Darwinian effect on Firms' Export Decision.

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Abstract

We develop a theoretical framework for a novel industry level effect "Darwinian Effect": lower industry level opportunity cost has a negative effect on export revenues for firms serving that industry, relative to other industries. This effect arises from an industry level relative productivity improvement that leads to a lower opportunity cost. Lower opportunity cost decreases the relative price index of the industry thus increasing the relative competitiveness of the sector. As a result, the probability of firm level export participation falls in the industry. We test this prediction using plant level data from Chile and Colombia; finding support for our hypothesis.

1 Introduction

Melitz (2003) suggests that firm's productivity is an important determinant of its export decision. One can aggregate up firm level productivity to get the industry level productivity. But how does industry level productivity interact with a firm's export participation? On one hand, improvement in the industry level productivity, *ceteris paribus*, implies higher export activity in the industry. If an industry has higher export activity, then the non-exporting firms can learn more from their competitors, and there will be greater spillover effect (see for example, Bernard & Jensen (2004)). Greater spillover effect implies greater chances of export participation. Spillover effect is well studied in the extant literature. On the other hand, improvement in industry level productivity, *ceteris paribus*, implies lower opportunity cost relative to other sectors in the economy. As the relative opportunity cost falls, the industry can utilize scare resources more efficiently relative to other sectors in the economy. Higher relative efficiency in a sector translates into lower relative price index in the output market and thus greater competition. As the competitiveness in a sector increases, a firm's export participation is expected to decline, after controlling for its rank in the productivity distribution. In this article, we focus on this latter channel by extending the Melitz (2003) framework into a two-sector partial equilibrium setting. We show that improvement in relative productivity in an industry leads to greater competition, and thus lower export participation -what we term to be the "Darwinian effect".

Melitz (2003) considers a single sector with heterogeneous firms and maps firm level productivity into a firm level price. There is a negative association between productivity and price. Aggregating up to the industry level, there is a negative association between the industry level productivity and the aggregate price index. Here we extend Melitz (2003) to a two-sector model and map relative industry level productivity into relative aggregate price index. The relative productivity has a negative association with the relative aggregate price index. For two identical firms serving in different industry, we show that an increase in relative productivity reduces relative prices and thus increases competitiveness. Higher competitiveness lowers relative export revenue, which reduces the chances of export participation for the firm serving the industry with relative productivity improvement. We find empirical support for our theoretical prediction using plant-level panel data from Chile and Columbia.

Note that improvement in relative productivity implies lower opportunity cost. And according the Ricardian model, lower opportunity cost is associated with greater exports from the sector, in a general equilibrium set up. However, here we find that lower industry level opportunity cost has a negative effect on the firm level export decision. Hence the Darwinian effect illustrates a paradox: lower opportunity cost reduces firm level export participation but increases industry level export activity.

2 Model

We look at a partial equilibrium model with firm level heterogeneity. The economy has 2 sectors indexed by 1 and 2. These industries are identical in every dimension. We assume foreign countries aggregate price indices are exogenous to exporters and are not equal. This difference in foreign price index results in different level of competition in export markets for industry 1 and 2. In the preceding section we first look at the demand side of the model at home country.

2.1 Demand

Individual has a Cobb-Douglas preference over industry output[1].

$$U = Q_1^{\frac{1}{2}} Q_2^{\frac{1}{2}} \tag{1}$$

These industry outputs are the CES aggregate of available variety. Hence, Q_i is given by:

$$Q_i = \left[\int_{\phi_i \varepsilon \Omega_i} q_i(\phi_i)^{\frac{\sigma-1}{\sigma}} d\phi_i \right]^{\frac{\sigma}{\sigma-1}} \quad \text{for } i = 1, 2 \tag{2}$$

[1] Using a general exponent, such as $\beta_i \varepsilon (0, 1)$ that makes the utility homogenous of dergee one, works fine.

Ω_i pins down the active mass of firms in industry i. $\sigma > 1$ is the constant elasticity of substitution that is same across industries[2]. Since the upper tire of the utility assumes Cobb-Douglas, half of the aggregate income is used to consume the industry basket that has all the varieties. Hence if the aggregate income is R, the demand for a variety $q_i(\phi_i)$ is given by:

$$q_i(\phi_i) = \frac{1}{2} R P_i^{\sigma-1} p_i(\phi_i)^{-\sigma} \quad \text{for } i = 1, 2 \tag{3}$$

where, P_i is i industry's aggregate price index and $p_i(\phi_i)$ is the price of the variety. The expression for the aggregate price index is then given by:

$$P_i^{1-\sigma} = \int_{\phi_i \epsilon \Omega_i} p_i(\phi_i)^{1-\sigma} d\phi_i \quad \text{for } i = 1, 2 \tag{4}$$

This index is the price of the industry basket with all the available variety.

2.1.1 Export Demand

Demand for home country's exported variety depends on foreign country's aggregate income (R_f) and aggregate price indices (P_{1f}, P_{2f}). Home exporters take these parameters as given and can only export if the exporter's price indices are smaller compared to foreign price indices. In this paper we assume this is true ($P_{ix} < P_{idf}$ for $i = 1, 2$) and there is always some firms with high enough productivity in home country who can export. Hence, the exporter's demand can be expressed as,

$$q_{ix}(\phi_i) = R_f P_{if}^{\sigma-1} p_{ix}(\phi_i)^{-\sigma} \text{ for } i = 1, 2 \tag{5}$$

$p_{ix}(\phi_i)$ is the price charged by exporters in the foreign market. Hence, we find demand for an export variety depends directly on foreign aggregate income and price index[3]; but effects indirectly on firms' own price.

2.2 Supply

Firms draws their productivity, ϕ_i, for a period from a Pareto distribution $g(\phi_i) = \frac{\alpha}{\phi_i^{\alpha+1}}$ $\forall \phi_i > 1$ that is same across industries. They pay a fixed cost of production, f, if they want to serve the local market. To serve the export market they pay a fixed cost to export $f_x > f\tau^{1-\sigma}$. An exporter pays an additional cost of tariff $\tau > 1$. If the observed productivity is high enough, they self select themselves to be exporters. Other wise, they serve domestic market only. Firms serve in a monopolistically competitive output market and uses labor ($l_i(\phi_i) = \frac{q_i(\phi_i)}{\phi_i} + f$) as a factor of production, where the labor market is perfect. We assume workers are homogenous and can move freely across

[2] Elasticity of substitution can be different across industries. However, to keep our analysis simple we assume it is same across industries.

[3] The foreign price index is raised to $(\sigma - 1)$ for simplification of the equlibrium expression.

industries; as a result both industries offer same wage. Hence, firms' optimal pricing strategy is $p_i(\phi_i) = \frac{\sigma}{\sigma-1}\frac{w}{\phi_i}$, where w is the equilibrium wage. If a firm decides to export a variety the pricing strategy is $p_{ix}(\phi_i) = \tau p_i(\phi_i)$; where, τ is the tariff/transportation cost[4]. The expression for revenue looks similar to Melitz, $r_i(\phi_i) = \frac{1}{2}R\left(\frac{\sigma}{\sigma-1}\frac{w}{\phi_i}\right)^{1-\sigma} P_i^{\sigma-1}$ and the expression for profit is then,$\pi_i(\phi_i) = \frac{r_i(\phi_i)}{\sigma} - f$ for i=1,2. Similarly, the export revenue is given by, $r_{ix}(\phi_i) = R_f\left(\frac{\sigma}{\sigma-1}\frac{w\tau}{\phi_i}\right)^{1-\sigma} P_{if}^{\sigma-1}$ and profit from exporting has the following expression.

$$\pi_{ix}(\phi_i) = \frac{r_{ix}(\phi_i)}{\sigma} - f_x \text{ for } i = 1, 2 \tag{6}$$

It is obvious to notice from this that firms' revenue and profit has a positive relation with own productivity. Hence, a firm serves in export market only when they observe a positive profit opportunity. This can be used to pin the marginal exporting firm that makes zero profit ($\pi_{ix}(\phi^*_{ix}) = 0$) and the revenue of cutoff firm is then, $r_{ix}(\phi^*_i) = \sigma f_x$. This pins down the minimum productivity required to serve in the export market given market conditions of an industry at a foreign location. As a result, the equilibrium productivity distribution of domestic producers is $\frac{g(\phi)}{1-G(\phi^*)} = \frac{\alpha{\phi^*}^\alpha}{\phi^{a+1}}$ for all $\phi{>}\phi^*$ and exporters distribution is $\frac{g(\phi)}{1-G(\phi^*_x)} = \frac{\alpha{\phi^*_x}^\alpha}{\phi^{a+1}}$ for all $\phi{>}\phi^*_x > \phi^{*}$[5].

Hence, in equilibrium the aggregate price index of exporters is given by, $P_i^{1-\sigma} = \int_{\phi^*}^{\infty} M_i p_i(\phi)^{1-\sigma}\frac{\alpha{\phi^*_i}^\alpha}{\phi^{a+1}}d\phi$. M_i is the active mass of firms and is pinned down by the market clearing condition, $M_i = \frac{\frac{1}{2}R}{r_i(\widetilde{\phi}_i)}$. Note that $r_i(\widetilde{\phi}_i)$ is the revenue of average firm serving in industry i. Similarly, exporters price index is given by:

$$P_{ix}^{1-\sigma} = \int_{\phi^*_{ix}}^{\infty} M_{ix} p_{ix}(\phi)^{1-\sigma}\frac{\alpha{\phi^*_{xi}}^\alpha}{\phi^{a+1}}d\phi \text{ for i=1,2} \tag{7}$$

Note that, $M_{ix} = p_{xi}M_i$ and $p_{xi} = \left(\frac{\phi^*_i}{\phi^*_{xi}}\right)^\alpha$ is the probability of a firm being an exporter given it survives domestic competition. Hence, it is the average price of all exporters from home country.

[4] We assume both industries face symmetic tariff rate. This assuption can be relaxed. However, our data sets do not have information on destination specific tariff rates. As a result we cannot test how firms' export changes with it and restrict our analysis only to symmetic tariff rate.

[5] It is possible to show that the aggregate productivity index in industry i is then, $\widetilde{\phi}_i^{\sigma-1} = \int_{\phi^*_i}^{\infty}\phi_i^{\sigma-1}\frac{\alpha\phi^*_i}{\phi^{\alpha+1}}d\phi_i = \frac{\alpha}{\alpha-(\sigma-1)}{\phi^*_i}^{\sigma-1}$ for i=1 & 2. But, exporters index is $\widetilde{\phi}_{ix}^{\sigma-1} = \frac{\alpha}{\alpha-(\sigma-1)}{\phi^*_{ix}}^{\sigma-1}$ for i=1 & 2.

2.3 Relative revenue and Industry Opportunity Cost

Lets consider 2 firms with identical productivity level ($\phi_1 = \phi_2 = \overline{\phi}$) who serve in export market of different industries. Hence, price charged by these firms are same as well; $p_{1x}(\overline{\phi}) = p_{2x}(\overline{\phi}) = \frac{\sigma}{\sigma-1}\frac{w\tau}{\overline{\phi}}$. Note that we are assuming tariff faced by firms in different industries are identical. Under these conditions the relative demand for their varieties across industries is $\frac{q_{1x}(\overline{\phi})}{q_{2x}(\overline{\phi})} = \left[\frac{P_{1f}}{P_{2f}}\right]^{\sigma-1}$ and it depends only on the foreign aggregate price indices. This can be expressed as relative revenue since prices charged by these firms are identical.

$$\frac{r_{1x}(\overline{\phi})}{r_{2x}(\overline{\phi})} = \left[\frac{P_{1f}}{P_{2f}}\right]^{\sigma-1} \tag{8}$$

Note that foreign aggregate price indices are an average of their price index of locally produced variety (P_{idf}), that is exogenous to home exporters, and imported variety (P_{ix}) from home. We make a simplifying assumption that the total price index in the foreign is a geometric mean of these price indices. Hence, we can express the foreign price index as; $P_{if}^{\sigma-1} = (P_{ix}P_{idf})^{\frac{\sigma-1}{2}}$[6]. However to say anything about industry opportunity cost, we need to understand how exporters price index is related to their industry aggregate price index at home.

Claim 1 *Home exporter's price index ($P_{ix}^{1-\sigma}$) can be expressed as home aggregate price index ($P_i^{1-\sigma}$) and is given by* $P_{ix}^{\sigma-1} = (\tau P_i)^{\alpha}\left(\frac{A}{P_{if}}\right)^{\alpha-(\sigma-1)}$; *where,* $A = \left[\left(\frac{R_f}{\frac{1}{2}R}\right)^{-1}\frac{f_x}{f}\right]^{\frac{1}{\sigma-1}}$.

A detail proof of the claim can be found in the appendix. Using Claim 1, we can simplify the expression for relative price index of foreign in equation (8). This implies the relative foreign price index takes the form: $\frac{r_{1x}(\overline{\phi})}{r_{2x}(\overline{\phi})} = \left[\frac{P_{1f}}{P_{2f}}\right]^{\sigma-1} = \left[\frac{P_{1df}}{P_{2df}}\right]^{\frac{(\sigma-1)^2}{(\sigma-1)+\alpha}}\left[\frac{P_1}{P_2}\right]^{\frac{\alpha(\sigma-1)}{(\sigma-1)+\alpha}}$[7]. Now, the expression for relative exporters revenue depends on the relative aggregate price index in the foreign. In the next step, we express relative price index at home as relative productivity.

Claim 2 *There is an inverse relationship between relative aggregate price index and aggregate productivity index* ($\frac{P_1}{P_2} = \left(\frac{\tilde{\phi}_1}{\tilde{\phi}_2}\right)^{-1}$).

[6] We use geometric mean to make the model tractable.

[7] Note that, $\left[\frac{P_{1f}}{P_{2f}}\right]^{\sigma-1} = \left[\frac{P_{1df}}{P_{2df}}\right]^{\frac{(\sigma-1)}{2}}\left[\frac{P_1}{P_2}\right]^{\frac{\alpha}{2}}\left[\frac{P_{1f}}{P_{2f}}\right]^{\frac{\alpha-1-\sigma}{2}}$. Since both sides have a common term, we can simplify this.

Check appendix for detail proof. Using claim 2 we can find that $\left(\frac{P_1}{P_2}\right)^{\frac{\alpha(\sigma-1)}{(\sigma-1)+\alpha}} = \left(\frac{\widetilde{\phi}_1}{\widetilde{\phi}_2}\right)^{\frac{\alpha(1-\sigma)}{(\sigma-1)+\alpha}}$. Finally, we can express the relative exporting revenue as:

$$\frac{r_{1x}(\overline{\phi})}{r_{2x}(\overline{\phi})} = \left[\frac{P_{1df}}{P_{2df}}\right]^{\frac{(\sigma-1)^2}{(\sigma-1)+\alpha}} \left(\frac{\widetilde{\phi}_1}{\widetilde{\phi}_2}\right)^{\frac{\alpha(1-\sigma)}{(\sigma-1)+\alpha}} \tag{9}$$

Proposition 3 *If 2 firms observe identical productivity level and they serve in different industries, then under Pareto distribution the relative revenue of these firms decrease with an increase of relative industry average productivity.*

Proof. From equation (9) we can find $\frac{d\frac{r_{1x}(\overline{\phi})}{r_{2x}(\overline{\phi})}}{d\frac{\widetilde{\phi}_1}{\widetilde{\phi}_2}} = \left[\frac{P_{1df}}{P_{2df}}\right]^{\frac{(\sigma-1)^2}{(\sigma-1)+\alpha}} \frac{\alpha(1-\sigma)}{(\sigma-1)+\alpha} \left(\frac{\widetilde{\phi}_1}{\widetilde{\phi}_2}\right)^{\frac{\alpha(1-\sigma)}{(\sigma-1)+\alpha}-1} < 0$. This expression is negative since we assume $\sigma > 1$. ■

From the last step, it becomes obvious to notice that firms profit reduces as the opportunity cost goes down. Hence, holding everything else constant a firm serving in an industry with lower opportunity cost implies lower profit and firms tend to participate less in the export market.

2.4 Darwinian Effect

As we can see from the above comparative static exercise, the relative revenue of two firms with identical productivity level but serving in different industries is indirectly related to relative industry level aggregate productivity indices. Since decrease in revenue results in lower profit by equation (6), it is obvious that results in lower participation in the export market. At this point we feel that we owe a formal definition of this effect; since, to our knowledge none has formally talked about this effect in the literature.

Definition 4 *An increase in relative industry productivity indices (or a decrease in opportunity cost) results in lower relative aggregate price index and higher competition. Holding everything else constant, when firms have identical productivity level but serve in different industries, higher competition induces less participation in the export market. This effect is defined as Darwinian effect*[8].

It is important to understand the mechanism that causes this effect. As we have mentioned above, it all starts by an increase in an industry productivity relative to another industry. Improvement in industry productivity is casued by some exogenous factor: such as change in foreign market condition (P_{idf}). This change makes the foreign market more competitive and as a result less productive exporters now cannot serve in this market.

[8] Similar effect can be defined for domestic market as well.

As the industry level productivity rises, following Melitz (2003), the aggregate price index falls and the export market of such industry becomes competitive. This increases the minimum required productivity for the marginal exporter that makes zero profit. Hence, a decrease in OC for an industry sorts better firms compared to other industries. This tends to trim some of the fat from the industry and makes it relatively efficient compared to other industries. As a result firms participation in the export market becomes harder if the OC of an industry goes down.

It is worth mentioning that lower OC in the context of Neoclassical trade models results in Comparative Advantage, henceforth CA, and implies higher industry export. Since we are in a partial setting we cannot claim CA from lower OC[9]. However at the partial setting, an industry with lower OC exports more compared to other industries. Then how come at the firm level lower OC implies less likely to export? If it is true then who is exporting that results in higher export volume in the industry level?

One possible answer to this dilemma might lie on the distribution of firms productivity. May be couple of the firms with export status are extremely productive compared to their competitor in the industry. As a result, the industry observes a lower OC and simultaneously industry export volume is higher as well. Another possible explanation may come from Spillover effect. As mentioned previously both Spillover and Darwinian effect results from industry productivity improvement. If Spillover effect always dominates then it is possible to rectify this dilemma[10].

3 Data

We use 2 different data sets to test our hypothesis. These are Chilean and Colombian Plant level census data of their manufacturing sector only. The two digit industry classification of these countries are similar and the description of these industries are presented in Table 1. In the subsections we will discuss these data sets separately.

[9] An industry with CA implies higher mass of exporters (check Fan, Lai & Qi (2011)). Hence, how CA interacts with firms' export decision is an open question.

[10] Which one of these effects dominates still remains an open question.

Table 1

2 digit code and description of the industry	
SIC 2	2 digit industry description
31	Food, Beverages and Tobacco
32	Textile, Wearing Apparel and Leather Industries
33	Wood and Wood Products, Including Furniture
34	Paper and Paper Products, Printing and Publishing
35	Chemicals and Chemical, Petroleum, Coal, Rubber and Plastic Products
36	Non-Metallic Mineral Products, (except of Petroleum and Coal)
37	Basic Metal Industries
38	Fabricated Metal Products, Machinery and Equipment
39	Other Manufacturing Industries

Every 2 digit industries and then classified into 3 digit sub-industries. In this paper a plant changing their 3 digit industry code is identified as an exiting firm.

3.1 Chilean Plants

The data was collected by a statistical agency, Instituto Nacional de Estadistica. It has been extensively used in trade literature. It is an unbalanced panel of 10,927 plants over the period of 1979 to 1996.

The data set uniquely identifies these plants with at least 10 or more workers. Since the data includes all the plants with at least 10 workers, an exit from the data set does not imply exit from the industry in reality; however, we model it as an exiting firm. After we define exit decisions based on the data set, we observe a total of 5,461 exiting0 and 7,132 exporting events. One important dimension of the data is that it has export information from 1990-96.

The data set consists of plant level factor input information, such as skilled and unskilled labor, investments in machinery, land, real estate, fixed asset, total asset etc. On the other hand, it has information on firms sales, inventories, profit/loss, gross output etc. The data set also have information on firms' import decision. These imports are their raw material used in production.

We also collected data on consumer price index from Chilean Central Bank website. This helps us to construct inflation rate. Finally, we used this data to construct inflation adjusted variables. All the variables are expressed in terms of 1979 Chilean Peso.

3.2 Colombian Plants

The data is collected from Colombian Industrial Survey. The data set is an unbalanced panel of 17,763 plants served during 1977-91 and has total of 103,010 data points of manufacturing sector only. It has information on firms employing worker from 0 to 7,395; hence, a plant not in the survey implies exit decision for the plant. The data set do not identify plants uniquely across years. However, it is possible to use end and beginning of year state variables to assign unique ID to plants and form a panel data set[11].

The data set has export decisions from 1982. Total number of export events during this period is 9,446 and total exit decision is 10,459. It also has information on purchase of fixed assets, production of assets, value of sales of fixed assets, etc. Using these variables along with depreciation information we can construct capital and investment information by individual firms. Usage of energy and beginning of the year raw materials gives us the intermediate input. Lastly, the data set has information on firms total sales as an indicator of revenue.

We also collected data on consumer and producer price index from Colombia Central Bank website. From this we can construct inflation information to construct inflation adjusted variables. All the variables are expressed in 1977 Colombian Peso.

4 Empirical Methodology

Empirically we face two different challenges; estimating firms' TFP and estimating the likelihood function using fixed effect logit and linear probability model with fixed effects. We proceed by explaining the techniques used to estimate the TFP and then follow it by the likelihood estimation.

4.1 TFP estimation

Estimation of the total factor productivity begins with identifying the production function. Suppose firm i produces output Q_{ijt} at time t and serves in the industry j. A firm has three factor inputs: a) labor (L_{ijt}), b) capital (K_{ijt}) and c) intermediates (M_{ijt}). Suppose they all face a Cobb-Douglas production function, $Q_{ijt} = \varphi_{ijt} L_{ijt}^{\alpha_l} K_{ijt}^{\alpha_k} M_{ijt}^{\alpha_m}$; where the TFP is identified by φ_{ijt}. Taking natural log to this production function leads to the basic estimation equation: $q_{ijt} = \alpha_{0+}\alpha_l l_{ijt} + \alpha_k k_{ijt} + \alpha_m m_{ijt} + \omega_{ijt} + \varepsilon_{ijt}$, where I assume that $\varphi_{ijt} = \exp(\alpha_0 + \omega_{ijt} + \varepsilon_{ijt})$[12]. α_0 is the time invariant measure of average productivity across all plants and ω_{ijt} is the plant specific productivity level. We use Olley & Pakes (henceforth OP) regression at two digit industry level to estimate the coefficient associated with labor (α_l), capital (α_k) and intermediate input (α_m). Hence, plant level TFP is given by; $TFP_{ijt} = q_{ijt} - \widehat{\alpha}_l l_{ijt} - \widehat{\alpha}_k k_{ijt} - \widehat{\alpha}_m m_{ijt}$.

[11] Refer to Roberts (1996) for the matching algorithm in greater details.

[12] ε_{ijt} is assumed to be iid normal, which is a common assumption.

4.2 Likelihood Estimation

A firm exports if the revenue of exporting is greater than the cost to export. Hence, the probability to export by firm "i" serving in industry "j" at time "t" can be explained by:

$$\Pr(EX_{ijt} = 1) = f(TFP_{ijt}, OC_{jt}, Spill_{jt}, \delta_{it}, \gamma_{jt}) \tag{10}$$

Where, TFP_{ijt} is firm's won TFP, OC_{jt} is industry opportunity cost, Spill_{jt} is spillover effect, δ_{it} captures some firm specific characteristics and lastly γ_{jt} is industry specific characteristics. We discuss these variables in greater details in the preceding paragraphs.

Note, the term $OC_{jt} = \frac{\text{j industry's weighted average productivity at time t}}{\text{Weighted aggregate productivity of the economy without j}}$[13]. Given the construction pattern of our opportunity costs, it is possible to argue that a very high productive firm in an industry can result in a lower industry OC. To address this issue, we assume that firms sales have a Pareto distribution and then estimate the shape parameter of the distribution to use it as a control variable[14]. We estimate the shape parameter by running a simple OLS at the 2 digit industry code, where the dependent variable is log of firms rank divided by total active firms in an industry and the independent variable is the log of firms' sale. Hence, the coefficient of the sales parameter is used as a shape parameter[15]. Hence, only a fat right tail would result in a lower opportunity cost.

The interpretation of OC is not very trivial either and requires some clarification. It is important to notice that it is defined as the relative industry TFP compared to rest of the economy. Hence, an increase in relative TFP actually reduces OC; since the industry is using resources efficiently compared to rest of the economy. As a result an industry with lower OC can generate higher output using smaller inputs. This, coincidently, implies that rest of the economy has to give up less output to increase the production of an industry with a lower OC.

$Spill_{jt} = \frac{\text{total export by j industry}}{\text{total output produced by j industry}}$; hence, it is the portion of final output that has been exported from an area code by an industry. The construction of this variable captures the portion of goods that have been exported and the portion of factor inputs that have been imported in an industry[16]. It is also interesting to note that firms serving in same area code and industry observes a stronger spillover effect[17].

δ_{it} has some other firm level control variables that we think is important for their export decision. We control for inflation adjusted import of raw material and the relative rank of the firm in the industry they serve in. The latter one

[13] These weights are firms' output share compared to the industry and aggregate economy respectively.

[14] The best solution to this problem would be to estimate the shape parameter of TFP. However, since we estimate TFP and it explains production we think it is a good proxy for TFP and use the shape parameter of the sales instead.

[15] Refer to Segarra & Teruel (2012).

[16] There are other ways to capture this effect as well; refer to Bernard and Jensen (2004).

[17] After the estimation, any form of marginal effects can confirm this result. Since it is not the central massage of the paper, we restraint from this discussion.

particularly is important to our analysis since it is possible to imagine that higher competition may benefit a really high productive firm. This mechanism is well understood from Melitz (2003), where the theory predicts that high productive firms goes through an expansion of market share and makes more profit from exporting. We construct this variable in two different ways due to limitation of the data set; they are discussed in the preceding paragraphs

For Chile we have information on firms income and gross output. As a result, the ratio of this gives us a proxy for the price charged by the firms. From this we are able to construct industry level aggregate price index[18]. Hence, the ratio of industry price index and firms' won price measures the rank of the firm in that industry. If this variable is greater(smaller) than one then firm is more(less) productive compared to the industry; since, higher price implies lower productivity. Relative Rank of a firm, in the context of Chile, also has another important significance in our analysis. The data set does not have tariff/tax information. If we assume that they are profit maximizing firms, then there pricing strategy must consider tariff/tax rate as well. As a result, indirectly, we are also controlling for tariff/tax rates.

For Colombia, we take a slightly different measure as we do not have information on their outputs. Rather the data set collects some other informations, those are interesting in our eyes and can capture this effect. The Colombian data set has information on their spending of publicity and advertising. Obviously, we expect a firm with bigger market share to have a higher rank in the industry and by extension spend more on publicity. We construct this variable taking the ratio of firms expenditure on publicity and weighted average expenditure of publicity at the 2 digit industry level. Hence, the interpretation becomes similar to the previous case.

Since we have data in tariff/tax for Colombian data we use it as an explanatory variable as well. Colombian industrial survey collects data on tariff faced by their exports and also the tariff rate they face for imported raw materials. We contract inflation adjusted tariff/tax information faced by each firms. These values are expressed in terms of 1977 Colombian Peso.

γ_{jt} is the industry level control variables: such as relative factor endowments, industry dummy and the Pareto shape parameter of sales. Following Rybczynski theorem, an increase in a factor endowment results in an increment of an industry output that uses the factor intensively. To control for this we took the ratio of labor endowments at the industry and aggregate level. Since, the data disaggregates labor by skilled and unskilled; we are able to construct two control variable out of this.

Industry level dummy captures any unobserved variation that we cannot control for; such as destination specific exchange rate, industry wide production or export subsidy, destination specific tariff/transportation costs, etc. The importance of the these variable has been discussed in other papers. However,

[18] The data set provides yearly aggregate producer price index. We also construced this index from our proxy variable for price for comaprison. The correlation between these variables is 99.79%. With CPI this variable has a correlation of 99.8%.

since our data do not have these informations we think industry dummy can control for these variations.

We expect that firms have some firm specific characteristics that are not observed by the econometrician. For example: managerial expertise, entrepreneurial skills, etc. Hence, to us it seems a fixed effect model is an appropriate fit[19]. We estimate this model using logit and linear probability model with fixed effects. Linear probability model has appealed to trade economists due to its simplicity. However, from econometrics point of view it has a lot of limitations. Hence, we use it as a benchmark mark model and we intend to compare it with the logit model with fixed effects.

5 Results

Since we are using point estimates of logit regression, we cannot interpret the magnitude and restraint ourselves to interpret the signs only. The first thing to notice is that results are quite symmetric across countries. To us it seems obvious since they are both Latin American countries serving almost in the same time frame and the producers probably face similar export market conditions.

Table 2

Aggregate Estimation Results

	Chile		**Colombia**	
VARIABLES	Logit Fe	LPM Fe	Logit Fe	LPM Fe
TFP	0.396*	0.0215**	0.747***	0.0285***
	(0.227)	(0.010)	(0.052)	(0.002)
OC	-2.772***	-0.108***	-1.679**	-0.0463**
	(0.870)	(0.028)	(0.708)	(0.023)
Spillover	0.157***	0.00508***	0.150***	0.00578***
	(0.039)	(0.001)	(0.009)	(0.0002)
Shape	-12.93***	-0.718***	-11.17***	-0.462***
	(2.703)	(0.111)	(2.470)	(0.076)
Relative rank	3.44e-13 ***	1.03e-14***	0.170**	0.0134***
	(6.87e-14)	(2.42e-15)	(0.071)	(0.003)
Import of Input	7.03e-11*	5.76e-13	3.49e-07	1.64E-08
	(4.13e-11)	(5.96e-13)	(5.22e-07)	(1.06e-08)
Skilled	9.136	0.966***	9.192**	0.832***
	(6.752)	(0.308)	(4.286)	(0.118)
Unskilled	-9.733*	-0.636***	-19.07***	-1.234***
	(5.476)	(0.240)	(5.759)	(0.187)
Tax			1.99e-06	9.47e-08***
			(1.66e-06)	(3.27e-08)
Observations	3,334	16,574	11,149	68,734
Number of id	500	2,726	1,445	14,260

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

We plan to leave the results of OC and spillover effect till the end of this section as the comparison of them is the main contribution of this paper.

[19] Refer to Bernard & Jensen (2004).

Following New-New trade literature it is obvious to expect that firms' TFP impacts the likelihood function positively. This is true for both of the models and for both countries and is in-line with both the theory and empirical findings with the literature. For Colombia both models predicts a positive impact at 1% significance level; on the contrary for Chile LPM has a positive effect at 5% significant level and Logit has significance at 10%. The shape parameter of sales, which is assumed to be Pareto and is a standard assumption in trade literature, has a negative impact at 1% significant level for all four cases. It is understood from Pareto distribution that a bigger(smaller) shape parameter results in a thinner(fatter) right tail; hence, a large(small) shape parameter implies that an industry has lower(higher) mass of high productive firms. Following Darwinian effect this provides more chance for a firm to participate in the export market; but, following Spillover effect it has the opposite impact. The results suggests that the latter effect dominates.

If a firm is relatively more productive compared to its competitors, occupies a bigger market share in an industry then the relative rank of the firm in the industry it serves is higher. This comparison is important as Melitz (2003) predicts, trade/trade liberalization benefits bigger firms. Our estimation suggests a similar story. It has a positive impact on firms export decision. Hence, if the relative rank of a firm in an industry goes up, it tends to be more competitive compared to the industry and gains ability to compete with its competitor in the export market. For both countries we observe a positive impact for this variable; however, for Chile we have 1% significance in both models and for Colombia we have 1% significance in LPM but 5% significance in logit model.

The next sets of variables are skilled and unskilled labor. As explained previously, these variables are defined as the relative endowment of industry to aggregate. Note, if endowments at the industry level grows bigger relative to the economy then it is possible for firms to use more of this factor without paying a high wage. On the contrary, we also expect that a high productive firm may want to use more skilled workers as a factor of production. Our results, agree with our intuition. It can be found from Table 3 that for skilled labor we have a positive impact in all the cases. These results exhibits 1% significance level for all the cases other than logit model for Chile. On the other hand, Unskilled labor has a negative impact on their export decision and is significant at 1% level other than Logit model for Chile (where it is significant at 10%).

Interestingly, tariff/tax does not have any significance in determining the export choice for Colombian plants with logit model. However, with LPM we observe a positive impact at 1% significant level. We constructed inflation adjusted tariff/tax paid by a firms. The construction of this variable sums the total tariff paid when exporting their final output and when importing raw material as a factor input. Import of raw material has positive impact only for Chilean plants. However, only with logit model we observe a significant effect of 5%.

The sign on the spillover effect is expected to be positive. Previous studies has also found similar results: check Bernerd & Jensen (2004); Aitken, Hanson & Harrison (1997); Greenway, Sousa & Wakelin (2004). The idea is simple and intuitive, as a firm serves in an industry that does a lot of exporting than it can learn from it and become an exporter. Hence, a firm serving in an industry with a lot of exporting activity should observe a positive impact for their exporting decision as well. Our result agrees with this and predicts a positive impact on the likelihood of firms' exports if it serves in an industry with a lot of exporting activity via spillover effect.

Going back to the comparative static, Darwinian effect works in the opposite direction compared to spillover effect. Darwinian effect rises from a decrease in OC at the industry level. This makes the export market relatively competitive and results in a decrease in the probability for firms' export. As mentioned earlier, OC is measured by relative TFP of the industry compared to rest of the economy. Hence, an increase in the relative TFP of industry implies a decrease in the OC of this industry. As predicted by the comparative static, an increase in relative industry TFP or decrease in OC has a negative impact on firms export. The data also agrees with this result, where for Chile we find a negative impact at 1% significance for both models; but, for Colombia we find a negative impact at 5% significance level. Hence, as relative TFP of industry rises or OC falls the firms observe a negative impact on their export choice via Darwinian effect.

The mechanism of this is quite interesting as well. It is obvious to note that both Spillover and Darwinian effect is related to industry level productivity growth. As the industry TFP improves the spillover effect becomes stronger since it can export more in the international market. On the contrary, this growth in industry TFP implies that now the OC falls and that makes the export market competitive. As a result the Darwinian effect kicks in and that results in a negative impact on firms' export choice.

6 Conclusion

The paper finds a new industry level determinant, Darwinian effect, that works in the opposite direction compared to Spillover effect. We provide a comparative static with firm level heterogeneity as a theoretical evidence of Darwinian effect and also find empirical evidence for Chilean and Colombian micro level data set. We also provide a formal definition of the effect.

Apart for that, we tested other important determinants of firms export; such as: firms' won TFP, import of raw material, tariff/tax, endowment effects and lastly industry specific effects. Our predictions are in-line with the literature. Other than that we had to control for all moments of the TFP distribution. However since we estimate TFP in this paper, we proxy that with firms sales to have a cleaner estimate of firms OC. The parameter that sums up the moments also has an impact that agrees with out intuition.

Appendix

A.1 Prove of Claim 1.

Recall the exporters aggregate price index is $P_{ix}^{1-\sigma} = \int\limits_{\phi_{ix}^*}^{\infty} M_{ix} p_{ix}(\phi)^{1-\sigma} \frac{\alpha {\phi_{xi}^*}^{\alpha}}{\phi^{a+1}} d\phi$ for i=1,2. We use the expression for active mass of exporters to simplify it to $P_{ix}^{1-\sigma} = \int\limits_{\phi_{ix}^*}^{\infty} M_i \left(\tau p_i(\phi)\right)^{1-\sigma} \frac{\alpha {\phi_i^*}^{\alpha}}{\phi^{a+1}} d\phi$.

Now, we can express export cutoff as a function of domestic cutoff using the relative revenue expression of marginal firms ($\frac{r_{ix}(\phi_{ix}^*)}{r_i(\phi_i^*)} = \frac{R_f}{\beta R} \left(\frac{P_{if}}{P_i} \frac{\phi_{ix}^*}{\phi_i^*}\right)^{\sigma-1} \tau^{1-\sigma} = \frac{f_x}{f}$). Lets assume that $A = \left[\left(\frac{R_f}{\beta R}\right)^{-1} \frac{f_x}{f}\right]^{\frac{1}{\sigma-1}}$; hence, we can express the export cutoff ($\phi_{ix}^* = \phi^* \tau A \frac{P_{if}}{P_i}$). Now we can use it as the limit to our above integral to find the following expression.

$$P_{ix}^{\sigma-1} = (\tau P_i)^{\alpha} \left(\frac{A}{P_{if}}\right)^{\alpha-(\sigma-1)} \quad \text{for i=1,2}$$

A.2 Prove of Claim 2

We know that $P_i^{1-\sigma} = M_i p_i(\widetilde{\phi}_i)^{1-\sigma}$ for i=1,2. Hence, the expression for relative revenue is $\left[\frac{P_1}{P_2}\right]^{1-\sigma} = \frac{M_1}{M_2}\left[\frac{p_1(\widetilde{\phi}_1)}{p_2(\widetilde{\phi}_2)}\right]^{1-\sigma}$. Now we can simplify this expression using the optimal pricing rule and expression for active mass of firms to obtain ($\left[\frac{P_1}{P_2}\right]^{1-\sigma} = \frac{r_2(\widetilde{\phi}_2)}{r_1(\widetilde{\phi}_1)}\left[\frac{\widetilde{\phi}_1}{\widetilde{\phi}_2}\right]^{\sigma-1}$).

Let's take the relative revenue of the average and marginal firm for an industry. Hence, we get $\frac{r_i(\widetilde{\phi}_i)}{r_i(\phi_i^*)} = \left(\frac{\widetilde{\phi}_i}{\phi_i^*}\right)^{\sigma-1}$ for i=1,2. Also note that $r_i(\phi_i^*) = \sigma f$. Use these expressions to derive the expression of average firm as a function of the relative productivities and revenue of marginal firm. As a result, the relative aggregate price index depends only on the cutoff productivity across industries. Lastly, using Pareto distribution assumption we can express them as the industry productivity indices to find ($\frac{P_1}{P_2} = \left(\frac{\widetilde{\phi}_1}{\widetilde{\phi}_2}\right)^{-1}$).

B. Data

The following data description is useful for this paper. All variables are expressed in log.

Chilean Data:

Output is calculated from difference of gross output to building machinery and vehicles produced for own use. From the table the expression for output in log levels is, y=ln(groutput-prodbld-prodmach-prodveh).

Intermediates is constructed from four variables from the table. These are total intermediate purchase, electricity bought, final inventory of raw material and lastly initial inventory of raw material. The expression for the variable is given by, m=ln(totipurc+elecbval-(finvrm-iinvrm)).

Labor input has only two components, skilled and unskilled workers. Their log of sum will yield the labor input. The expression for this input is n=ln(sklab+unsklab).

Capital is log of tnk80_new, that is the real capital stock in PPP adjusted thousands of 1980 Chilean Pesos. The expression for this is self explanatory, k=ln(tnk80_new).

Investment is the summation of three variables and they are real gross capital investment in building, real gross capital investment in machinery and real gross capital investment in vehicles. The construction looks like, i=ln(rinvcapb+rinvcapm+rinvcapv).

Colombian Data:

Output is the log of total sales. y=ln(s5).

Capital is constructed from couple of variables. It is the sum of Rent of fixed property, Machinery rental, total production of assets for own use, total reappraisal of fixed assets and total book value of fixed assets. Then, we subtract total value of sales of fixed assets and total yearly depreciation. Lastly we express this variable in 1977 peso terms.

Investment is the sum of total purchase of new fixed assets and used fixed assets. Then we subtract total yearly depreciation and express everything in 1977 Colombian Peso.

Intermediates is the sum of energy consumed in quantity beginning of year raw materials expressed in 77 pesos.

Labor is the log of total labor.

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