Ricardian Trade and The Impact of Domestic Competition on Export Performance*

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Abstract

This paper develops and empirically examines a model of relative productivity differences both within and across industries for small open economies. We decompose the effect of industry productivity on export performance into direct effect of own firm productivity and an indirect effect of higher peer firm productivity. In a sample of Chilean and Colombian plants, we find evidence of both a positive direct effect and a negative indirect effect. The empirical evidence supports our theoretical prediction that industry-specific factors of production and asymmetric substitutability between domestic and foreign varieties drive the negative indirect effect.

JEL Codes: F10, F11, F12.

Keywords: Ricardian trade, firm heterogeneity, specific factors, Armington, nested CES preferences.

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1 Introduction

The positive correlation between productivity and exporting is among the most robust findings in empirical international trade. At the industry level, this provides the foundation for the Ricardian model in which relative productivity differences determine patterns of specialization. Empirical support for this model is plentiful and includes contributions by Macdougall (1951,1952), Stern (1962), Harrigan (1997), Eaton and Kortum (2002), Kerr (2009), and Costinot, Donaldson, and Komunjer (2011). In the Ricardian model producers achieve superior exporting outcomes because they can access relatively higher productivity levels in certain industries. Simultaneously, another literature focuses on the firm as the unit of analysis and suggests that successful export performance is due to certain firms having high enough productivity to overcome the costs of exporting.[1] Neither literature takes a stand on how firm and industry productivity interact in determining exporting outcomes.

This paper combines these two views by examining both empirically and theoretically how a firm's export performance depends not just on its own productivity, but also on the relative productivity of the industry in which it resides. We place this problem in the context of comparative advantage by asking whether, conditional on the direct effect of its own productivity, a firm is indirectly affected by residing in a country's Ricardian comparative advantage industry.

We summarize the question and identification strategy with a simple thought experiment. Consider two countries (Chile and Colombia) and two industries (machinery and chemicals) and assume that, regardless of their absolute productivity, Chile possesses Ricardian comparative advantage in machinery relative to chemicals, while Colombia is relatively more productive in chemicals.[2] Comparing firms of identical productivity, will the ones residing in the comparative advantage sectors, a machinery firm in Chile or a chemicals firm in Colombia, have superior, equal, or inferior export-related outcomes on world markets relative to the ones that reside in the comparative disadvantaged sectors? In a regression context we answer this question by considering the impact on export performance of own

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[1] E.g. Bernard, Eaton, Jensen, and Kortum (2003), Melitz (2003), and Melitz & Ottaviano (2008).

[2] This example reflects the actual pattern of comparative advantage, as displayed in Table 2 and discussed below.

productivity and industry-country productivity, controlling for industry and country fixed effects, to properly identify comparative, rather than absolute, advantage.

Because of the nature of the question, we require micro data across industries and countries. This requirement is satisfied by plant-level data for Chile and Colombia for 1990-1991 that have been used extensively in the international trade literature. Employing this data, we find a positive direct effect of own firm productivity and a negative indirect effect of peer firms' productivity on a firm's export performance. Consistent with previous research, we find that more productive firms have a higher propensity to export and a larger level of exports. However, conditional on own productivity, plants with relatively more productive domestic peer firms sell less abroad and have a lower propensity to export. These results imply that residing in a relatively productive industry in a given country entails a key tension: any firm in the industry is likely to be relatively productive, but so are its peer firms, which compete in domestic markets for resources and/or in foreign export markets. To reconcile our findings with the empirical literature on comparative advantage, we show both theoretically and empirically that the positive direct effect dominates the negative indirect effect; that is, industry-level Ricardian predictions hold for both the proportion of firms exporting and the level of exports. We also show that existing models of firm heterogeneity integrating comparative advantage predict that industry affiliation should have a positive impact or no impact on external performance after conditioning on own-firm characteristics when wages are set at the national level.

We model and empirically scrutinize two modifications to the canonical model to explain our results. Specifically, we focus on competition in the product and factor markets, which we discuss in turn.[3]

To build our case for an explanation based on the product-market competition channel, we argue that two varieties produced within the same national border are likely to be more substitutable than two varieties produced in different countries. This is a weaker version

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[3] Because we do not depart substantially from the canonical model, we do not invoke technology "spillovers" nor any technology transfer. See Keller (2002) for a summary of the technology transfer literature literature. Our thought experiment is related to, but ultimately distinct from, the literature on the effects of FDI, considered as a change in the competitive pressure faced by firms not the target of FDI. See Aitken and Harrison (1999) and Sembenelli and Siotis (2008).

of the common Armington (1969) assumption, according to which products are only differentiated by source country, and are perfectly substitutable if produced within the same country. In this environment, relatively higher productivity of peer exporting firms translates into more competitive economic conditions for firms exporting out of the same country and industry. This effect will be stronger for industries in which two domestic varieties are relatively more substitutable than a domestic and a foreign variety. We hypothesize that this is true for more differentiated products, where there is more scope for national differentiation. For differentiated goods such as wine, for example, it is plausible that producers face two distinctive tiers of competitors. Chilean wine varieties are a more substitutable product with each other than with wines produced in other countries. Conversely, we posit that for homogeneous goods, such as commodities that are either reference priced or sold on organized exchanges, there is less room for national differentiation. For this type of good, having particularly productive domestic peers does not affect the performance of individual firms: what matters is competition in the world market. We find evidence of this channel: the effect of productivity of peer firms has a stronger negative impact for industries that are more differentiated, using the classification introduced by Rauch (1999).

We also explore factor market competition as an alternative channel that rationalizes our findings. According to this mechanism, higher relative productivity in an industry leads to a relatively higher wage of the specific factor associated with that industry. This increases all costs, including the fixed costs of exporting, and lowers the probability of exporting and the level of exports for a firm with a given productivity level. Industry-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. We find evidence of this channel in the data, as the industry wage correlates negatively with firm performance after having been purged of country- and industry-specific effects.

We employ plant-level data for the countries of Chile and Colombia in our analysis of productivity and export performance in the face of domestic competition. The data and country selection is ideal for four reasons. First, detailed plant-level data allows us to create measures of variables such as productivity, output, and employment that are comparable across countries. Second, these two countries export in similar industries to similar markets and are likely to face comparable competitive conditions in world markets based on their geographic location and level of development. 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 to control for destination specific characteristics. An upward sloping relationship suggests that these two countries compete in similar countries and industries.

Third, Chile and Colombia are small open economies with only a negligible amount of trade between them for the time period we consider. In 1990 and 1991 Colombian exported less than 1 percent of its total exports to Chile and Chilean exports to Colombia comprise less than 3 percent of its total exports. By contrast, Colombian and Chilean exports to G7 countries, Brazil, and Argentina are roughly 70 and 63 percent, respectively (IMF Direction of Trade Statistics Database, 2010). These trade patterns justify our focus on small countries that export to a large world market.

Lastly, analyzing relative productivity patterns between two countries of similar levels of development is well suited to the Ricardian framework as opposed to the Heckscher-Ohlin model. For the Heckscher-Ohlin model, if endowments are similar, it is not obvious how specialization should vary. However, when analyzing across-industry relative productivity patterns, it is not obvious why two countries of similar development levels should possess the same across-industry relative productivity patterns. In fact, we find that Chile and Colombia exhibit higher-than-average variation in relative productivity across sectors, compared to other developing countries.[4]

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[4] In an exercise available from the authors we compute the standard deviation of relative produtivities of Chile and Colombia, constructed from Table 2. Such computation yields a figure of 0.73. As a benchmark we compute the standard deviation of relative productivity for each developing country in Morrow (2010), compared to a multilateral benchmark. The average of such standard deviations is 0.44, with a standard

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 our empirical evidence, and section 5 concludes.

2 Relation to the Literature

Our model integrates elements of two established literatures: one that examines industry-level Ricardian productivity differences as a force for comparative advantage and another examining heterogeneous firms within an industry. While the Ricardian model has experienced a renaissance recently, this literature has not addressed the interaction of heterogeneity both within and across industries. The firm heterogeneity literature models firms in a given industry, but does not ask how firms respond to residence in either a comparative advantage or disadvantage industry. Important exceptions include Demidova (2008) and Bernard, Redding, and Schott (2007) who focus on within and across industry heterogeneity in the context of large open economies.

Demidova (2008) presents a rich two-industry North-South model that predicts that own country-industry productivity should have a positive indirect effect on exporting probability conditional on the own firm productivity direct effect. In her model, high average firm productivity in a differentiated industry in the North discourages Southern entry in that industry. This causes the endogenous toughness of competition in the South to diminish further encouraging Northern exports to the South in that industry. Our work is complementary to Demidova (2008) in that we explore similar issues and how they might vary across large and small open economies. Bernard, Redding, and Schott (2007) present a two-industry, two-country model with Heckscher-Ohlin-based comparative advantage and firm productivity heterogeneity. Lower relative factor prices of the country's abundant factor lead to lower fixed costs of exporting in the industry that uses that factor relatively intensively, so that a firm of a given productivity in this industry is more likely to be able to export profitably.

Both models predict a positive indirect effect of residing in the comparative advan-

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deviation of 0.23.

tage industry, but this is due to their general equilibrium, large open economy structure (Demidova) or their emphasis on Heckscher-Ohlin forces (Bernard, Redding, and Schott). Our empirical finding of a negative indirect effect of industry productivity on a firm's exports and its probability of exporting after conditioning on firm productivity motivates this investigation. We start by showing that the canonical model of firm heterogeneity for a small open economy with Ricardian foundations predicts no role for industry productivity in determining firm exporting outcomes.

Suppose that one of multiple small open economies exports to a large world market. By definition, assume that any economy examined is sufficiently small and takes the world equilibrium as given. The market structure is Dixit-Stiglitz with each firm producing a unique variety. ϕ_{fic} represents productivity for firm f in industry i in country c; w_c is a country-specific wage. Firm exports to the world, $r_x(\phi)$, are as follows where A_i is a demand shifter that each small open economy takes as given, τ represents iceberg transportation costs, and $\rho = (\sigma - 1)/\sigma$ where $\sigma > 1$:[5]

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

Assuming that countries c and c' face the same τ, relative export revenues from the world market for two firms in different countries, but in the same industry, are as follows,

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

In this case, industry productivity should have no effect on relative export performance as relative demand is determined by firm- and country- but not industry-country-level characteristics. A similar prediction can be derived for the probability of exporting. We refer to this as the prediction of the "baseline model." In the next section, we present our theoretical framework.

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[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. Similar notation is used by Helpman, Melitz, and Yeaple (2004).

3 Model

This section starts by deriving the basic elements of the model and a series of propositions that highlight the direct and indirect effects of industry productivity on firm export performance. First, we show that countries with a comparative advantage in an industry will feature relatively higher specific factor wages and lower CES export price indexes in that industry. Second, we show that comparative advantage in an industry leads to larger export volumes and a larger proportion of exporting firms. Third, we show that firms face a higher minimum level of productivity necessary for exporting in a comparative advantage industry. Fourth, a firm of a given productivity level exports in lower volumes if it resides in a comparative advantage industry due to factor- and product-market competition. Fifth, we show that the observed average productivity in an industry can be used as an accurate proxy for underlying Ricardian productivity differences as defined in our model.

We now present the general structure of the model. There are three industries. Each small open economy produces, consumes and exports goods 1 and 2. Good 0 is imported from the world to balance trade in each country. In line with the empirical evidence presented in the introduction, we assume that the small open economies do not trade with each other. Due to our small open economy assumption, 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.

3.1 Demand

The preferences of the representative consumer in country c are defined by the following three-tier Cobb-Douglas utility function:

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

where Q_{ic} is a nested CES aggregator for industry i. Specifically Q_{ic} takes the following form:

$$Q_{ic} = \left[\sum_{c' \in C} \left[\left(\int_{\omega \in I_{ic'}} q_{ic}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \right]^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} \quad \text{with } \sigma > 1, \epsilon > 1,$$

where c' is the producing country, i is the industry, and ω indexes varieties.[6] C is the set of all countries from which c consumes. The lowest tier aggregates within-industry varieties produced within a given country into a country-industry CES aggregator. The next tier aggregates these country-industry aggregators into an industry-level CES aggregate. The top tier is comprised of Cobb-Douglas preferences over industry aggregates. The elasticity of substitution between two varieties from the same country in a given industry is σ. The elasticity of substitution between industry country-level aggregates is ϵ. If $\sigma = \epsilon$, varieties in an industry are equally substitutable regardless of origin. In this case this three-tier structure collapses down to a familiar two-tier structure (e.g. Romalis, 2004). If $\sigma > \epsilon$, then varieties within an industry-country bundle are more substitutable than varieties across bundles. The opposite holds if $\sigma < \epsilon$.

3.2 Production

The two factors of production are labor, which is freely mobile across industries earning a wage w_c, and a factor specific to industry i, that we denote by K_{ic} and which earns return s_{ic}. This specific factor can be physical or human capital or any factor of production that is immobile over the time span considered. The aggregate endowment of (mobile) labor is L_c.

Within each industry i and country c, there is continuum of firms, each producing a different variety, and characterized by a productivity level ϕ as in Melitz (2003). A firm with productivity ϕ produces quantity q and possesses the following homothetic total cost function:

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

where $f w_c^{1-\eta} s_{ic}^{\eta}$ is a fixed cost of production and η is the share of costs spent on the specific

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[6] As is common, we constrain σ >1; the imposition of $\epsilon > 1$ is to maintain the fundamental Ricardian result that lower relative prices result in greater sales when comparing industries across countries.

factor K_{ic}. The higher ϕ is, the lower total costs of producing quantity q. The parameter η is restricted to be the same across industries and countries.

We introduce Ricardian productivity differences by allowing the distribution of productivity draws to vary across both countries and industries. We follow a large number of papers in using the Pareto as a useful approximation to the true underlying distribution of productivity across firms (e.g. Chaney, 2008 and Helpman, Melitz, Yeaple, 2004). Specifically, we assume that, within each industry i, the productivity parameter ϕ follows a Pareto distribution with a shape parameter k and minimum draw $\phi_{m,ic}$.[7] In an industry with higher $\phi_{m,ic}$, firms draw from a distribution with a higher average productivity. This is the source of Ricardian productivity differences in our model.

Upon entry, firms must pay a sunk cost $f_e w_c^{1-\eta} s_{ic}^{\eta}$ to draw a level of productivity in industry i. Upon drawing a productivity level ϕ, a firm makes two decisions. First, it decides whether to produce or not for the domestic market. Analogous to Melitz (2003), we indicate by $\phi_{d,ic}$ the productivity threshold for domestic production such that profits in the domestic market of a firm with that level of 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, conditional on producing domestically, the firm decides whether to export or not. Firms that export incur an additional fixed cost $f_x w_c^{1-\eta} s_{ic}^{\eta}$ and a per-unit iceberg transport cost, $\tau > 1$. The exporting threshold $\phi_{x,ic}$ is such that profits in the world 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.

Revenue in the world market for an exporting firm with productivity ϕ in industry i is as follows:

$$r_{x,ic}(\phi) = E_i \left(\frac{\tau w_c^{1-\eta} s_{ic}^{\eta}}{\rho \phi} \right)^{1-\sigma} (P_{x,ic})^{\sigma-1} \left(\frac{P_{x,ic}}{P_i^W} \right)^{1-\epsilon}, \tag{1}$$

where E_i is world expenditure in industry i, $P_{x,ic}$ is the price index associated with varieties supplied by country c in industry i on world markets, and P_i^W is the top-tier price index on the world market for industry i. All exporting countries face the same P_i^W. Absorbing the

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[7] The cumulative density function of parameter ϕ is therefore: $G_{ic}(\phi) = 1 - \left(\frac{\phi_{m,ic}}{\phi}\right)^k$. We restrict $k > \sigma - 1$ to ensure that all integrals converge.

top-tier CES price index and industry expenditure into the industry constant A_i implies export revenues take the following form:

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

world market conditions, $A_i = E_i(P_i^W)^{1-\sigma}$, are not affected by the export decisions of firms in country c, due to the small open economy assumption. The importance of the relative magnitude of σ in relation to ϵ is clear here. Holding firm productivity and industry wages constant, if two domestic varieties are closer substitutes than a domestic and a foreign variety ($\sigma > \epsilon$), a lower export price index for country c in industry i will lower firm export revenue. The opposite will hold if two domestic varieties are more distant substitutes than a domestic and a foreign variety.

Exploiting the Pareto distribution, the observed probability of exporting is equal to the proportion of operational firms that export and is equal to $p_{x,ic} = \left(\frac{\phi_{d,ic}}{\phi_{x,ic}}\right)^k$. For a given production cutoff, $\phi_{d,ic}$, this probability is declining in the exporting cutoff, $\phi_{x,ic}$, as exporting is relatively more difficult. For a given exporting cutoff, $\phi_{x,ic}$, the probability of exporting conditional on production is increasing in the production cutoff, $\phi_{d,ic}$, as there are fewer firms that are not exporting but still operating.

In Melitz (2003), the zero profit and free entry conditions for entry into domestic and foreign markets uniquely determine the equilibrium cutoffs, $\phi_{x,ic}$ and $\phi_{d,ic}$. The mass of firms, M_{ic} is determined residually in a two-step procedure. Our model employs similar zero profit and free entry expressions that we relegate to the online Technical Appendix for brevity. In our case, however, the cutoffs are determined simultaneously with the mass of firms as both are partially determined by the return to the specific factor. To derive properties of the equilibrium, we employ an industry-specific factor market clearing condition. Firms' revenues are split between the mobile factor and the specific factor such that a share η of total revenues in industry i is paid to K_{ic}:

$$\eta M_{ic}\overline{r}_{ic} = s_{ic}K_{ic}, \tag{3}$$

where $\overline{r}_{ic}$ is the average revenue of a firm operating in industry i. Consider now a second small open economy c' exporting to a large world market. We allow the two countries to differ in size, both in terms of population and specific factor endowments. We assume that the countries' productivity distributions are such that country c' has a comparative advantage in industry 1 while country c has a comparative advantage in industry 2. Specifically, we assume, without loss of generality, that minimum draws across countries and industries are ranked according to the following inequality:

$$\frac{\phi_{m,1c}}{\phi_{m,2c}} < \frac{\phi_{m,1c'}}{\phi_{m,2c'}}. \tag{4}$$

We start by asking whether the minimum productivity necessary for exporting will be relatively higher in a country's Ricardian comparative advantage industry by deriving whether $\frac{\phi_{x,1c}}{\phi_{x,2c}} \gtreqless \frac{\phi_{x,1c'}}{\phi_{x,2c'}}$. Using the expression for export revenues in equation (2) and the zero profit condition for exporting, $r_{x,ic}\left(\phi_{x,ic}\right) = \sigma f_x w_c^{1-\eta} s_{ic}^{\eta}$, the relationship between the export cutoffs in the two countries in industry i is then: $\frac{\phi_{x,ic}}{\phi_{x,ic'}} = \left[\frac{P_{x,ic}}{P_{x,ic'}}\right]^{\frac{\epsilon-\sigma}{\sigma-1}} \left[\frac{w_c^{1-\eta} s_{ic}^{\eta}}{w_{c'}^{1-\eta} s_{ic'}^{\eta}}\right]^{\frac{\sigma}{\sigma-1}}$. We take the ratio of this expression across the two industries 1 and 2 and rearrange to obtain the following relationship between relative export cutoffs and relative specific factor returns:

$$\frac{\phi_{x,2c}/\phi_{x,2c'}}{\phi_{x,1c}/\phi_{x,1c'}} = \left[\frac{s_{2c}/s_{2c'}}{s_{1c}/s_{1c'}}\right]^{\frac{\eta\sigma}{\sigma-1}} \left[\frac{P_{x,1c}/P_{x,2c}}{P_{x,1c'}/P_{x,2c'}}\right]^{\frac{\sigma-\epsilon}{\sigma-1}}. \tag{5}$$

Although the price indexes depend on wages, equation (5) is useful for partially decomposing product- and factor-market competition. If $\sigma = \epsilon$, such that product-market competition does not play a role, the larger the relative return to the specific factor in industry i-country c, the higher the relative exporting cutoff. If $\eta = 0$ such that factor specificity plays no role, the country with a relatively lower CES price index for its exports will have a higher exporting cutoff if domestic varieties are more substitutable than a domestic and a foreign variety ($\sigma > \epsilon$). The opposite will hold if two domestic varieties are less substitutable than a domestic and a foreign variety.

We assume that $\sigma \geq \epsilon$ such that the elasticity of substitution across varieties produced within a country is weakly larger than the elasticity of substitution across bundles of goods coming from different countries. This is very closely related to the Armington (1969) assumption that goods are perfectly substitutable if they are produced in the same country, but are differentiated by source country. However, our assumption is weaker in that we assume that the elasticity of substitution across varieties within a country is finite. Imbs and Mejean (2009) make an identical assumption in the trade literature. The empirical literature that has estimated elasticities of substitution among varieties, starting from Feenstra (1994) and Broda and Weinstein (2006) and more recently Feenstra, Obstfeld, and Russ (2010), has focused on the Armington elasticity, the equivalent of ε. This is due to a relative paucity of data sufficiently disaggregated within countries to allow for estimation of σ.[8]

An additional assumption is that within each country c, each industry i is endowed with the same amount of specific factor such that $K_{ic} = K_c \; \forall i, c$. This assumption is made for analytical tractability, but it merits discussion. In the long run, as specific factors migrate to the industry with the highest return, there should be no effect of industry productivity on firm export performance through specific factors as all factor prices equate across industries. If endowments of specific factors are positively correlated with average productivity, this will lower the wage of the specific factor, but will make our empirical result less likely to appear in the data. If allocations of the specific factors are negatively correlated with average productivity, this will amplify the results derived below due to wages of specific factors being pushed up by both higher relative demand and lower relative supply of the specific factor.

3.3 Propositions

We now derive five propositions that motivate our empirical work as described in the beginning of this section. All proofs are relegated to the online Technical Appendix or are available from the authors upon request.

Proposition 1 *If* $\frac{\phi_{m,1c}}{\phi_{m,1c'}} < \frac{\phi_{m,2c}}{\phi_{m,2c'}}$ *then the relative return to the specific factor in c is higher in industry* 2 *than in industry* 1 *, compared to* c'*, i.e.* $\frac{s_{1c}}{s_{1c'}} < \frac{s_{2c}}{s_{2c'}}$ *and the ratio of relative*

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[8] Ideally, one would use transaction level import data so that the elasticity between varieties within a country-industry group might be separately identified from the elasticity of substitution between country-industry groups.

export price indexes will be less in industry 2 than in industry 1 such that $\frac{P_{x,1c}}{P_{x,1c'}} > \frac{P_{x,2c}}{P_{x,2c'}}$

Proof. *See online Technical Appendix.* ■

The intuition for these results is simple. First, as firms in an industry draw from a productivity distribution with a higher average, firms in the industry are on average more productive, produce more and have a higher demand for the industry-specific factor which drives up its return. Second, more productive firms result in a lower CES price index as the cost of a unit of consumption will be lower in the industry in which firms are more productive. Proposition 2 shows that common Ricardian predictions hold at the industry level, such that if a country has a comparative advantage in an industry, then the total industry value of export shipments, R_{ic}, will be higher in that same industry and the proportion of active firms that export, $p_{x,ic}$, will also be higher in that industry.

Proposition 2 *If* $\sigma > \epsilon$ *and* $\frac{\phi_{m,1c}}{\phi_{m,1c'}} < \frac{\phi_{m,2c}}{\phi_{m,2c'}}$ *then* $\frac{R_{1c}}{R_{1c'}} < \frac{R_{2c}}{R_{2c'}}$ *and* $\frac{p_{x,1c}}{p_{x,1c'}} < \frac{p_{x,2c}}{p_{x,2c'}}$

Proof. *See online Technical Appendix.* ■

Proposition 3 shows that the minimum level of productivity necessary to export will be relatively higher in a country's comparative advantage industry, leading to a firm of a given productivity level being less likely to export.

Proposition 3 *If* $\sigma > \epsilon$ *and* $\frac{\phi_{m,1c}}{\phi_{m,1c'}} < \frac{\phi_{m,2c}}{\phi_{m,2c'}}$ *then the ratio of export cutoffs will be less in country* c' *than in* c *such that* $\frac{\phi_{x,1c}}{\phi_{x,1c'}} < \frac{\phi_{x,2c}}{\phi_{x,2c'}}$.

Proof. *The result follows from Proposition 1 and equation (5).* ■

Proposition 4 shows that a similar intuition holds for the level of exports. A firm of a given productivity level ϕ_0 will have a lower level of exports if it resides in a country's comparative advantage industry.

Proposition 4 *If* $\frac{\phi_{m,1c}}{\phi_{m,1c'}} < \frac{\phi_{m,2c}}{\phi_{m,2c'}}$*, then, given its productivity level* ϕ_0*, a firm in* c *has higher export revenues in industry* 1 *than in industry* 2*, compared to* c'*, i.e.* $\frac{r_{x,1c}(\phi_0)}{r_{x,1c'}(\phi_0)} > \frac{r_{x,2c}(\phi_0)}{r_{x,2c'}(\phi_0)}$.

Proof. *Using the definition of export revenues in (2), relative export performance measure across industries and countries is:*

$$\frac{r_{x,1c}\left(\phi_0\right)}{r_{x,1c'}\left(\phi_0\right)}\Big/\frac{r_{x,2c}\left(\phi_0\right)}{r_{x,2c'}\left(\phi_0\right)}=\left[\frac{s_{1c}}{s_{1c'}}\Big/\frac{s_{2c}}{s_{2c'}}\right]^{\eta(1-\epsilon)}\left[\frac{P_{x,1c}}{P_{x,2c}}\Big/\frac{P_{x,1c'}}{P_{x,2c'}}\right]^{\sigma-\epsilon}.$$

The result then follows from proposition 1. ■

In sum, propositions 3, 4 and the structure of the model predict that own-firm productivity should have a positive direct effect on firm exporting but that industry productivity should have a negative indirect effect.

However, there is still a disconnect that needs to be addressed. Our theoretical model is based on Ricardian comparative advantage based on the minimum draw in a distribution. Unfortunately, this minimum draw is generally unobserved. This would be true even with a continuum of firms given that only firms with draws above $\phi_{d,ic}$ will appear in the data in equilibrium. The following proposition shows that average productivity in an industry will be positively and monotonically related to the minimum draw upon which the distributions are based. This allows us to use industry productivity as a theoretically consistent proxy for the underlying minimum draw.

Proposition 5 *If* $\frac{\phi_{m,1c}}{\phi_{m,1c'}}<\frac{\phi_{m,2c}}{\phi_{m,2c'}}$, *then* $\frac{\overline{\phi}_{d,1c}}{\overline{\phi}_{d,1c'}}<\frac{\overline{\phi}_{d,2c}}{\overline{\phi}_{d,2c'}}$ *where* $\left(\overline{\phi}_{d,ic}\right)^{\sigma-1}=\frac{1}{1-G\left(\phi_{d,ic}\right)}\int_{\phi_{d,ic}}^{\infty}\phi^{\sigma-1}g\left(\phi\right)d\phi$ *is the composite productivity of an "average" operating firm.*

Proof. *See online Technical Appendix.* ■

The most transparent manner to assess product and factor market competition is to exploit the multiplicative structure of the export revenue function of equation (2), which can be log-linearized. Unfortunately, the underlying country-industry CES price indexes $P_{x,ic}$ are unobservable. For this reason, we derive a version of the export revenue function in which export revenues are a function of observed average country-industry productivity and observed wages which include payments to the specific factor:

$$r_{x,fic}(\phi)=A_cA_i'(\phi_{fic})^{\sigma-1}\left[\overline{\phi}_{d,ic}\right]^{\frac{k(1-\sigma)(\sigma-\epsilon)}{k(\sigma-\epsilon)+(\epsilon-1)(\sigma-1)}}\left[w_c^{1-\eta}s_{ic}^{\eta}\right]^{\frac{k\sigma(\sigma-\epsilon)}{k(\sigma-\epsilon)+(\epsilon-1)(\sigma-1)}+1-\sigma}, \qquad (6)$$

where the constants A_i' and A_c are industry- and country-specific terms that do not depend on country-industry nor firm terms. The derivation of this expression and the precise definitions of the constants A_c and A_i' are presented in the online Technical Appendix. We now explore the empirical validity of the theory exposited above.

4 Empirical Results

This section explores the empirical predictions of Section 3 that, conditional on the direct effect of own productivity, a plant in a comparative advantage industry has a lower probability of exporting and exports lower volumes due to the indirect effect of industry productivity. We first describe the data employed and our measures of productivity. The following section presents empirical results that are inconsistent with the baseline model of firm heterogeneity. We then explore the factor and product-market competition channels between industry-level productivity and plant-level outcomes, conditional on own plant productivity. We conclude by exploring the robustness of our results.

4.1 Data

Plant-level data come from the statistical agencies *Instituto Nacional de Estadistica* and *Administrativo Nacional de Estadistica* for Chile and Colombia, respectively. These data have been used extensively in the trade literature.[9] Industry affiliation is at the ISIC 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. Table 1 presents summary statistics for the data including the total number of observations in each year and the country composition of each industry.[10] 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-level productivity. We prefer value added per worker as a measure of productivity, as opposed to total factor productivity,

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[9] E.g. Roberts and Tybout (1996), Levinsohn (1993), Hsieh and Parker (2007), Levinsohn and Petrin (2003, 2011), Hallak and Sivadasan (2009).

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

because of difficulties in comparing capital stocks across countries and time.[11] In order to compare productivity differences across countries, we ensure that the data are comparable. We want to remove non-productivity related relative price differences in value added. To do so we use 3-digit output deflators from the central bank of each country to put all value added data in 1980 constant country-specific pesos for each country.[12] We then use the December exchange rate for 1980 in each country to transform value added in each industry into non-PPP adjusted 1980 U.S. dollars.[13] 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 at the 3-digit ISIC level. As noted in Harrigan (1999), it is important to remove these price differences as deflators are constructed comparing similar goods such that price differences are unlikely to reflect quality differences. Because these deflators are country-industry specific, they will control for price differences that are not controlled for by the separate introduction of country and industry fixed effects. Because of our difference-in-difference strategy, all (multiplicative) country-specific and industry-specific terms in productivity (and in all outcome variables) will be differenced out. See the online Data Appendix for more details.

To calculate measures of value added per worker, we create measures of labor input. For each country, skilled and unskilled workers are proxied by non-production and production workers. We have verified that unskilled and skilled labor are similarly defined across Chile and Colombia. Production and non-production workers are weighted by their shares in the total wage bill by country and industry to create a Cobb-Douglas composite labor input. All of our results are robust to using firm-level factor shares. Because we rely on measures of

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[11] We have examined capital stock data for these two countries and have decided they are unusable in this context. Specifically, while flow variables such as value added and employment will not be affected by *past* inflation, measurement of stock variables such as capital can be affected by the high and variable inflation that affected both countries in the mid-1980s.

[12] The lack of plant-level prices in the context of estimating productivity is a common problem in the literature: productivity measures might reflect firm and plant price differences instead of efficiency variation. Recent work, including Katayama, Lu, and Tybout (2009) and Foster et al. (2008), presents evidence regarding the difficulties in using value measures of output per unit of inputs as measures of productivity. Foster, et al. (2008) indicate that revenue-based and physical productivities are highly correlated, are similarly dispersed, and present similar stylized facts in terms of plant survival. Unfortunately, decompositions of revenue-based and physical productivities cannot be easily done with most microdata, including ours.

[13] We put prices in PPP adjusted 1980 real dollars because this is the year for which the Penn World Tables provides the finest level of disaggregation in terms of the number of goods. The exchange rate was relatively stable in 1980 leading to insensitivity to different months.

real value added per worker, any differences in the effectiveness of labor that are pervasive across industries will be absorbed into the country fixed effect used in the estimation.

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. Because a small number of plants in an industry-country panel might lead to a collinearity problem between the plant and industry productivity measures, we drop industries with less than 25 plants in either country.[14] In addition, industry productivity is constructed excluding the plant in question. 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 with the remaining 84% due to within industry variation. To partially mitigate measurement error in the productivity measures, we instrument for plant-level value added per worker using its one year lagged value for the same plant. Table 2 presents industry-level log productivity differences demeaned by country averages, the standard deviation of log firm productivity within country-industry panels, and the proportion of active firms that export.

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) while we suppress the time subscript t. We start by estimating the probability of exporting as a function of plant- and industry-level productivity controlling for the relevant fixed effects:

$$Pr\left(r_{x,fic} > 0\right) = F\left(\beta_{plant}\phi_{fic} + \beta_{ind}\phi_{ic} + \beta_{\text{chile}}\text{chile}_c + \beta'_{ind}\Delta_i\right) + \nu_{fic}, \tag{7}$$

where $F(\bullet)$ is the logit operator, 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 Δ_i is a vector of industry-specific fixed effects that control for factors including, but

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[14] This leads to us dropping ISICs 361, 362, 371, and 372. Eslava et al. (2010) make an identical restriction on industry size.

not restricted to, world demand and scale at the industry level. All standard errors are heteroskedasticity consistent and clustered at the country-industry level to correct for the highly correlated values of industry productivity across plants within the industry.

Logit results are presented in table 3. We also estimate linear probability of exporting models for ease of interpretation. Own-plant productivity has a positive direct effect on the probability of exporting while industry productivity has a negative indirect effect. Under the baseline model of firm heterogeneity with small open economies, the coefficient on industry productivity for exporting probability should be zero as wages will be country-level fixed effects and industry-level demand shifters, including all CES price indexes on world markets, will be controlled for by industry-specific fixed effects.

Proposition 2 implies an important linear restriction on the coefficients ϕ_{fic} and ϕ_{ic}. Because the country possessing a Ricardian comparative advantage in an industry will export with a higher probability, we should observe $\beta_{plant} + \beta_{ind} > 0$. This restriction is a direct implication of Ricardian comparative advantage holding at the industry level. The p-values for this restriction are presented in the final row of this table. In unreported results, we find that only 6 percent of predicted probabilities fall outside of the zero to one range, suggesting that the linear probability model is a reasonable approximation to the logit.

The magnitudes in the linear probability model suggest that if plant productivity doubles holding productivity of peer firms constant, that plant's probability of exporting increases by 15 to 19 percentage points for 1990 and 1991, respectively. If the productivity of peer firms doubles holding productivity constant for a given plant, that plant's probability of exporting falls 8.6 to 14 percentage points for 1990 and 1991, respectively. Finally, if the productivity of all firms in an industry doubles, the probability of exporting for a representative firm increases by 7.4 to 5 percentage points for 1990 and 1991, respectively.[15] For reference, the unconditional probability of exporting in this sample for 1990-1991 is 0.22 for Colombia and 0.20 for Chile.

In the second specification, we analyze the value of exports as a function of own-plant

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[15] The final two magnitudes are simply the sum of the positive direct effect and the negative indirect effect.

productivity and industry productivity:

$$r_{x,fic} = \beta_{plant}\phi_{fic} + \beta_{ind}\phi_{ic} + \beta_{\text{chile}}\text{chile}_c + \beta'_{ind}\Delta_i + \varsigma_{fic}. \tag{8}$$

The country- and industry-specific constants, as well as the national wage w_c, will be absorbed by country- and industry-specific fixed effects. We start with results that present the direct effect of own plant productivity and the indirect effect of industry productivity on export performance. Table 4 shows that the qualitative results from table 3 continue to hold. Own plant productivity increases sales while the indirect effect of the productivity of other plants in the industry diminishes sales abroad. While the sign on industry productivity is of the sign predicted by theory for both years, the results for 1990 are indistinguishable from zero for export levels. However, these results become much stronger and uniform when we explicitly examine the product and factor market competition channels in section 4.3.

Figures 2-3 present this information graphically. In each graph, we purge the left-hand side variable from tables 3 and 4 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. Data in the figures are pooled for the years 1990 and 1991. Finally, we plot them against Chilean relative to Colombian industry productivity. Note that there is one observation for each industry-year such that each industry appears twice. Visual inspection suggests that no single industry is responsible for the patterns in the regressions results, although we explore this econometrically in the robustness section.

We are naturally concerned with possible reverse causality, i.e. exports affecting productivity. Although the mechanisms exposited in the firm heterogeneity literature take a strong stand that productivity causes exporting, the empirical literature is more nuanced.[16] We stress that the variable we are most interested in these estimations is industry-level and not plant-level productivity. Although if plant productivity suffers from endogeneity due

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[16] Bernard and Jensen (1999) find strong evidence of the sorting into exporting of the most productive firms. Conversely, Van Biesebroeck (2005) and De Loecker (2007) find evidence of increased productivity due to exporting. Trefler (2004) finds evidence of productivity gains both within firms and due to reallocation across firms in Canada following the Canada-U.S. Free Trade Agreement.

to reverse causation, the impact on the industry coefficient is not obvious. To partially address these concerns, industry productivity is constructed excluding the plant in question. In these specifications, arguments about the endogeneity of productivity in the cross section are less relevant because, for a given plant, the impact of other plants' productivity upon its export-related outcomes does not depend on the source of the productivity of other firms, merely that productivity differences exist and negatively impact the outcomes of the plant in question.

4.3 Decomposing Factor and Product-Market Competition

The results above suggest that plants of a given productivity level attain superior economic outcomes abroad when they reside in less economically competitive industries. However, the transmission mechanisms are unclear given that industry productivity can operate either through product- or factor-market competition in our model. In this section, we explore the roles that factor and product-market competition might play in generating these results by using the theoretically derived export revenue function, equation (6). As specified in the theory section, if two domestic varieties are more substitutable than a domestic and a foreign variety, high industry-level productivity in a country will contract the residual demand curve more for competing plants from the same country than for competitors from the foreign country leading to inferior exporting outcomes for the first set of competitors. If factors are industry-specific, a superior distribution of productivity in an industry bids up the wages of the specific factor leading to a lower probability of exporting and a lower level of exports conditioning on plant productivity.

The product-market competition hypothesis can be tested by imposing a specific structure on how the difference between "product- level" elasticity and "country-level" elasticity, $(\sigma - \epsilon)$, varies across industries. This difference captures the degree to which products are more substitutable within countries than across countries. We posit that for homogenous goods, for example commodities which are traded on world-wide exchanges, Chilean varieties are virtually indistinguishable from varieties produced by other countries, (i.e. $\epsilon \approx \sigma$). Conversely, we hypothesize that for differentiated goods it is the case that $\epsilon < \sigma$. This assumption is meant to reconcile two independent stylized facts. First, there exist goods that seem to be nationally differentiated consistent with the Armington assumption such that, on average, $\sigma > \epsilon$ as suggested by Feenstra, Obstfeld, and Russ (2010) and Imbs and Mejean (2009). However, for goods sold on organized exchanges, there is little room for national differentiation such that $\sigma \approx \epsilon$. These considerations lead us to hypothesize that $(\sigma - \epsilon)$ is lower for homogeneous goods and higher for more differentiated goods.

To empirically test the product-market competition channel we construct a variable that captures the nature of the good produced by industry i as relatively homogeneous or differentiated. For this we rely on the classifications of Rauch (1999). These classifications indicate if an industry is "homogeneous" (h), "reference priced" (r), or "differentiated" (d). We review these classifications in detail in the online Data Appendix. The final column of table 1 presents shares that reflect the degree to which an industry is composed of goods classified as differentiated.

We interact the percentage of differentiated goods in industry i $(\%\text{diff})_i$ with average productivity $\ln(\phi_{ict})$. Since our hypothesis implies that $(\sigma_d - \epsilon_d) > (\sigma_r - \epsilon_r), (\sigma_h - \epsilon_h)$ (where σ_d is σ for a differentiated good industry), we expect a negative sign on the interaction as country-industry productivity is likely to have more of a negative effect in industries where the relevant competitors are the other domestic producers. This can also be seen as the structural coefficient on industry productivity in equation (6) goes to zero when $\epsilon = \sigma$; this will be most likely when $(\%\text{diff})_i$=0 and there is little room for national differentiation.

Following equation (6), we control for factor market competition by explicitly introducing industry average wages as our measure of $w_c^{1-\eta} s_{ic}^{\eta}$. The country-specific mobile wage will be absorbed into the country-specific fixed effect, while industry average wages are measured by total salaries and benefits in the industry-country-year divided by total employment excluding the plant in question. Equation (6) also predicts that more differentiated industries lessen the negative effect of s_{ic} leading us to interact it with $(\%\text{diff})_i$ for consistency with the theoretical framework. The baseline equation of interest becomes:

$$\begin{aligned}\ln(r_{fict}) &= \beta_{plant}\ln(\phi_{fict}) + \beta'_{ind}\ln(\phi_{ict}) + \beta_{ind}\,(\%\text{diff})_i \times \ln(\phi_{ict}) \\ &\quad +\beta'_{ind\_wage}\ln(s_{ict}) + \beta_{ind\_wage}\,(\%\text{diff})_i \times \ln(s_{ict}) \\ &\quad +\beta_{\text{chile}}\text{chile}_{ct} + \beta'_{ind}\Delta'_{it} + \vartheta_{fict},\end{aligned}$$

where we include the time subscript due to the pooled nature of the results we present. To summarize, theory predicts that, because of product-market competition, $\beta_{ind} < 0$ and that, because of factor market competition, $\beta'_{ind\_wage} < 0$ and $\beta_{ind\_wage} > 0$.

Table 5 presents pooled results where robust standard errors are clustered by country-industry. The share of exports that are differentiated goods only varies by industry and is then collinear with the industry fixed effects and is dropped. Column (1) tests the product-market competition channel and finds that the negative coefficient on industry productivity is greater in absolute magnitude in industries with higher shares of differentiated exports. However, equation (6) suggests that industry wages should be included as an additional control. Column (2) includes factor market competition and finds that higher industry wages lead to lower export levels as predicted. This suggests that both factor market and product-market competition are at work in this sample. Column (3) shows that the coefficient on industry wages differs across Rauch classifications as predicted by theory as it is less negative for more differentiated industries. Evaluating the coefficient on industry productivity from column (3) at the average value of $\%\text{diff}_i$ delivers a value of -0.36 whose absolute value is less than the absolute value of the coefficient on plant productivity (0.80). This means that the direct effect dominates the indirect effect for industry productivity such that industry-level Ricardian predictions hold.

We can employ the coefficient estimates from column (3) of Table 5 to recover structural parameter values for an average sector. According to equation (6) the coefficient on plant productivity implies a value of σ of 1.8. By examining the standard deviation of log productivity within each country-industry-year panel, we can calculate a value for k=1.7. A very similar value is calculated using a log rank-log productivity regression to calculate k

as in Helpman, Melitz, and Yeaple (2004). We can then use our values of σ, k, and equation (6) to calculate ϵ=1.65. We note that while these estimates are similar to macroeconomic estimates of the elasticity of substitution, they are less than those based on import data at highly disaggregated levels. See Imbs and Mejean (2009) for a thorough discussion of these differences.

Table 6 presents these same regressions by year. Although the point estimates are less precise, similar results hold with respect to the pooled sample. Three additional points are worth making. First, the results for 1990 are in line with theory in this table, compared to the results of table 3. Second, the coefficients on industry productivity and industry productivity interacted with the differentiated share are *jointly* significant at the 10% level for column (4). Third, the coefficient on industry wage interacted with the differentiated goods is positive as predicted by theory although imprecisely estimated by year. Estimates of epsilon are similar to those reported based on table 5.

Are these calculated values of σ and ϵ consistent with coefficients estimated in past industry-level estimations of the Ricardian model? We can answer this by asking what the implied industry-level elasticity of exports with respect to industry productivity is based on a model where σ differs from ϵ. This can be done by solving for the theoretically appropriate $P_{x,ic}$ in terms of observed industry average productivity, exploiting the second tier CES relationship $\frac{R_{ic}}{R_{ic'}} = \left(\frac{P_{x,ic}}{P_{x,ic'}}\right)^{1-\epsilon}$, and predicting a reduced form coefficient based on the values of σ, ϵ, and k from table 5. [17] One should keep in mind that this exercise relies strongly on our Pareto functional form assumption and the reader should take note of this in interpreting these results.[18] Our estimates of these structural variables from column (1) of table 5 imply an industry-level elasticity of 0.43. This is between the industry Ricardian coefficients of 0.31 and 0.30 by Kerr (2009) and Morrow (2010), respectively, and coefficients in the neighborhood of unity estimated by Costinot, Donaldson, and Komunjer

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[17] Referring to equations in the online Technical Appendix, this is done by solving for $\frac{P_{x,1c}}{P_{x,2c}}$ in terms of $\frac{\bar{\phi}_{d,1c}}{\bar{\phi}_{d,2c}}$ using equations (A.6) and (A.9)-(A.12) in the online Technical Appendix.

[18] Combes, Duranton, Gobillion, Puga, and Roux (2011) find evidence using French firm-level data that productivity is better approximated by a mix between the log-normal and Pareto distributions with a majority of the weight being assigned to the log-normal distribution. Integrating such a mix with the market structure outlined here is beyond the scope of this paper.

(2011) although Kerr (2009) and Costinot, Donaldson, and Komunjer (2011) use bilateral trade data and Morrow (2010) uses production data.

We are naturally concerned about the role that measurement error might play in our finding that the direct effect of firm productivity is stronger than the full industry effect that integrates both direct and indirect effects. Specifically, suppose that measurement error arises from accounting differences that lead to differences in physical quantities counted or measurement error in inputs. If this type of measurement error is driving our results, we should find it uniformly across industries. Because section 4.3 finds that this effect is more common in differentiated industries, we do not believe that measurement error of the first type is driving our results. Rather, it is the imperfect substitutability of goods across borders that we explicitly model along with factor market competition that drives an industry-level effect that is smaller than the direct effect of own firm productivity.

4.4 Robustness

We explore the robustness of our results in two ways. For brevity, the tables illustrating these results are relegated to the online Technical Appendix. Due to the relatively small number of industries upon which our analysis is based, we are concerned about the stability of our results. Table A1 replicates table 5 except that industries are dropped one by one to show that the results involving the Rauch classifications are not overly sensitive to a single industry. For all specifications, the coefficient on industry productivity interacted with percent differentiated is negative as indicated by theory. In addition the coefficients on industry wage and industry wage interacted with percent differentiated are negative and positive as indicated by theory although point estimates for the latter are imprecise. Table A2a presents baseline specifications including a quadratic term for own plant productivity to control for non-log-linear effects for which industry productivity may be proxying. The coefficient on industry productivity changes little relative to the results in tables 2 and 3. Table A2b shows that the results involving Rauch classifications are robust to these higher order terms as well.

5 Conclusion

This paper provides a 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 for a given firm 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. In doing so, we complement the established literature on industry-level Ricardian outcomes with a richer depiction of the underlying market structure in the context of firm heterogeneity.

Using plant-level data for Chile and Colombia for 1990 and 1991, we find the common result that own firm productivity enhances exporting outcomes, but we also identify a negative indirect effect of higher peer firm productivity that worsens exporting outcomes for firms of a given productivity level. We model and empirically scrutinize two channels for these results. First, we introduce imperfect relative substitutability using a nested-CES with a modified Armington assumption approach in which two varieties produced within the same border are better substitutes on international markets than two varieties produced in different markets. Consequently, a higher level of relative productivity in an industry for a given country will contract residual demand for all other firms in the industry. However, demand will contract more for firms producing relatively more substitutable varieties. Second, we introduce factor market competition involving factors of production that are immobile across industries within a country. Comparing industry-specific wages across countries, higher relative productivity levels in one country increase the wage of the factor that is specific to that industry. Higher wages increase sunk, fixed, and marginal costs of production and exporting leading to a lower probability of exporting and lower levels of exporting conditional on own firm productivity.

Avenues for future research are plentiful. First, we can ask how the short run specificity of factors at the industry-level can diminish the gains from trade liberalization given firm heterogeneity within those industries. Second, we are only able to examine differential substitutability between home and foreign varieties from the supply side. We would ideally like to examine it from the demand side as in Broda and Weinstein (2006), while allowing for price variation both within and across origin countries for a given good. While Feenstra, Obstfeld, and Russ (2010) and Imbs and Mejean (2009) offer preliminary contributions in this field, we hope that the increased availability of cross country transaction-level data will facilitate this research.

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Table 1

Data Summary

	1990			1991			
ISIC	#Chile	# Colombia	Total	# Chile	# Colombia	Total	Differentiated Share
311-Food products	654	751	1405	642	707	1349	0.066
312- Misc. food products	34	154	188	34	148	182	0.292
321-Textiles	210	380	590	210	361	571	0.494
322-Wearing apparel	153	716	869	142	652	794	1.000
323-Leather products	31	86	117	30	83	113	0.891
324-Footwear	66	201	267	66	195	261	1.000
33-Wood products exp. furniture1	131	136	267	123	118	241	0.954
332 Furniture	52	171	223	52	159	211	1.000
341-Paper and products	33	137	170	35	127	162	0.025
342-printing and publishing	83	296	379	88	282	370	1.000
351Industrial chemicals	27	125	152	27	120	147	0.006
352-Other chemicals	107	270	377	107	262	369	0.982
355-Rubber products	32	61	93	32	59	91	1.000
356-Plastic products	92	293	385	90	288	378	1.000
369-Other mineral products	60	246	306	60	231	291	0.494
381-Fabricated metal	211	462	673	204	431	635	1.000
382-Machinery, exp. electric	85	287	372	81	272	353	1.000
383-Machinary, electric	28	187	215	29	169	198	1.000
384-Transport Equip.	54	201	255	52	185	237	1.000
390-Misc. Products	35	139	174	33	122	155	0.842
Total	2178	5299	7477	2137	4971	7108	

Table 2

Productivity and Exporting Statistics

	Chile			Colombia		
Industry	VA per Worker	Std. Dev.	Pr($exp > 0$)	VA per Worker	Std. Dev.	Pr($exp > 0$)
311	0.28	0.8	0.11	0.57	0.73	0.08
312	1.94	0.82	0.37	0.72	0.83	0.11
321	-0.72	0.57	0.22	0.41	0.69	0.25
322	-0.96	0.47	0.11	-0.51	0.39	0.17
323	-0.07	0.93	0.15	-0.57	0.51	0.57
324	-0.64	0.49	0.3	-0.83	0.44	0.35
331	-0.02	0.54	0.18	0.64	0.46	0.11
332	0.05	0.51	0.13	-0.6	0.28	0.06
341	1.47	0.96	0.31	0.59	0.84	0.2
342	-0.59	0.65	0.09	-0.69	0.45	0.12
351	0.64	0.6	0.48	2.2	0.77	0.38
352	0.82	0.66	0.45	1.66	0.77	0.27
355	0.73	0.6	0.27	0.45	0.71	0.28
356	0.51	0.52	0.19	0	0.56	0.24
369	1.2	0.79	0.16	0.53	0.72	0.1
381	-0.39	0.6	0.19	-1.03	0.54	0.18
382	-0.66	0.56	0.16	-0.91	0.51	0.24
383	0.06	0.66	0.23	-0.7	0.77	0.27
384	-0.08	0.57	0.11	-0.26	0.61	0.17
390	-0.48	0.34	0.12	0.33	0.58	0.33

(log) industry productivity is demeaned by the country average.

Table 3

Propensity to Export

[Dependent variable =1 if the plant exports and =0 otherwise]

	1990				1991			
	Logit		OLS		Logit		OLS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(log) VA per Worker$_{fic}$	1.18***	1.26***	0.14***	0.15***	1.28***	1.40***	0.18***	0.19***
	(0.077)	(0.085)	(0.014)	(0.015)	(0.10)	(0.10)	(0.016)	(0.018)
(log) VA per Worker$_{ic}$		-0.63*		-0.085*		-0.98***		-0.14***
		(0.32)		(0.047)		(0.26)		(0.041)
Observations	7477	7477	7477	7477	7108	7108	7108	7108
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
R^2	0.13	0.14	0.11	0.12	0.15	0.16	0.15	0.15
Restriction p-val		0.027		0.12		0.087		0.19

Robust and clustered standard errors in parentheses. Clustered standard errors by country-industry panel (e.g. Chile 311). *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Logit results include pseudo R^2 statistics.

Table 4

Export Revenue

[Dep. variable=(log) export value]

	1990		1991	
	(1)	(2)	(3)	(4)
(log) VA per Worker$_{fic}$	0.75***	0.78***	0.81***	0.87***
	(0.11)	(0.11)	(0.10)	(0.11)
(log) VA per Worker$_{ic}$		-0.19		-0.55**
		(0.26)		(0.27)
Observations	1251	1251	1491	1491
Industries	20	20	20	20
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
R^2	0.19	0.19	0.19	0.20
Restriction p-val		0.033		0.19

Robust and clustered standard errors in parentheses. Clustered standard errors by country-industry panel (e.g. Chile 311). ***p<0.01, ** p<0.05, * p<0.1.

Table 5

Identification through Rauch Classification (Pooled)

[Dep. variable=(log) export value]

	(1)	(2)	(3)
(log) VA per Worker$_{fict}$	0.82***	0.80***	0.80***
	(0.091)	(0.089)	(0.089)
(log) VA per Worker$_{ict}$	0.0045	0.42	0.52
	(0.31)	(0.32)	(0.36)
(log) VA per Worker$_{ict}$	-0.69*	-1.16***	-1.27***
x (% diff)$_i$	(0.35)	(0.43)	(0.47)
(log) Wage per Worker$_{fict}$		-1.85*	-2.69**
		(1.05)	(1.14)
(log) Wage per Worker$_{fict}$			0.80*
x (% diff)$_i$			(0.44)
Implied σ	1.82	1.80	1.80
Implied ϵ	1.47	1.56	1.65
Observations	2742	2742	2742
Industries	20	20	20
Industry-Year FE	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes
R^2	0.20	0.20	0.20

Robust and clustered standard errors in parentheses. Clustered standard errors by country-industry panel (e.g. Chile 311, 1990). ***p<0.01, ** p<0.05, * p<0.1.

Table 6

Identification through Rauch Classification (Annual)

[Dep. variable=(log) export value]

		1990			1991	
	(1)	(2)	(3)	(4)	(5)	(6)
(log) VA per Worker$_{fict}$	0.77***	0.77***	0.77***	0.87***	0.87***	0.87***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
(log) VA per Worker$_{ict}$	0.21	0.34	0.45	-0.25	-0.044	0.17
	(0.30)	(0.39)	(0.44)	(0.34)	(0.25)	(0.31)
(log) VA per Worker$_{ict}$	-0.79**	-0.95*	-1.04*	-0.56	-0.81**	-0.95**
x (% diff)$_i$	(0.34)	(0.55)	(0.55)	(0.43)	(0.37)	(0.35)
(log) Wage per Worker$_{fict}$		-0.57	-1.87		-0.94	-5.04
		(1.28)	(2.77)		(1.12)	(3.26)
(log) Wage per Worker$_{fict}$			1.34			4.40
x (% diff)$_i$			(2.96)			(3.33)
Implied σ	1.77	1.77	1.77	1.87	1.87	1.87
Implied ϵ	1.57	1.59	1.62	1.36	1.40	1.53
Observations	1251	1251	1251	1491	1491	1491
Industries	20	20	20	20	20	20
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.20	0.20	0.20	0.20	0.20	0.20

Robust and clustered standard errors in parentheses. Clustered standard errors by country-industry panel (e.g. Chile 311). ***p<0.01, ** p<0.05, * p<0.1.

Figure 1: Destination Markets for Chilean and Colombian Exports

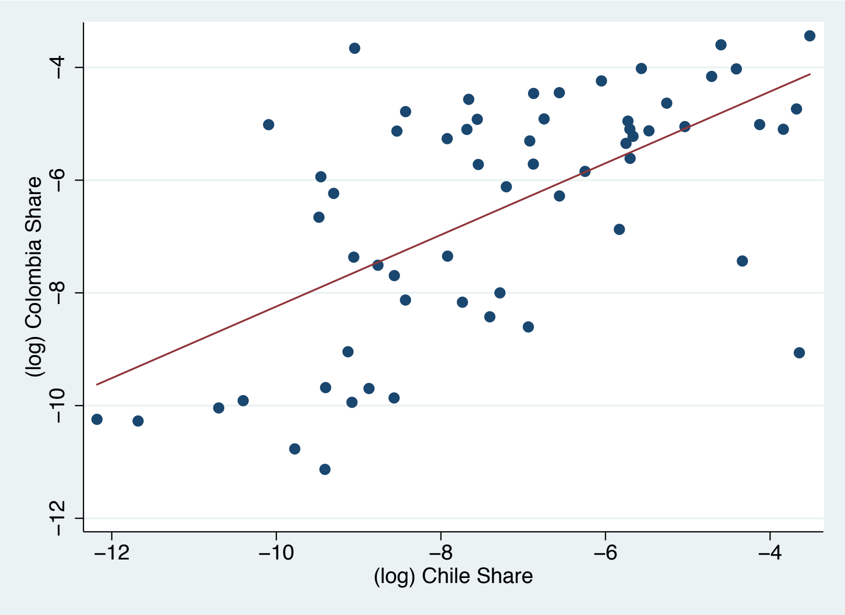

Figure 2: Negative Impact of Industry Productivity on Firm Export Decision

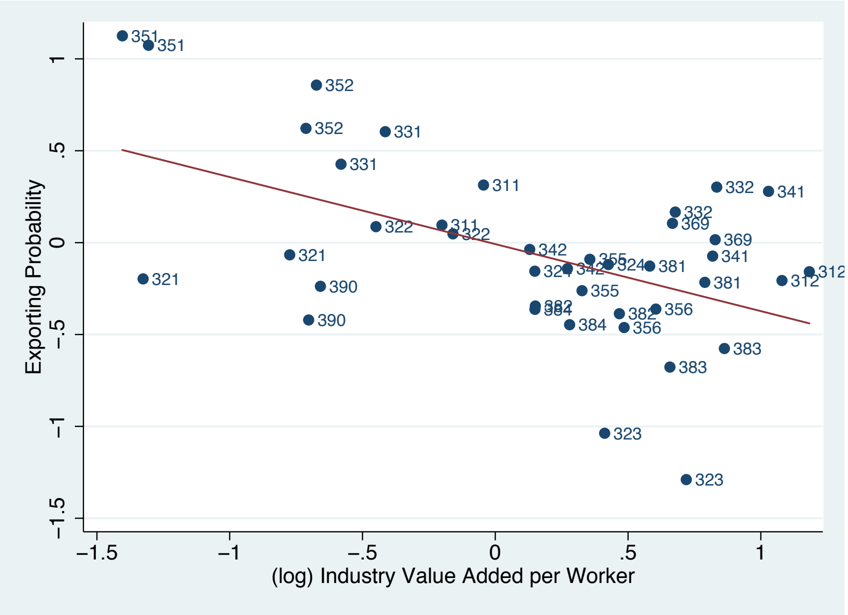

Figure 3: Negative Impact of Industry Productivity of Firm Export Volumes