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Is Exporting a Source of Productivity Spillovers?

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Abstract

This paper investigates whether exporting generates positive productivity spillover effects on other plants operating in the same industry and whether exporting affects productivity of plants in vertically related industries. Using plant-level data from Chile we find that exporters improve productivity of their local suppliers but not of plants that purchase intermediate inputs from them. We also find evidence of horizontal spillovers from exporting. Exporting by foreign-owned plants generates positive spillovers in all directions: to their suppliers, customers, and to other plants in the same industry. Domestic exporters increase productivity of their suppliers and, to a lesser extent, that of plants in the same sector.

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1. Introduction

Many people believe that exporting firms generate knowledge about technologies and foreign markets which can be used by other exporters and non-exporters in ways that increase their productivity. Surprisingly, we know little about the effects of exporting on other firms' productivity and whether foreign-owned exporters, domestic exporters, or both, are the ones who generate spillovers. Using data for Chilean manufacturing plants, we investigate whether exporting by both foreign-owned and domestic plants generates positive productivity spillover effects on plants operating in the same industry and in vertically related industries.

Most of the previous literature studies the effect of general exporting activity on the probability of exporting and export performance (e.g. Aitken, et al., 1997; Clerides, et al., 1998; Barrios, et al., 2003; Bernard and Jensen, 2004a) but, with only few exceptions (e.g. Clerides, et al., 1998; Javorcik, 2004; Girma et al., 2004; Görg and Hijzen, 2004), it has overlooked the effect of exporting on productivity. Moreover, no study exists looking at productivity spillovers from exporting by domestic plants.

In general, scholars find very little support for the idea that exporting increases the probability of exporting and export performance of other firms. We believe that only looking at the impact of spillovers on export performance may be misleading. Since there are sunk-entry costs to export markets,[1] it may be difficult to observe general exporting activity inducing entry to export markets unless spillover effects are big enough to compensate for these entry costs. Moreover, most of the studies look for intra-industry spillovers and ignore the potential linkages from buyers of output to suppliers of inputs and vice versa.

[1] See Roberts and Tybout (1997), and Bernard and Jensen (2004a).

From a policy point of view, it is important to analyze whether these spillover effects exist or not. The existence of spillovers from exporting has been traditionally used as a justification for the adoption of export promotion programs. Many countries in the world have encouraged exports with the idea that they might fuel economic growth. Researchers have investigated whether these export promotion programs are justified by testing the existence of learning-by-exporting.[2] But from a policy perspective, the relevant question is whether exporting generates spillovers to other firms. The existence of learning by exporting itself is not necessarily a justification for export promotion unless it can be shown that these learning effects spill over the rest of firms.

Our paper is related to the economic development literature which argues that export activity may generate demonstration effects or provide new technologies that are not available for domestic producers.[3] This paper is also consistent with microeconomic evidence documenting that exporters are more productive than non-exporters. Starting with the study by Bernard and Jensen (1999) for the U.S., scholars have found evidence of productivity differentials in favor of exporters.[4] In the case of Chile, Álvarez and López (2005) show that after controlling for size and foreign capital participation, exporters are 19 percent more productive in terms of total factor productivity than non-exporters. These differentials make learning by domestic firms from highly-productive exporters potentially important.

We make several contributions to the empirical literature. First, we test for the existence of spillovers from exports on plant productivity. Second, we not only consider spillovers from plants in the same industry, but also explore the role of vertically linked activities. Third, we analyze if

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[2] See recent surveys by López (2005), Greenaway and Kneller (2005), and Wagner (2005).

[3] Some scholars, however, are more skeptical about the existence of these spillover effects. See Rodrik (1999), and Panagariya (2000).

[4] See, for example, Bernard and Wagner (2001) for Germany; Isgut (2001) for Colombia; and Baldwin, and Gu (2003) for Canada. Wagner (2005) surveys the empirical strategies and results of 45 studies for 33 countries. He concludes that the evidence is robust in terms that exporters are more productive than non-exporters. Interestingly, most of these studies reveal that firms self-select in international markets while exporting does not necessarily have a positive effect on firm productivity (see also López, 2005).

there is a different impact between domestic and foreign-owned plants' exports. By making this distinction, we investigate if spillovers, as other authors have claimed, are mostly provided by multinational enterprises. And fourth, we address several estimation issues that have plagued previous studies. In particular, unlike previous works, we take into account the possible endogeneity of our spillover variables by employing IV estimation methods. We construct three different types of sector-level real exchange rates and use them as instruments. Our identification assumption is that real exchange rate is correlated with industries export orientation, but it does not affect plants productivity directly. In addition, following Aitken et al. (1997), we control for general concentration of economic activity at region and industry level to make sure that we are effectively capturing the impact of export activity, and not the impact of agglomeration or specific advantages of some locations.

Using information for Chilean manufacturing plants from 1990 to 1999, we find strong support for the view that exporters improve productivity of their local suppliers. We also find evidence of horizontal spillovers from exporting but not from exporters to their customers. Exporting by foreign-owned plants generates positive spillovers in all directions: to their suppliers, customers, and to other plants in the same sector. Our finding that domestic exporters increase productivity of their suppliers and, to a lesser extent, that of plants operating in the same industry indicates that positive spillovers are not only associated with a larger presence of multinational exporters, but also with exporting activity of domestic firms. Thus, we conclude that researchers could have underestimated the role of domestic exporters in generating positive effects on other firms' productivity.

2. Spillovers from Exporting

The presumption that spillovers from exporting exist has been traditionally used as a justification for the adoption of export promotion programs. Several arguments for why exporting may generate these spillovers have been proposed. For example, consider a firm entering in a new market or developing a new product for foreign markets; it faces several costs such as promotional investments, making contacts with new clients, and technological innovation expenditures. Once the firm achieves its objective, however, there is no impediment for other firms to enter this market or imitate the new product without also paying these costs. This positive externality suggests that investment in opening new markets and developing new products may be lower than the socially optimal level (Westphal, 1990). Other authors argue that exporters tend to adopt efficient and competitive management styles, and training of a higher quality of labor which may benefit firms in other sectors (e.g. Keesing, 1967; Feder, 1982; Edwards, 1993).

The existence of these externalities and the role for export promotion, however, are highly controversial. Advocates of active export promotion policies have used such justifications to support government intervention. According to Lall (2002), the evidence suggests that export promotion policies have been effective for improving export performance in newly industrialized economies. Skeptics argue that these policies distort competition and undermine the multilateral free trade system.[5]

Therefore empirical evidence on this regard is important to evaluate whether these spillovers exist. Table 1 shows the studies that have studied the existence of spillovers from exporting. Most of the studies explore potential technological or information spillovers from

[5] Panagariya (2000), for example, discusses how traditional and recent arguments fail on theoretical and empirical grounds as justifications for the implementation of selective policies for export promotion, while Rodrik (1999) argues that there is not robust evidence of spillovers emanating from exporting activities.

exporters to other firms' export performance. They analyze how export concentration affects the probability of exporting and/or export intensity (measured as the export to sales ratio). These analyses typically focus on firms operating in the same industry and/or region and in some cases they distinguish between exports by domestic firms from exports by multinational corporations. These studies either do not find evidence that export activity increases the probability of exporting (e.g. Clerides et al., 1998; Barrios et al., 2003; Bernard and Jensen, 2004a) or find that only multinational exporters generate spillovers (e.g. Aitken et al., 1997; Greenaway, et al., 2004; Ruane and Sutherland, 2004). The effect of exporting activity on export intensity of exporters is also not clear. While some find a positive effect of exporting activity by multinationals on export intensity (e.g. Greenaway, et al., 2004) others find a negative effect (e.g. Ruane and Sutherland, 2004).

Table 1 also shows studies that have looked at productivity spillovers from exporting. Most of them focus on foreign-owned exporters and consider the intra-industry aspect of spillovers. Only Clerides et al. (1998) study the potential productivity spillovers from domestic exporting. But their results do not provide support for their existence. Using Colombian plant-level data they find that high export activity is not, in general, associated to lower production costs. In fact, in some cases exporting appears to increase costs of production. As seen in the table, none of the studies looks for spillover across sectors from domestic exporters through buyer-seller relationships. There are several ways by which exporters may affect their suppliers (backward spillovers). They may transfer knowledge and technically assist firms in upstream industries, so they can satisfy higher quality requirements in foreign markets. In addition, an expansion of export industries may increase the demand, or generate new demand, for intermediate inputs in upstream sectors.[6]

[6] In Chile this seems to be the case with recent expansions in exports of wine and salmon. Once these industries maturated, there was a growing demand for specialized inputs.

There are also arguments favoring the existence of forward export spillovers. This would be the case when downstream industries may become more productive as a result of gaining access to new, improved, or less costly intermediate inputs. Although these spillovers have been commonly associated to the presence of multinationals, there are no reasons to disregard that exporters may be responsible for the same phenomenon. Consider, for example, the Chilean case of fruit exports. Fruit is raw material for production of juice, canned fruit, and other more elaborate products. It is reasonable that technological advances in industries producing the input or the introduction of a new variety (raw fruit) may have an important effect on downstream industries (juice, canned fruit).

The arguments presented in this section refer to positive spillovers. Theoretical considerations, however, prevent us of being too optimistic. First, horizontal spillovers may be unobserved in practice because firms have incentives to prevent information flows to competitors. Second, export expansion in some regions or industries may increase the cost of labor or of other specialized inputs. In these cases, the net spillover effect may be ambiguous. The net effect on plant productivity then depends on the balance between the positive effect provided by technological transfer and the negative effect of increased competition on input prices and the scale of production.[7]

[7] This negative effect has been denominated “congestion.” Evidence on this regard has been found by Karpaty and Kneller (2006) for the entry of multinationals in Sweden.

3. Data and Econometric Strategy

3.1 Data

The empirical analysis is based on the Annual National Industrial Survey (ENIA) carried out by the National Institute of Statistics of Chile (INE) for the years 1990 through 1999. This survey covers the universe of Chilean manufacturing plants with 10 or more workers. A plant is not necessarily a firm; however, a significant percentage of firms in the survey are actually single-plant firms (Pavcnik, 2002). The INE updates the survey annually by incorporating plants that started operating during the year and excluding those plants that stopped operating for any reason.

For each plant and year, the ENIA collects data on production, value added, sales, employment and wages (production and non-production), exports, investment, depreciation, energy usage, foreign licenses, and other plant characteristics. In addition, plants are classified according to the International Standard Industrial Classification (ISIC) rev 2. Using 4-digit industry level price deflators, all monetary variables were converted to constant pesos of 1985. Plants do not report information on capital stock, thus it was necessary to construct this variable using the perpetual inventory method for each plant.

3.2 Econometric Strategy

We study the role of productivity spillovers from export activities by considering an augmented production function which explicitly incorporates the role of spillovers:

(1) $$y_{ijrt} = \alpha_0 + \alpha_1 k_{ijrt} + \alpha_2 l_{ijrt}^{NP} + \alpha_3 l_{ijrt}^{P} + \beta_1 \ln(Horizontal_{jt}) + \beta_2 \ln(Backward_{jt}) + + \beta_3 \ln(Forward_{jt}) + \varepsilon_{ijrt},$$

where y_{ijrt} is the log of value added of plant *i* operating in sector *j* and region *r* at time *t*; k_{ijrt} is the log of plant's capital stock, while l_{ijrt}^{NP} and l_{ijrt}^{P} are the logs of non-production and production labor respectively. The horizontal spillover variable for a given industry, say *j*, is defined as the exports to sales ratio of that industry:

$$(2) \qquad Horizontal_{jt} = \frac{\sum_{i \in j} Exports_{ijt}}{\sum_{i \in j} Sales_{ijt}}.$$

Thus, we are assuming that the larger the share of exports in a given industry, the larger the potential spillover effect. The $Backward_{jt}$ variable is a proxy for the export orientation of industries that are supplied by industry *j*:

$$(3) \qquad Backward_{jt} = \sum_{k, k \neq j} \alpha_{jk} Horizontal_{kt} ,$$

where α_{jk} is the proportion of sector *j*'s output supplied to sector *k*. We calculate these coefficients using data from the input-output matrix of Chile, constructed by the Central Bank of Chile, at the 3-digit ISIC level for the year 1996. Given that we are interested in linkages within the country and across productive sectors, we exclude the output for final consumption as well as the imports of intermediate products. Finally, the $Forward_{jt}$ variable attempts to measure the export orientation of industries that supply inputs to industry *j*:

$$(4) \qquad Forward_{jt} = \sum_{k, k \neq j} \sigma_{jk} Horizontal_{kt} ,$$

where σ_{jk} is the share of inputs purchased by industry *j* from industry *k* in total inputs purchased by industry *j*.

Figure 1 shows the average value for the period 1990-1999 of the horizontal variable at the 3-digit sector level. As can be seen, the most export-oriented sectors are basic chemicals (351), non-ferrous metals (372), paper (341), wood (331), and iron and steel (371), while sectors such as non-metallic products (369), petroleum products (353, 354), plastic (356), and professional equipment (385) export a very low fraction of their output.

Figures 2 and 3 show the backward and the forward variables, respectively. There are important differences across industries. For example, the backward variable, which measures the average export orientation of sectors that are supplied by the given industry, is high in ceramics and glass (361, 362), plastic (356), and basic chemicals (351), but very close to zero for transport equipment (384), footwear (324), and rubber products (355). The forward variable, which measures the export orientation of sectors that provide inputs to the given industry, also varies across sectors. High values are observed in printing (342), furniture (332), metal products (381), leather products (323), and beverages (313), while low numbers are found in iron and steel (371), non-ferrous metals (372), and wood products (331).

For estimation purposes, it will be convenient to re-write equation (1):

(5) $$\begin{aligned} y_{ijrt} - \alpha_1 k_{ijrt} - \alpha_2 l_{ijrt}^{NP} - \alpha_3 l_{ijrt}^{P} = \alpha_0 + \beta_1 \ln(Horizontal_{jt}) + \beta_2 \ln(Backward_{jt}) + \\ + \beta_3 \ln(Forward_{jt}) + \varepsilon_{ijrt} \end{aligned}.$$

The left-hand side of this equation is the traditional measure of the log of total factor productivity (TFP) at the plant level. To measure TFP we estimate a Cobb-Douglas production function for each 3-digit level industry using the method proposed by Olley and Pakes (1996) and later modified by Levinsohn and Petrin (2003a, 2003b), which corrects the simultaneity bias associated with the fact that productivity is not observed by the econometrician but it may be observed by the firm (see Appendix for more details). The residuals of these regressions correspond to our measures of productivity. Once TFP has been measured, we estimate the following equation:

(6) $$TFP_{ijrt} = \alpha_0 + \beta_1 \ln(Horizontal_{jt}) + \beta_2 \ln(Backward_{jt}) + \beta_3 \ln(Forward_{jt}) + \varepsilon_{ijrt}.$$

There are several estimation issues that need discussion. First of all, there may be unobserved plant characteristics which make some plants more productive. In that case the error term in equation (6) can be decomposed into $\varepsilon_{ijrt} = c_i + u_{ijrt}$, where c_i is the unobserved plant-specific effect, and u_{ijrt} is an error term. Then (6) becomes:

$$(7) \qquad TFP_{ijrt} = \alpha_0 + \beta_1 \ln(Horizontal_{jt}) + \beta_2 \ln(Backward_{jt}) + \beta_3 \ln(Forward_{jt}) + c_i + u_{ijrt}.$$

In the estimation, we treat c_i as fixed effects and use OLS to estimate the parameters of the within transformation of (7). Since there may be also sector, region, and year specific effects that affect productivity we add a full set of 3-digit sector, region, and year dummy variables.

A second issue is that we need to control for the geographic concentration of the industry. Suppose, for example, that plants tend to agglomerate in some sectors and regions.[8] These agglomeration effects may make plants that operate in that industry/region more productive and, if the sector is also exporting a high fraction of their output, we may erroneously conclude that exporting increases productivity of the plants. To control for this possibility, we include a measure of the geographic concentration of the economic activity in the sector/region. We use two measures of concentration:

$$\text{Concentration } 1_{rjt} = \frac{\left(Employment_{rjt} \big/ Employment_{jt} \right)}{\left(Employment_{rt} \big/ Employment_{t} \right)},$$

and

$$\text{Concentration } 2_{rjt} = \frac{\left(Gross\ Ouput_{rjt} \big/ Gross\ Output_{jt} \right)}{\left(Gorss\ Output_{rt} \big/ Gross\ Output_{t} \right)}.$$

[8] See Head and Mayer (2004) for a survey on agglomeration and trade.

A third estimation issue is a possible endogeneity of the spillover variables. Suppose, for instance, that some sectors export more because the plants that operate in that sector are more productive. Furthermore, some plants may increase their productivity with the purpose of becoming exporters (Halward-Driemeier et al., 2002; López, 2005). Similarly, more productive plants may self-select and supply inputs to sectors with a high export orientation. In these cases the error term in equation (7), u_{ijrt}, will be correlated with the spillover variables, so that the OLS estimates will be inconsistent. To address this problem, we use the method of instrumental variables. We instrument our three spillover variables using sector-level real exchange rates. We assume that the level of the real exchange rates is correlated with the export shares but not with variables other than exports that affect productivity (the error term in equation (7)). We argue that this is a reasonable assumption for two reasons. First, there is plenty of evidence that variations in real exchange rate are associated with significant changes in exports.[9] Second, it seems hard to argue that measures of real exchange rate at the industry-level can affect a variable such as productivity that is measured at plant-level. Following recent models of firm heterogeneity and international trade, we may expect a positive relationship between real exchange rate and industry average productivity, but not for individual plants' productivity. In fact, a real depreciation may be thought of as a reduction in trade costs, which according to Melitz (2003) and Bernard et al. (2006), raises the level of competition and the aggregate productivity of the industry.

We construct three real exchange rates indices. The first one (RER_{jt}) is a weighted average of the bilateral real exchange rates between Chile and the 15 main destination countries of the Chilean exports of the industry:

[9] Recent evidence by Bernard and Jensen (2004b) show that real depreciations increase the export share of US plants in the manufacturing sector.

$$RER_{jt} = \sum_{c=1}^{C} \theta_{cj} RER_{ct} \ ,$$

where RER_{ct} is the bilateral real exchange rate between Chile and country c;[10] $C=15$ is the number of countries; and θ_{cj} is defined as:

$$\theta_{cj} = \frac{1}{T} \sum_{t=1}^{T} \frac{Exports_{cjt}}{Exports_{jt}} \ ,$$

where $Exports_{cjt}$ is the value of exports from industry j to country c at time t; $Exports_{jt}$ is the value of exports from industry j at time t; and T is the number of periods trade data is available (9 years, from 1991-1999). This index is assumed to be correlated with the export share of the sector (the Horizontal variable).

The other two instruments measure the real exchange rate that exporters face in upstream sectors ($RER\text{-}Backward_{jt}$) and the real exchange rate faced in downstream sectors ($RER\text{-}Forward_{jt}$). They are defined following equations (3) and (4):

$$RER - Backward_{jt} = \sum_{k, k \neq j} \alpha_{jk} RER_{kt} \text{ , and}$$

$$RER - Forward_{jt} = \sum_{k, k \neq j} \sigma_{jk} RER_{kt} \ ,$$

where we are assuming that the higher the real exchange rate that exporters face in downstream and upstream sectors, the higher the export share of those sectors.

We use these instruments to obtain predicted values of our three spillover variables, which are then used to estimate the effect of exporting on plant productivity. The real exchange rates turn out to be highly correlated with export shares at the sector level. A simple regression between industries' export share and real exchange rates, both in logs, gives us a coefficient of 1.34 and a t

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[10] The bilateral real exchange rate between Chile and country c is: $RER_{ct}=NomER_{ct}*P_{ct}/P_{Chile,t}$. $NomER_{ct}$ is the nominal exchange rate between Chile and country c (Chilean pesos / country's c currency), while P_{ct} and $P_{Chile,t}$ are producer price level indices for country c and Chile, respectively. The nominal exchange rates and producer prices were obtained from the International Financial Statistics of the International Monetary Fund. In cases in which the producer price was not available the consumer price index was used.

statistic of 7.68. In order to check the validity of these instruments, we follow the traditional procedures of looking at the individual t statistics for the coefficients of the three measures of exchange rates, and the F statistics for the model including all the exogenous variables. The first-stage regressions confirm that our instruments are adequate. The t statistics for the coefficient of real exchange rates reveal that these variables are always significant at 1%. A more formal test is the Anderson-Rubin test of the significance of the endogenous regressors.[11] The null hypothesis tested is that the coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and is numerically equivalent to estimating the reduced form of the equation (with the full set of instruments as regressors) and testing that the coefficients of the excluded instruments are jointly equal to zero. In all our estimations, the null hypothesis is rejected at 1%, confirming the validity of our instruments.[12] Figures 4, 5, and 6 are scatterplots of the true spillover variables against their predicted values. These figures show that the real exchange rate accounts for most of the variation in the export shares.

Table 2 shows descriptive statistics for all the relevant variables. There are 49,106 plant-year observations, but after eliminating the ones for which we could not estimate TFP, we end up with 40,476 observations.

4. Results

4.1 Basic Results

Table 3 reports our basic results of estimating equation (7). The first three columns of numbers are the plant fixed effects estimates without taking into account the endogeneity problem. Column

[11] This is different from Anderson-Rubin test for overidentifying restrictions. In our case, the model is exactly identified because we have three endogenous regressors and three excluded instruments.

[12] The same conclusion is reached when we use as an alternative test of weak identification the Cragg-Donald test. All of these tests for first step regressions are generated by the command xtivreg2 in Stata.

(1) shows that the coefficient on backward and horizontal are positive, although only backward is statistically significant. A 1% increase in the ratio exports/sales in downstream industries increases productivity of plants in upstream industries in 0.291%, on average. Thus, sectors with higher exports increase the productivity of plants that provide inputs to those sectors but do not increase the productivity of plants that operate in the same industry. The forward variable is negative but not significant. In columns (2) and (3) we control for the industry/region concentration of economic activity. The labor concentration (concentration 1) is not significant and does not change the estimates. The output concentration (concentration 2) is positive and statistically significant suggesting that there may be some positive agglomeration externalities. The coefficients for the spillover variables remain the same and the forward variable becomes marginally significant at 10%.

In column (4) of Table 3 we present the estimates using the IV method with plant fixed effects. All estimates are higher than the OLS estimates and now the horizontal variable is statistically significant. A 1% increase in the exports/sales ratio increases productivity of plants in the same industry by 0.05%, while productivity of plants in upstream industries increases by 0.52%. These results are robust to the inclusion of concentration measures (columns 5 and 6). In sum, our evidence is consistent with the view that exporters provide positive spillovers to their suppliers and to other plants in the same industry.

Why are the IV estimates higher than the OLS estimates? In our estimations, the export share is used to proxy for the different ways in which interactions between plants raise productivity (technical assistance to suppliers, demonstration effects, etc.). The export share is likely to be correlated with these interactions but this correlation may be not perfect. Thus, in the presence of measurement errors, OLS are biased downward. In addition, our export data at plant-level comes from a survey, so the export data at industry-level may not coincide with the actual amount exported. This suggests that the instrumented exports may be better predictors of the spillover effects.

4.2 Who Generates Spillovers: Foreign-Owned or Domestic Exporters?

For a developing country, like Chile, it is possible that foreign-owned exporters are the main source of technologies and knowledge. In other words, positive productivity spillovers may be more likely to occur from exports by foreign-owned plants than from exports by domestic plants. To analyze this possibility we split our spillover variables into two components: (1) exports by foreign-owned plants; and (2) exports by domestic plants. Thus, we define the horizontal-foreign spillover variable as:

$$Horizontal - Foreign_{jt} = \frac{\sum_{i \in j} F_{ijt} Exports_{ijt}}{\sum_{i \in j} Sales_{ijt}},$$

where F_{ijt} is a dummy variable equal to one if plant i belonging to sector j has a positive amount of foreign ownership at time t. In the same way we define the horizontal-domestic variable considering exports by domestic plants only. The variables backward-foreign, backward-domestic, forward-foreign and forward-domestic are defined following formulas (3) and (4).

Table 4 shows the results of estimating (7) using the exports of foreign-owned plants in our spillover variables. Columns (1)-(3) refer to the case of OLS with plant fixed effects, while (4)-(6) are the IV estimates with plant fixed effects. In all six cases the estimates for the three spillover measures are positive and statistically significant, even when a concentration index is included. A 1% increase in the export/sales ratio increases productivity of plants in upstream industries by 0.16%-0.34%, in downstream sectors by 0.09%-0.27%, and in the same sector by 0.10%-0.23%.

These results give strong support to the idea that foreign-owned plants generate positive spillover effects.

As a robustness check, we also estimate the effect of exporting by foreign-owned plants on productivity of domestic plants only. The results, not presented here, are almost identical to those in Table 4. This is consistent with the idea that affiliates of multinational corporations generate positive productivity spillovers to domestic plants.

Do these findings mean that domestic exporters do not generate spillover effects? The answer can be obtained from Table 5 which presents the estimates by using exports of domestic plants only. We see that the estimate for backward is always positive and statistically significant. A 1% increase in exports/sales increases productivity of plants in upstream sectors by 0.24%-0.49%. For the forward and the horizontal variables the OLS and the IV regressions give slightly different results. While the estimates for forward are negative in all six cases, they are not significant when we use IV (columns 4-6). The horizontal variable, on the other hand, is positive but never significant if we use OLS, and marginally significant at 10% when we use IV estimation. There is then strong evidence that domestic exporters generate positive productivity spillovers to their suppliers, some support for spillovers to other plants of the same industry but no evidence that they benefit their customers.

In sum, our results suggest that positive spillovers are not only associated with a larger presence of multinational exporters, but also with domestic exporters. In other words, by focusing exclusively on foreign-owned firms, researchers have been underestimating the role of domestic exporters in generating positive effects on other plants' productivity.

5. Conclusions

Unlike most studies that have analyzed intra-industry or horizontal spillovers from export activities, this paper focuses on inter-industry or vertical spillovers through backward (from potential customers) and forward linkages (from potential suppliers). Anecdotal evidence suggests that vertical spillovers, at least from exporters to their suppliers, may be important.

Using data from the manufacturing sector of Chile for the period 1990-1999, we confirm the existence of positive productivity spillovers from exporters to their suppliers. This is evidence of backward spillovers. We also find evidence that higher exporting activity in a given sector increases the productivity of the plants operating in that sector. We do not find, however, evidence of spillovers from exporters to their customers.

When we distinguish between foreign-owned plants exports and domestic plants exports we discover that foreign-owned exporters generate positive productivity spillovers to their suppliers, customers, and to other plants in the same industry. This is consistent with the perception that multinational corporations transfer technologies in developing countries. But this does not mean than domestic exporters do not improve the performance of other plants. We find strong support for the existence of backward spillover effects from domestic exporters to their local suppliers and some evidence that they benefit plants in the same sector.

Although we have been able to address several estimation issues that have plagued previous studies such as the identification of spillover effects, the simultaneity problem, and the role of unobserved plant characteristics, we still believe more work and better data are needed to identify the exact mechanisms by which exporters transfer knowledge and technologies to other firms operating either in the same industry or in other industries. Ideally, one would like to have data on individual transactions between an exporter and its supplier and its customers.

Appendix: TFP Construction

To compute TFP we estimate a Cobb-Douglas production function separately for each industry. Specifically, for each 3-digit sector, we estimate the following equation:

(A1) $y_{it} = \beta_0 + \beta_1 k_{it} + \beta_2 l_{it}^{NP} + \beta_3 l_{it}^{P} + \varepsilon_{it}$,

where y_{it} is the log of value added of plant *i* at time *t*; k_{it} is the log of plant's capital stock, while l_{it}^{NP} and l_{it}^{P} are the logs of non-production and production labor respectively. TFP is defined as:

$$TFP = \exp\left(y_{it} - \widehat{\beta}_1 k_{it} - \widehat{\beta}_2 l_{it}^{NP} - \widehat{\beta}_3 l_{it}^{P} \right).$$

If ε_{it} is uncorrelated with the right-hand side variables in equation (A1), then the production function could be estimated using OLS. However, although productivity is not observed by the econometrician it may be observed by the firm, thus ε_{it} is likely to be correlated with the regressors. Following Olley and Pakes (1996), and Levinsohn and Petrin (2003a and 2003b) we explicitly consider this endogeneity problem by writing $\varepsilon_{it} = \omega_{it} + \eta_{it}$, where ω_{it} is the transmitted productivity component and η_{it} is an error term that is uncorrelated with input choices, and assuming that $m_{it} = m_{it}(k_{it}, \omega_{it})$, where m_{it} is the intermediate input. Levinsohn and Petrin (2003a) show that this relationship is monotonically increasing in ω_{it}, so the intermediate input function can be inverted to obtain $\omega_{it} = \omega_{it}(k_{it}, m_{it})$. Then, equation (A1) becomes:

(A2) $y_{it} = \beta_2 l_{it}^{NP} + \beta_3 l_{it}^{P} + \phi(k_{it}, m_{it}) + \eta_{it}$,

where $\phi(k_{it}, m_{it}) = \beta_0 + \beta_1 k_{it} + \omega_{it}(k_{it}, m_{it})$.

Equation (A2) can be estimated using the procedures discussed in Petrin, Poi, and Levinsohn (2004). As in Levinsohn and Petrin (2003a), we use consumption of electricity as the intermediate input that allows the identification of the elasticity of capital.

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Table 1: Previous Studies on Exporting Spillovers

	Probability of Exporting and/or Export Intensity	Productivity	
		From Foreign-Owned Exporters	From Domestic Exporters
Horizontal	AHH*, CLT, BGS, GK, S, GSW, BJ, RS, KK, KP	CLT, GGP, GH	CLT
Backward	KP	J, GGP	None
Forward	KP	GGP	None

* Study deals with endogeneity of industry/region export shares.
AHH: Aitken, Hanson and Harrison (1997); CLT: Clerides, Lach and Tybout (1998); BGS: Barrios, Görg and Strobl (2003); GK: Greenaway and Kneller (2003); S: Sjöholmm (2003); GSW: Greenaway, Sousa and Wakelin (2004); BJ: Bernard and Jensen (2004a); RS: Ruane and Sutherland (2005); KK: Karpaty and Kneller (2005); KP: Kneller and Pisu (2005); GGP: Girma, Görg and Pisu (2005); GH: Görg and Hijzen (2004); J: Javorcik (2004).

Table 2: Descriptive Statistics

	Number of Observations	Mean	Std. Dev.	Min	Max
ln(TFP)	40,476	6.93	1.14	-4.57	12.74
ln(Horizontal)	49,106	-2.43	0.95	-5.70	-0.61
ln(Backward)	49,106	-4.78	1.29	-9.60	-2.90
ln(Forward)	49,106	-3.29	0.74	-5.62	-1.82
ln(Concentration 1)	49,106	0.12	0.68	-5.26	2.81
ln(Concentration 2)	49,106	0.13	0.94	-10.37	3.65
ln(RER)	49,106	4.58	0.15	3.65	4.76
ln(RER-Backward)	49,106	3.29	0.91	-0.37	4.29
ln(RER-Forward)	49,106	3.69	1.15	0.90	4.73

Concentration 1: Labor; Concentration 2: Gross Output.

Table 3: Productivity Spillovers from Exporting

	Plant Fixed Effects			IV – Plant Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
Backward	0.291	0.291	0.291	0.519	0.519	0.527
	(3.88)**	(3.89)**	(3.88)**	(4.45)**	(4.45)**	(4.52)**
Forward	-0.092	-0.092	-0.094	-0.008	-0.008	-0.018
	(1.68)	(1.69)	(1.72)+	(0.16)	(0.16)	(0.35)
Horizontal	0.034	0.034	0.034	0.053	0.053	0.051
	(0.93)	(0.93)	(0.92)	(2.24)*	(2.24)*	(2.18)*
Concentration 1		-0.003			0.002	
		(0.13)			(0.16)	
Concentration 2			0.068			0.067
			(4.20)**			(6.27)**
Number of Observations	40,476	40,476	40,476	39,648	39,648	39,648
R-Squared	0.183	0.183	0.184	0.177	0.177	0.178
Anderson-Rubin F-Stat				12.49**	12.51**	12.25**
Cragg-Donald F-Stat				224.94**	224.94**	224.89**

Notes: Absolute value of t statistics in parentheses (z statistics for IV regressions). Standard errors were clustered at the industry level in (1)-(3). Sector, region, and year dummy variables were included but not reported. + significant at 10%; * significant at 5%; ** significant at 1%. Concentration 1: Labor. Concentration 2: Gross Output. All variables in logs.

Table 4: Productivity Spillovers from Exporting by Foreign-Owned Plants

	Plant Fixed Effects			IV – Plant Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
Backward-Foreign	0.161	0.161	0.161	0.341	0.341	0.329
	(3.26)**	(3.26)**	(3.25)**	(4.45)**	(4.44)**	(4.31)**
Forward-Foreign	0.091	0.091	0.091	0.262	0.261	0.266
	(2.13)*	(2.13)*	(2.14)*	(4.38)**	(4.37)**	(4.46)**
Horizontal-Foreign	0.104	0.104	0.104	0.226	0.225	0.210
	(2.67)*	(2.67)*	(2.70)*	(2.68)**	(2.68)**	(2.50)*
Concentration 1		0.000			0.010	
		(0.01)			(0.65)	
Concentration 2			0.068			0.068
			(4.14)**			(6.37)**
Number of Observations	40,476	40,476	40,476	39,648	39,648	39,648
R-Squared	0.184	0.184	0.185	0.169	0.169	0.171
Anderson-Rubin F-Stat				12.49**	12.51**	12.25**
Cragg-Donald F-Stat				166.03**	166.79**	166.61**

Notes: Absolute value of t statistics in parentheses (z statistics for IV regressions). Standard errors were clustered at the industry level in (1)-(3). Sector, region, and year dummy variables were included but not reported. + significant at 10%; * significant at 5%; ** significant at 1%. Concentration 1: Labor. Concentration 2: Gross Output. All variables in logs.

Table 5: Productivity Spillovers from Exporting by Domestic Plants

	Plant Fixed Effects			IV – Plant Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
Backward-Domestic	0.242	0.242	0.243	0.483	0.483	0.493
	(2.97)**	(2.98)**	(2.98)**	(3.78)**	(3.77)**	(3.86)**
Forward-Domestic	-0.105	-0.105	-0.107	-0.024	-0.024	-0.033
	(2.37)*	(2.37)*	(2.42)*	(0.47)	(0.47)	(0.65)
Horizontal-Domestic	0.003	0.003	0.003	0.040	0.040	0.038
	(0.11)	(0.11)	(0.11)	(1.72)+	(1.71)+	(1.65)+
Concentration 1		-0.001			0.004	
		(0.07)			(0.26)	
Concentration 2			0.069			0.069
			(4.22)**			(6.40)**
Number of Observations	40,476	40,476	40,476	39,648	39,648	39,648
R-Squared	0.182	0.182	0.183	0.174	0.174	0.175
Anderson-Rubin F-Stat				12.49**	12.51**	12.25**
Cragg-Donald F-Stat				156.68**	155.82**	156.39**

Notes: Absolute value of t statistics in parentheses (z statistics for IV regressions). Standard errors were clustered at the industry level in (1)-(3). Sector, region, and year dummy variables were included but not reported. + significant at 10%; * significant at 5%; ** significant at 1%. Concentration 1: Labor. Concentration 2: Gross Output. All variables in logs.

Figure 1: Horizontal Spillover Variable, 1990-1999

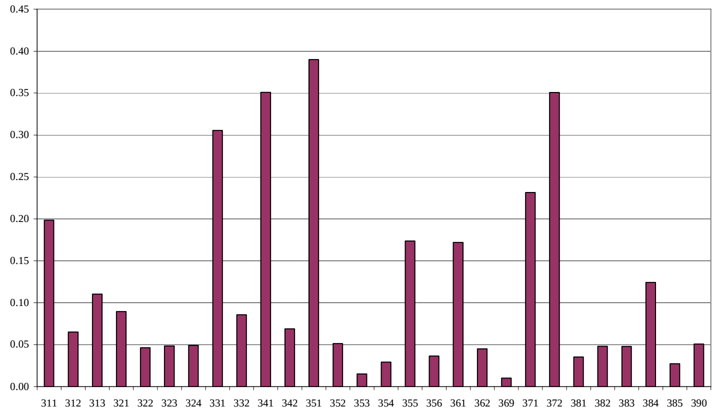

Figure 2: Backward Spillover Variable 1990-1999

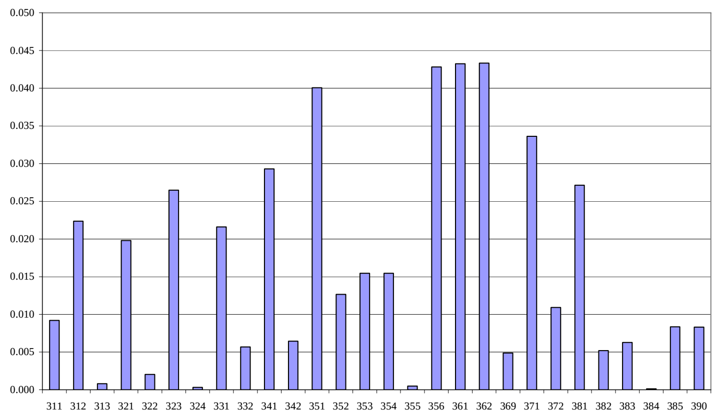

Figure 3: Forward Spillover Variable 1990-1999

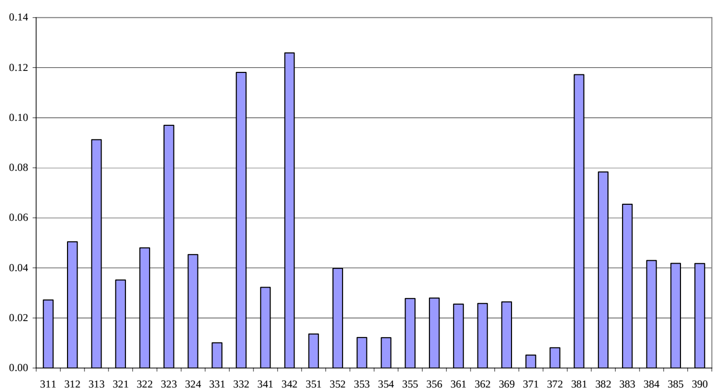

Figure 4: Actual vs. Predicted Horizontal Variable (In Logs)

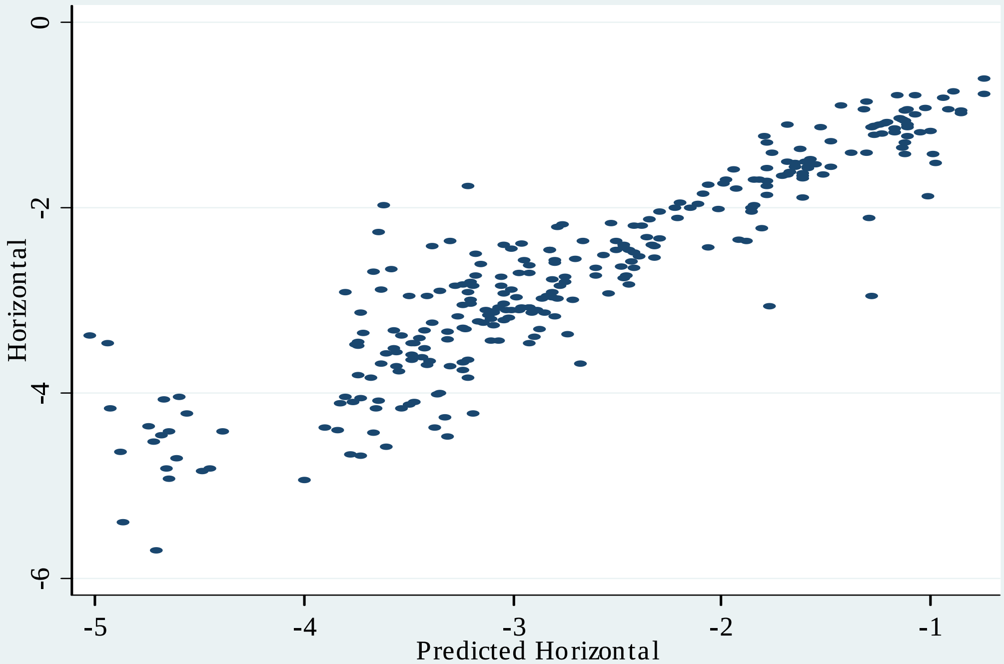

Figure 5: Actual vs. Predicted Backward Variable (In Logs)

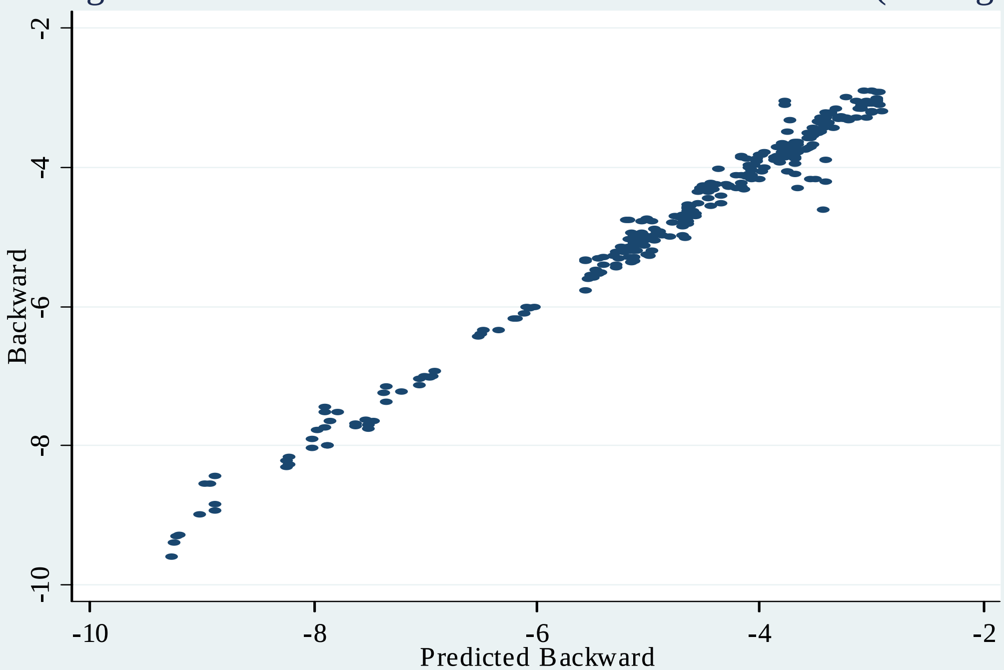

Figure 6: Actual vs. Predicted Forward Variable (In Logs)