}\right)^k. \tag{17}$$

Average firm revenues $\overline{r}_{ic}$ can be rewritten, similarly to Melitz (2003), as $\overline{r}_{ic} = \overline{\pi}_{ic} + f + \frac{1-G(\phi_{x,ic})}{1-G(\phi_{d,ic})} f_x$. Using the free-entry condition (3) to substitute $\overline{\pi}_{ic}$ and the Pareto cdf, average firm revenues can be expressed as:

$$\overline{r}_{ic} = \delta f_e \left(\frac{\phi_{d,ic}}{\phi_{m,ic}}\right)^k + f + \left(\frac{\phi_{d,ic}}{\phi_{x,ic}}\right)^k f_x \tag{18}$$

By replacing (18) in (7) we obtain the following equation:

$$\eta M_{ic}\sigma s_{ic}^{\eta}\left(\delta f_e \left(\frac{\phi_{d,ic}}{\phi_{m,ic}}\right)^k + f + \left(\frac{\phi_{d,ic}}{\phi_{x,ic}}\right)^k f_x\right) = s_{ic}K_{ic}. \tag{19}$$

We report the equivalent condition for the mobile factor, which earns a share $1-\eta$ of total revenues:

$$(1-\eta) M_{ic}\sigma s_{ic}^{\eta}\left(\delta f_e \left(\frac{\phi_{d,ic}}{\phi_{m,ic}}\right)^k + f + \left(\frac{\phi_{d,ic}}{\phi_{x,ic}}\right)^k f_x\right) = L_{ic}. \tag{20}$$

The next expression we derive can be seen as a sort of goods market equilibrium condition. Since there are no imports in sector i, the entire share α of domestic expenditure spent on varieties produced in sector i accrues to domestic firms as revenues in the domestic market. Let us denote by $r_{d,ic}(\phi)$ the domestic revenues of a firm with productivity ϕ in sector i. If Y_c is aggregate income (which is equal to aggregate expenditure E_c) then $\alpha Y_c = M_i \overline{r}_{d,ic}$, where $\overline{r}_{d,ic}$ are average revenues in the domestic market. Since $\overline{r}_{d,ic}/r_{d,ic}(\phi_{d,ic}) = \left(\frac{\overline{\phi}_{d,ic}}{\phi_{d,ic}}\right)^{\sigma-1}$ and $r_{d,ic}(\phi_{d,ic}) = \sigma f s_{ic}^{\eta}$[33] then we can establish, using (16), the following condition:

$$\alpha Y_c = M_{ic}\frac{k\sigma f s_{ic}^{\eta}}{k+1-\sigma} \tag{21}$$

For the remainder of the proof we are going to employ conditions (20), (19), (21), (17) and the correspondent conditions for the Foreign country, along with (8).

A result that will prove useful later is obtained by dividing equation (20) by (19) for sector 1

[33] This relationship derives from the fact that $\pi_{id}(\phi_{id}) = \frac{r_{id}(\phi_{id})}{\sigma} - f s_i^{\eta}$.

to find the following expression:

$$\frac{(1-\eta)s_{1c}K_{1c}}{\eta} = L_{1c} \tag{22}$$

We obtain a similar expression for sector 1 in the country c':

$$\frac{(1-\eta)s_{1c'}K_{1c'}}{\eta} = w_{c'}L_{1c'} \tag{23}$$

Analogous expressions can be derived for sector 2 in both countries.

We start by deriving M_{1c} and $M_{1c'}$ from (21) and the analogous condition for c'. We then substitute them into (20) and its equivalent for c' and, after some manipulation isolate $\phi^k_{d,1c}$ and $\phi^k_{d,1c'}$, assuming that equation (20) can be inverted:

$$\begin{aligned}
\phi^k_{d,1c} &= f\frac{\left[L_{1c}k-\alpha Y_c\left(k+1-\sigma\right)\left(1-\eta\right)\right]\phi^k_{m,1c}\phi^k_{x,1c}}{\left[\delta f_e\phi^k_{x,1c}+f_x\phi^k_{m,1c}\right]\alpha Y\left(k+1-\sigma\right)\left(1-\eta\right)} \\
\phi^k_{d,1c'} &= f\frac{\left[L_{1c'}kw_{c'}-\alpha Y_{c'}(1-\eta)(k+1-\sigma)\right]\phi^k_{m,1c'}\phi^k_{x,1c'}}{\left[\delta f_e\phi^k_{x,1c'}+\phi^k_{m,1c'}f_x\right]\alpha Y_{c'}(k+1-\sigma)(1-\eta)}
\end{aligned}$$

Now we can substitute $\phi^k_{d,1c}$ and $\phi^k_{d,1c'}$ into (17) and its Foreign equivalent to find $\phi^k_{x,1c}$ and $\phi^{*k}_{x,1c}$: :

$$\phi^k_{x,1c} = \frac{L_{1c}f_x\phi^k_{m,1c}\left(\sigma-1\right)}{\delta f_e\left(k-\sigma+1\right)\left[L_{1c}-\left(1-\eta\right)Y_c\alpha\right]} \tag{24}$$

$$\phi^k_{x,1c'} = \frac{w_{c'}L_{1c'}f_x\phi^k_{m,1c'}(\sigma-1)}{\delta f_e(k+1-\sigma)\left[w_{c'}L_{1c'}-(1-\eta)Y_{c'}\alpha\right]} \tag{25}$$

Substituting (24) and (25) into (8) delivers the expression:

$$\frac{w_{c'}L_{1c'}\left[L_1-\left(1-\eta\right)Y_c\alpha\right]}{L_{1c}\left[w_{c'}L_{1c'}-(1-\eta)Y_{c'}\alpha\right]}\left(\frac{\phi_{m,1c'}}{\phi_{m,1c}}\right)^k = \left(\frac{s_{1c'}}{s_{1c}}\right)^{\frac{k\sigma\eta}{\sigma-1}}\left(w_{c'}\right)^{\frac{k\sigma(1-\eta)}{\sigma-1}}. \tag{26}$$

First note that the expressions within each of the brackets are positive. This is because the first term represents total income to labor in that sector. The second term is the share of domestic revenues accruing to labor in each sector. As long as revenues from exports are positive the difference between the two terms is positive. An analogous expression for sector 2 is:

$$\frac{w_{c'} L_{2c'} \left[L_{2c} - (1-\eta) Y_c \alpha\right]}{L_{2c} \left[w_{c'} L_{2c'} - (1-\eta) Y_{c'} \alpha\right]} \left(\frac{\phi_{m,2c'}}{\phi_{m,2c}}\right)^k = \left(\frac{s_{2c'}}{s_{2c}}\right)^{\frac{k\sigma\eta}{\sigma-1}} (w_{c'})^{\frac{k\sigma(1-\eta)}{\sigma-1}} \tag{27}$$

Dividing equation (26) by (27) gives the following expression:

$$\frac{L_{1c'} L_{2c}}{L_{1c} L_{2c'}} \frac{\left[L_{1c} - \alpha(1-\eta) Y_c\right] \left[w_{c'} L_{2c'} - \alpha(1-\eta) Y_{c'}\right]}{\left[w_{c'} L_{1c'} - \alpha(1-\eta) Y_{c'}\right] \left[L_{2c} - \alpha(1-\eta) Y_c\right]} \left(\frac{\phi_{m,1c'} \phi_{m,2c}}{\phi_{m,2c'} \phi_{m,1c}}\right)^k = \left(\frac{s_{1c'} s_{2c}}{s_{2c'} s_{1c}}\right)^{\frac{\eta k\sigma}{\sigma-1}}$$

Since $Y_c = \sum_{i=1}^{2} L_{ic} + s_{ic} K_{ic}$, we can now substitute the expressions for L_{1c} and $L_{1c'}$ from (22) and (23) and the analogous expressions for L_{2c} and $L_{2c'}$. After some simplification we find the following:

$$\frac{s_{1c'} K_{1c'} s_{2c} K_{2c} \left[s_{1c} K_{1c} - \alpha \left(s_{1c} K_{1c} + s_{2c} K_{2c}\right)\right] \left[s_{2c'} K_{2c'} - \alpha \left(s_{1c'} K_{1c'} + s_{2c'} K_{2c'}\right)\right]}{s_{1c} K_{1c} s_{2c'} K_{2c'} \left[s_{1c} K_{1c'} - \alpha \left(s_{1c'} K_{1c'} + s_{2c'} K_{2c'}\right)\right] \left[s_{2c} K_{2c} - \alpha \left(s_{1c} K_{1c} + s_{2c} K_{2c}\right)\right]} \left(\frac{\phi_{m,1c'} \phi_{m,2c}}{\phi_{m,2c'} \phi_{m,1c}}\right)^k = \left(\frac{s_{1c'} s_{2c}}{s_{2c'} s_{1c}}\right)^{\frac{\eta k\sigma}{\sigma-1}} \tag{28}$$

Under the assumption that $K_{ic} = K_c \; \forall i, c$ after some simplification we can rewrite (28) as:

$$\underbrace{\frac{1 - \alpha - \alpha \frac{s_{2c}}{s_{1c}}}{1 - \alpha - \alpha \frac{s_{2c'}}{s_{1c'}}}}_{\Gamma} \times \underbrace{\frac{1 - \alpha - \alpha \frac{s_{1c'}}{s_{2c'}}}{1 - \alpha - \alpha \frac{s_{1c}}{s_{2c}}}}_{\Delta} \left(\frac{\phi_{m,1c'} \phi_{m,2c}}{\phi_{m,2c'} \phi_{m,1c}}\right)^k = \left(\frac{s_{1c'} s_{2c}}{s_{2c'} s_{1c}}\right)^{\frac{\eta k\sigma}{\sigma-1}}$$

We prove that $\frac{\phi_{m,1c'} \phi_{m,2c}}{\phi_{m,2c'} \phi_{m,1c}} > 1$ implies $\frac{s_{1c'} s_{2c}}{s_{2c'} s_{1c}} > 1$ by contradiction. We have to consider two cases. First, assume to the contrary that $\frac{s_{1c'} s_{2c}}{s_{2c'} s_{1c}} < 1$. This implies that, since $\frac{\phi_{m,1c'} \phi_{m,2c}}{\phi_{m,2c'} \phi_{m,1c}} > 1$, $\Gamma\Delta < 1$. Because $\frac{s_{2c}}{s_{1c}} < \frac{s_{2c'}}{s_{1c'}}$ then $\Gamma > 1$ and $\Delta > 1$ which contradicts the condition $\Gamma\Delta < 1$. Second, assume to the contrary that $\frac{s_{1c'} s_{2c}}{s_{2c'} s_{1c}} = 1$. This implies that, since $\frac{\phi_{m,1c'} \phi_{m,2c}}{\phi_{m,2c'} \phi_{m,1c}} > 1$, it must be the case that $\Gamma\Delta < 1$, but our assumption implies that $\Gamma = 1$ and $\Delta = 1$, which is not possible given out assumption. Since both cases lead to a contradiction we have proved the result.

8 Data Appendix

The key to plotting the above figures involves making the Chilean and Colombian firms as comparable as possible. This involves making output, labor input, capital input, and materials input comparable. I explain these in turn. The December average exchange rate is used to translate all variables into nominal U.S. dollars.

8.1 Labor Input

Labor is broken down into skilled and unskilled in each data set. Units of labor are measured in the number of workers in each data set. In addition, we can allow for the effectiveness of labor to vary across countries as in Caselli (2005) and as used by Morrow (2008). Using this procedure, labor is transformed into effective labor using data on educational attainment and assumptions about the returns to schooling. Labor input is assumed to be EL where L is the physical quantity of labor employed and E is the effectiveness of labor. The effectiveness of labor without any schooling is normalized to $E = 1$. Labor is assumed to become 13% more productive per year of schooling for years one through four of educational attainment, 10% more productive per year for years four through eight, and 7% per year for subsequent years. Based on these measures one unit of physical labor is assumed to be 2.04 units of effective labor for Chile and 1.65 for Colombia.

8.2 Capital Input

Capital was constructed using the perpetual inventory method in which capital stock is available for a single year and then subsequent capital stock is calculated by adding observed investment and subtracting assumed depreciation. Capital and investment are measured in thousands of the nominal domestic currency in each data set. For both countries, the depreciation rate is imposed to be 5% per year for buildings, 10% for machinery, and 20% for vehicles.

The following describes the construction of investment for Colombia:

- Building Investment=Purchases of New Fixed Assets: Structures+Purchases of Old Fixed Assets: Structures+Production of Assets: Structures+Reappraisal of Fixed Assets: StructuresSales of Fixed Assets: Structures.
  - Note: Despite the fact that we observe data on the purchases and sales of land in the Colombian data set, we choose not to include it in our measures of the capital stock. This is because we do not observe separate investment in land in the Chilean data set until 1989 and we are making the two data sets as comparable as possible.
- Machinery Investment=Purchases of New Fixed Assets: Machinery+Purchases of Old Fixed Assets: Machinery+Production of Assets: Machinery)+Reappraisal of Fixed Assets: MachinerySales of Fixed Assets: Machinery .
- Transportation Investment=Purchases of New Fixed Assets: Transportation+Purchases of Old Fixed Assets: Transportation+Production of Assets: Transportation+Reappraisal of Fixed Assets: TransportationSales of Fixed Assets: Transportation.
- Office Investment=Purchases of New Fixed Assets: Office+Purchases of Old Fixed Assets: Office+Production of Assets: Office+Reappraisal of Fixed Assets: OfficeSales of Fixed Assets: Office.

Each of these is deflated by the economy-wide investment deflator that is described next. There is no distinction between different types of investment with regards to the deflator used. Two dimensions need to be taken into consideration when constructing the deflator. First, the domestic investment price deflator must be used to make the investment numbers comparable over time. This is common to nearly all firm level studies. However, because we are trying to make two firm level data sets comparable, we also need to translate these variables into a common real currency. We choose to do this using the Penn World Tables PPP investment deflator.

Because the PWT deflators are measured by the country's PPP price level relative to the U.S., the first two terms in the denominator convert nominal 1980 Colombian values to PPP adjusted 1980 U.S. dollar values. The second and third terms in the denominator control for nominal and PPP price changes over time within Colombia and convert current Colombian pesos into PPP adjusted 1980 Colombian pesos. is taken to be 50.92 which is the December average Peso-Dollar exchange rate as in IMF international Financial statistics. PI is taken from Penn World Tables Edition 6.1. The Producer Price Index for capital is taken from : $http$: $//www.banrep.gov.co/statistics/sta_prices.htm$. The domestic capital formation deflator is taken from the PPI summary link which opens up to the file $\grave{O}is_srea_015.xls.\acute{O}$ All annual values use the June value of the Capital Formation variable where values are indexed so that June, 1980 is the base period.

The following describes investment for Chile:

- Building Investment=Investment in New Buildings+Investment in Used Buildings Sales of Buildings Improvements Done by Third Parties: Buildings+ Buildings Produced for Own Use.

  Note: Investment in land is not available for years prior to 1989 and, therefore, capital stock does not include investment in land.

- Machinery Investment=Investment in New Machinery+Investment in Used Machinery Sales of Used Machinery Improvements Done by Third Parties: Machinery+ Machinery Produced for Own Use.

- Vehicles Investment=Investment in New Vehicles +Investment in Used Vehicles Sales of Used Vehicles Improvements Done by Third Parties: Vehicles + Vehicles Produced for Own Use

Buildings are deflated using the implicit price deflator for construction. Machinery and Vehicles are deflated using the implicit price deflator for machinery. Nominal Pesos are transformed into real PPP adjusted U.S. dollars using a similar expression to the one for Colombia except that KPPI is now replaced by one of the two deflators described above.

8.3 Output

There are two measures of output for the Chilean Data. There is income which includes sales of goods produced, sales shipped to other establishments, resales, work done for third parties and repairs done for third parties. Then there is gross output which includes income, electricity sold, buildings produced for own use, machinery produced for own use, vehicles produced for own use and final inventory of goods in process. The specific calculation for gross output is (see Liu documentation)

There is a measure of the value of (gross) production in the Colombian data set. According to the documentation, this includes the value of all goods and byproducts produced by the establishment during the year at sales prices plus the value of work done for others, plus the value of electricity sold, work done within house, and addition to inventories. It is fairly clear that Gross Production in the Colombian data set included: the value of all goods and by-products sold, revenue from work done for third parties, value of electricity sold, value of operational income (value of installation, repair, and maintenance), change in Business inventories, and tax certificate revenue.

Revenue is reported in thousands of nominal Colombian Pesos. They are transformed into thousands of 1980 Colombian Pesos using the 3-digit ISIC producer price index which is available at: $http://www.banrep.gov.co/statistics/sta\_prices.htm$. The specific spreadsheet is provided at the link Producer Price Index (PPI) produced and consumed goods which links to the spreadsheet $i\_srea\_015.xls$.All variables are the June values with all observations indexed so that the value for 1980=1.00. Similar data was used for Chile that is available from the Instituto Nacional de Estadisticas and was graciously provided by David Greenstreet.

PPP Price deflators were constructed using the disaggregated PPP benchmark data that is available from the Penn World Tables. Unfortunately, the benchmark data are only available at five year intervals. In addition, the level of disaggregation changes from year to year. We choose to use the values from 1980 because Chile and Colombia are not covered in the 1985 survey. One fortuitous aspect of the 1980 benchmark is that it is available at the greatest level of disaggregation. The 1980 benchmark covers 155 industrial groupings, the 1985 benchmark covers 135 industrial groupings, and the 1996 benchmark only covers 31 industrial groupings. Consequently, we choose to use the 1980 data. This means that we are making the implicit assumption that all changes in the PPP deflator after 1980 can sufficiently be accounted for by a country fixed effect in which all industry level PPP deflators grow at the same rate. The mean (across industries) relative PPP deflator for Chile relative to Colombia is 1.747 and the median is 1.440. These can be compared to relative values of the PPP GDP deflator of 1.409, and 1.061 for investment goods.

Table 1
Data Summary

	1990			1991		
ISIC	#Chile	# Colombia	Total	# Chile	# Colombia	Total
311	657	761	1,418	642	710	1,352
312	34	154	188	34	148	182
321	210	380	590	210	361	571
322	153	717	870	142	654	796
323	31	86	117	30	83	113
324	66	201	267	66	195	261
331	131	136	267	124	118	242
332	52	171	223	52	159	211
341	33	137	170	35	127	162
342	83	296	379	88	282	370
351	27	125	152	27	120	147
352	107	271	378	107	262	369
355	32	61	93	32	59	91
356	92	293	385	90	288	378
369	60	246	306	60	231	291
381	211	462	673	204	431	635
382	85	287	372	81	272	353
383	28	188	216	29	170	199
384	54	201	255	52	185	237
390	35	139	174	33	122	155
Total	2,181	5,312	7,493	2,138	4,977	7,115

Table 2
Value of Production

	1990		1991		1990		1991	
	Production		Production		Value Added		Value Added	
RHS Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VA per worker$_{fict}$	1.37***	1.426***	1.426***	1.515***	1.423***	1.479***	1.469***	1.555***
	(0.054)	(0.054)	(0.06)	(0.053)	(0.058)	(0.06)	(0.053)	(0.04)
VA per worker$_{ict}$		−0.516*		−0.892***		−0.517*		−0.87***
		(0.295)		(0.291)		(0.293)		(0.282)
Observations	7493	7493	7115	7115	7493	7493	7115	7115
Industries	20	20	20	20	20	20	20	20
Industry FE	3 digit	3 digit	3 digit	3 digit	3 digit	3 digit	3 digit	3 digit
Country FE	yes	yes	yes	yes	yes	yes	yes	yes
Restriction p-val		0.002		0.027		0.000		0.012

Standard errors in parentheses. Standard errors clustered by country-industry level (e.g. Chile ISIC 311).
***=1% level, **=5% level,*=10% level,.

Table 3
Propensity to Export

RHS Variable	1990 Logit (1)	1990 Logit (2)	1991 Logit (3)	1991 Logit (4)	1990 Linear Prob. (5)	1990 Linear Prob. (6)	1991 Linear Prob. (7)	1991 Linear Prob. (8)
VA per worker$_{fict}$	1.204***	1.288***	1.287***	1.415***	0.149***	0.158***	0.18***	0.195***
	(0.08)	(0.089)	(0.105)	(0.107)	(0.012)	(0.014)	(0.016)	(0.018)
VA per worker$_{ict}$		−0.651**		−1.018***		−0.085*		−0.143***
		(0.332)		(0.264)		(0.047)		(0.042)
Obs.	7493	7493	7115	7115	7493	7493	7115	7115
Industries	20	20	20	20	20	20	20	20
Industry FE	yes	yes	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes	yes	yes
Restriction p-val		0.027		0.107		0.099		0.195

The dependent variable=1 if there are positive levels of exports, zero otherwise.
Standard errors in parentheses clustered by country-industry level (e.g. Chile ISIC 311).
***=1% level, **=5% level, *=10% level

Table 4
Domestic Revenue

RHS Variable	1990 (1)	1990 (2)	1991 (3)	1991 (4)
VA per worker$_{fict}$	1.338***	1.392***	1.372***	1.456***
	(0.054)	(0.053)	(0.053)	(0.047)
VA per worker$_{ict}$		−0.485*		−0.85***
		(0.282)		(0.28)
Obs.	7472	7472	7102	7102
Industries	20	20	20	20
Industry FE	yes	yes	yes	yes
Country FE	yes	yes	yes	yes
Restriction p-val		0.000		0.027

“Standard errors in parentheses.
***=1% level, **=5% level, *=10% level. Standard errors clustered by country-industry level (e.g. Chile ISIC 311).

Table 5
Export Revenue

RHS Variable	1990 (1)	(2)	1991 (3)	(4)
VA per worker_{fict}	0.755***	0.773***	0.809***	0.879***
	(0.108)	(0.109)	(0.097)	(0.112)
VA per worker_{ict}		-0.132		−0.51*
		(0.269)		(0.283)
Obs.	1251	1251	1491	1491
Industries	20	20	20	20
Industry FE	yes	yes	yes	yes
Country FE	yes	yes	yes	yes
Restriction p-val		0.0218		0.1463

"Domestic Revenue" is the value of production - value of exports.
"Standard errors in parentheses.
***=1% level, **=5% level. Standard errors clustered by country-industry level (e.g. Chile ISIC 311).

Table 6a
Four Digit ISIC Results (1990)

RHS Variable	Revenue (1)	Value Added (2)	Domestic Rev. (3)	Exports (4)	Pr(exp>0) (5)
va per worker_{fic}	1.388***	1.518***	1.346***	0.805***	1.604***
	(0.105)	(0.068)	(0.111)	(0.168)	(0.134)
VA per worker_{ic}	−0.997***	−1.141***	−0.967***	−0.866**	−1.442***
	(0.233)	(0.18)	(0.223)	(0.361)	(0.263)
Obs.	5000	4994	4893	723	5000
Industries	14	14	14	14	14
Industry FE	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes
Restriction p-val	0.053	0.031	0.047	0.849	0.483

Table 6b
Four Digit ISIC Results (1991)

RHS Variable	Revenue (1)	Value Added (2)	Domestic Rev. (3)	Exports (4)	Pr(exp>0) (5)
VA per worker_{fict}	1.408***	1.529***	1.355***	0.936***	1.618***
	(0.111)	(0.081)	(0.108)	(0.127)	(0.180)
VA per worker_{ict}	−0.952***	−1.133***	−0.952***	−0.82***	−1.605***
	(0.216)	(0.154)	(0.208)	(0.239)	(0.308)
Obs.	4799	4793	4789	887	4799
Industries	14	14	14	14	14
Industry FE	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes
Restriction p-val	0.0435	0.024	0.056	0.578	0.964

These notes apply to both Table 6a and 6b. The dependent variable in the logit =1 if there are positive levels of exports, zero otherwise. Standard errors presented in. parentheses. ***=1% level of certainty. Standard errors clustered by country-3-digit industry level (e.g. Chile ISIC 311).

Table 7
Robustness: Value Added productivity (pooled 1990-1991)

RHS Variable	Value (1)	Value (2)	Value Added (3)	Value Added (4)	Exports (5)	Exports (6)	Pr(exp> 0) (7)	Pr(exp> 0) (8)
tfp_{fict}	1.022***	1.507***	1.072***	1.571***	0.635***	1.03***	0.922***	1.456***
	(0.133)	(0.079)	(0.137)	(0.08)	(0.1)	(0.126)	(0.177)	(0.121)
tfp_{ict}		−1.043***		−1.073***		−0.697***		−1.048***
		(0.138)		(0.14)		(0.144)		(0.164)
Obs.	14608	14608	14608	14608	2763	2763	14608	14608
Industries	20	20	20	20	20	20	20	20
Industry-Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Country-Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Restriction p-val		0		0		0		0

The dependent variable=1 if there are positive levels of exports, zero otherwise. Standard errors in parentheses.
***=1% level. Standard errors clustered by country-industry level (e.g. Chile ISIC 311).

Table 8
Robustness: Non-Linear Firm Productivity (pooled 1990-1991)

RHS Variable	Value (1)	Value (2)	Value Added (3)	Value Added (4)	Exports (5)	Exports (6)	Pr(exp> 0) (7)	Pr(exp> 0) (8)
VA per worker_{fic}	1.466***	1.09***	1.513***	1.255***	0.837***	0.509**	1.348***	1.649***
	(0.051)	(0.123)	(0.053)	(0.114)	(0.088)	(0.293)	(0.092)	(0.399)
VA per worker^2_{fic}		0.072***		0.049**		0.053		-0.05
		(0.025)		(0.020)		(0.048)		(0.066)
VA per worker_{ic}	−0.663**	−0.698**	−0.656**	−0.68**	-0.302	-0.35	−0.802***	−0.787***
	(0.302)	(0.309)	(0.295)	(0.3)	(0.272)	(0.296)	(0.306)	(0.304)
Obs.	14608	14608	14608	14608	2763	2763	14608	14608
Industries	20	20	20	20	20	20	20	20
Industry-Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Country-Time FE	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses.
***=1% level, **=5% level. Standard errors clustered by country-industry level (e.g. Chile ISIC 311).

Table 9
Wages, Firm productivity, and Industry productivity (3-digit)

	1990 Dependent Variable			1991 Dependent Variable		
RHS Variable	Average Wage (1)	Skilled Wage (2)	Unskilled Wage (3)	Average Wage (4)	Skilled Wage (5)	Unskilled Wage (6)
VA per worker$_{fic}$	0.373***	0.473***	0.286***	0.396***	0.492***	0.305***
VA per worker$_{ic}$	(0.029)	(0.059)	(0.019)	(0.023)	(0.049)	(0.016)
VA per worker$_{ic}$	0.267***	0.35***	0.216***	0.17***	0.239**	0.145***
	(0.078)	(0.101)	(0.054)	(0.08)	(0.104)	(0.057)
Observations	7493	7493	7493	7115	7115	7115
Industries	20	20	20	20	20	20
Industry FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes

Table 10
25th and 75th Percentiles of TFP Differences

ISIC	Rel. VA/L (1)	diff(Rel. VA/L) (2)	$VA/L_{75} - VA/L_{25}$ (3)	Obs. (4)
311	-0.597	-0.134	1.295	1352
312	0.789	1.252	1.469	182
321	-1.235	-0.771	0.783	571
322	-0.980	-0.517	0.506	796
323	-0.040	0.423	0.717	113
324	-0.326	0.137	0.511	261
331	-1.128	-0.665	0.874	242
332	0.200	0.663	0.329	211
341	0.384	0.847	1.394	162
342	-0.207	0.256	0.600	370
351	-1.994	-1.531	1.178	147
352	-1.204	-0.740	1.057	369
355	-0.110	0.353	0.834	91
356	0.066	0.529	0.781	378
369	0.379	0.842	0.868	291
381	0.157	0.620	0.756	635
382	-0.295	0.168	0.613	353
383	0.274	0.737	1.079	199
384	-0.264	0.199	0.748	237
390	-1.207	-0.744	0.588	155
Median	-0.236		0.782	
(Weighted) Mean	-0.326		0.868	
25th percentile		-0.554		
75th percentile		0.631		

Column (1) presents the raw difference in (log) Chilean relative to Colombian industry TFP. Column (2) presents that difference relative to the median difference. Column (3) presents the (log) difference between a firm in the 75th percentile and one in the 25th when industry data is pooled across countries

Figure 1:

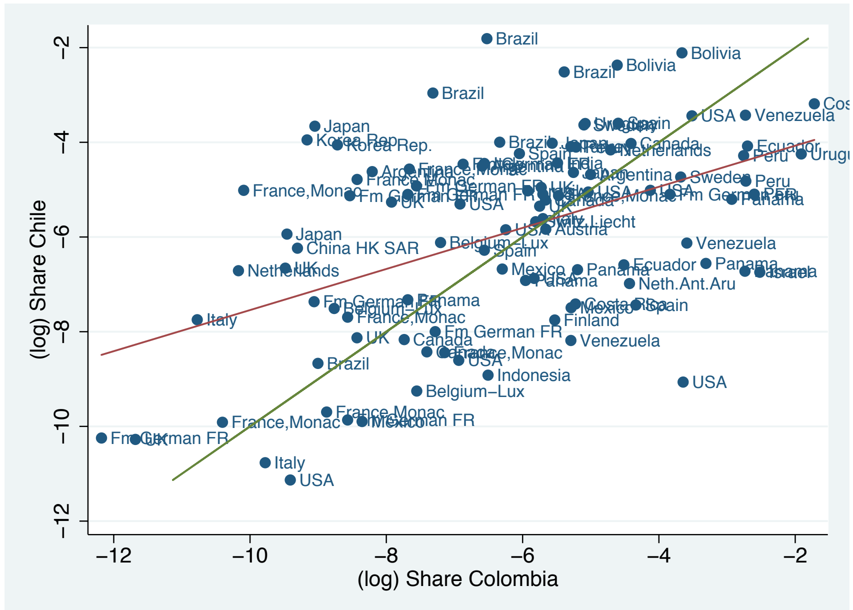


Figure 2:

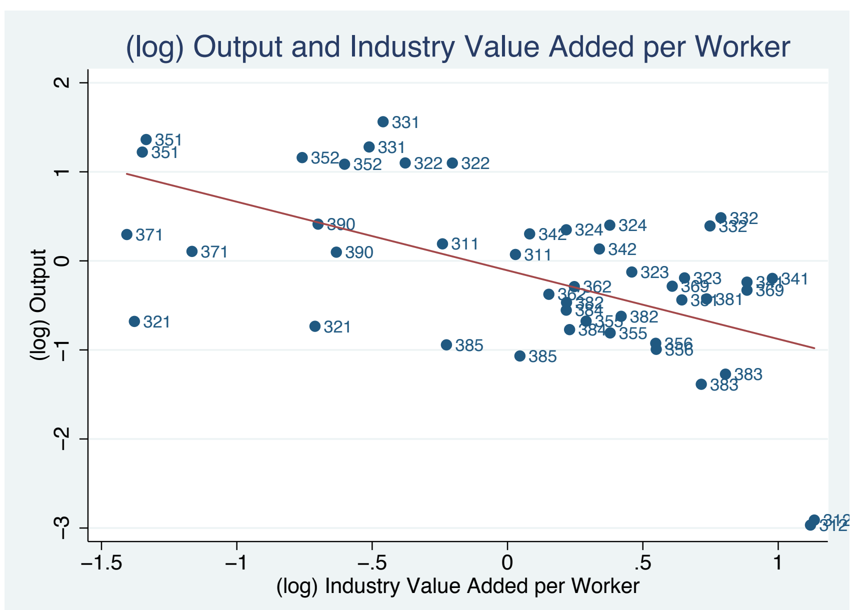


Figure 3:

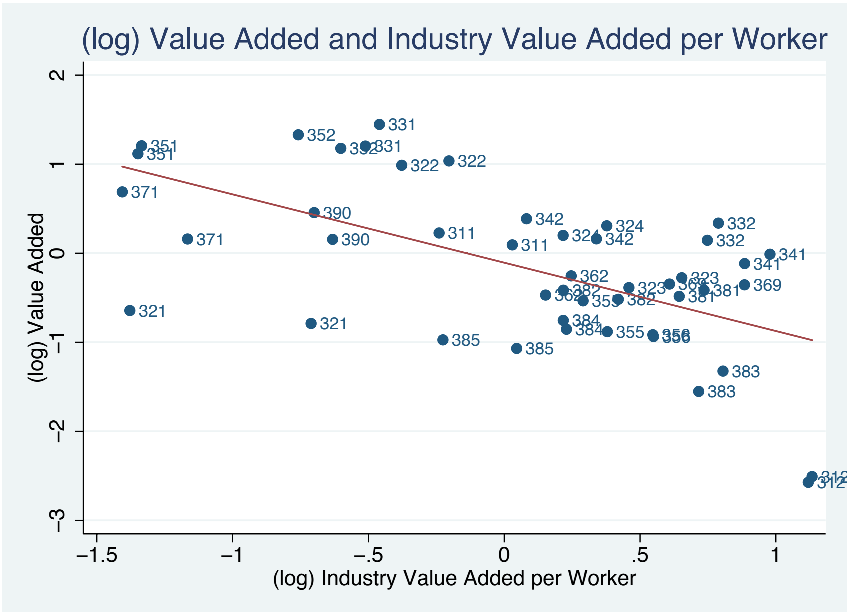


Figure 4:

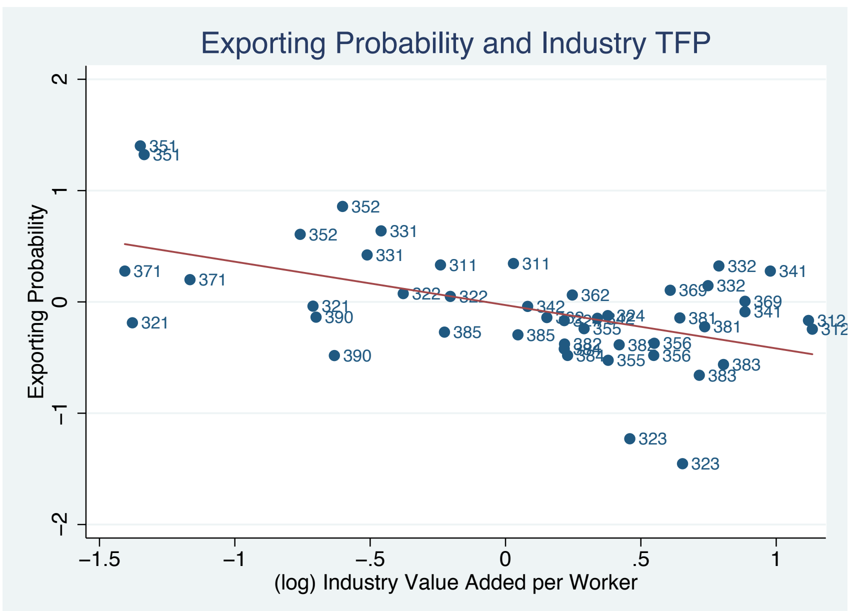
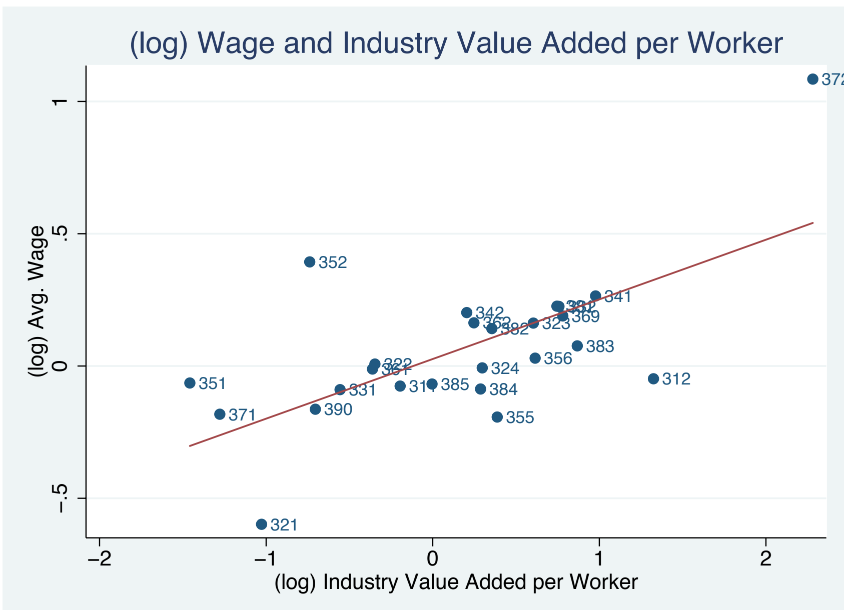


Figure 5:



(log) Wage and Industry Value Added per Worker
(log) Avg. Wage
(log) Industry Value Added per Worker
372
352
342
362
382
323
332
369
341
383
356
324
322
361
331
311
385
384
355
312
351
371
390
321
1
.5
0
−.5
−2
−1
0
1
2