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 in the same industry and on plants in vertically related industries. Using data for Chilean manufacturing plants from 1990 to 1999, we find strong evidence that domestic as well as foreign-owned exporting plants improve productivity of local suppliers. We also find some evidence of horizontal spillovers from exporting but these are mainly generated by plants with foreign ownership. These results suggest that positive productivity spillovers are not only generated by the presence of foreign-owned exporting plants but also by exporting activity of domestic firms. The results are robust to controls for agglomeration of economic activity, the importance of non-exporting foreign-owned plants, and plant unobserved heterogeneity. JEL no. F10, F23, O3, O54
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1 Introduction

Over the last decade there has been a growing interest in examining the relationship between exports and productivity using firm level data. Evidence for several countries shows that exporters are more productive than non-exporters and that the existence of trade costs may explain why only high-productivity firms export (Roberts and Tybout 1997; Bernard and Jensen 2004b). Some other studies examine the existence of spillovers or externalities from exporting. These studies focus on whether general exporting activity affects the probability of exporting and export performance

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(Aitken et al. 1997; Clerides et al. 1998; Barrios et al. 2003; Bernard and Jensen 2004b). But with only few exceptions (Clerides et al. 1998; Javorcik 2004; Görg and Hijzen 2004; Girma et al. 2008), they overlook the effect of exporting on productivity. Moreover, there are no studies examining productivity spillovers from exporting by domestically owned plants.

Previous papers on exporting spillovers find that, in general, exporting does not increase the probability of exporting and export performance of other firms. In this article we argue that examining the impact of spillovers on export performance exclusively is only one of the many relevant questions regarding the effects of exporting. Since there are sunk-entry costs to export markets,[1] it may be difficult to observe the effect of exporting activity on firms' entry to foreign markets, unless these spillover effects are large enough to compensate the payment of these entry costs. Moreover, most studies focus on intra-industry spillovers and ignore the potential vertical linkages through buyer-seller relationships.

Little is known about the effects of exporting on other firms' productivity and whether foreign-owned exporters, domestic exporters, or both generate spillover effects. This paper contributes to this growing literature by studying a novel question. Using data for Chilean manufacturing plants, this article investigates whether exporting by both foreign-owned and domestically owned plants generates positive productivity spillover effects on plants in the same industry and in vertically related industries (upstream and downstream sectors).

Given that exporters are also more productive than non-exporters, it is important to disentangle between spillovers from exporting and spillovers from the presence of high-productivity firms. We tackle this issue by examining the effect of exporting by both domestic and foreign-owned plants. Even though foreign-owned plants are more productive than domestic plants, we find that exports by domestic as well as foreign-owned plants generate productivity spillovers. The evidence of export spillovers is also robust to the inclusion of controls for the average productivity in the sector and in vertically related sectors. We argue that our results are consistent with productivity spillovers from exporting rather than spillovers from highly productive plants.

From a policy point of view, it is important to analyze whether productivity spillover effects from exporting exist or not. The existence of spillovers from exporting has been traditionally used as a justification for the use of

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

export promotion programs. Many countries have encouraged exports with the belief 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 positive effects on other firms. The existence of learning-by-exporting itself is not necessarily a justification for export promotion unless these learning effects spill over to other firms.

This paper is related to the economic development literature that argues that export activity may generate demonstration effects or provide new technologies not available to domestic producers.[3] This paper is also consistent with recent microeconomic evidence documenting that exporters are more productive than non-exporters. Starting with the study by Bernard and Jensen (1999) for the United States, scholars have found evidence of productivity differentials in favor of exporters.[4] In the case of Chile, Alvarez and López (2004, 2005) show that after controlling for size and foreign capital participation exporters are 19 percent more productive 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 directly on plant productivity. Second, we consider spillovers from plants in the same industry and extend the previous literature by exploring the role of vertically linked activities. Third, we compare the effect of domestic versus foreign-owned plants' exports; by making this distinction, we investigate if spillovers are, as other authors have claimed, mostly provided by multinational enterprises. And fourth, we address several estimation issues. In particular, we control for potential spillovers coming from non-exporting foreign-owned plants and, following Aitken et al. (1997), for general concentration of economic activity at the region and industry level to ensure that our estimates capture the impact of export activity and not the effect of agglomeration or specific advantages of some locations. We also discuss the possible endogeneity of

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2 See recent surveys by López (2005), Greenaway and Kneller (2007), and Wagner (2007).

3 See, for example, Westphal (2002). Some scholars are, however, more skeptical about the existence of these spillover effects (Rodrik 1999; Panagariya 2000).

4 See, for example, Bernard and Wagner (2001) for Germany; Isgut (2001) for Colombia; and Baldwin and Gu (2003) for Canada. Wagner (2007) 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 (López 2005).

our spillover variables and argue that employing IV estimation methods provides similar results.

Using information for Chilean manufacturing plants from 1990 to 1999, we find that exporters improve productivity of plants in upstream sectors (potential suppliers). We also find some evidence of horizontal spillovers from exporting, but these are mainly originated by foreign-owned plants. In general, our findings are consistent with the idea that exporting by foreign-owned plants generates positive spillovers to other plants. Our finding that domestic exporters increase productivity of their suppliers indicates that positive spillovers are not only associated with a larger presence of multinational exporters, but also with exporting activity of domestic firms. Thus, researchers could have underestimated the role of domestic exporters in generating positive effects on other firms' productivity.

The rest of this paper is structured as follows: Section 2 discusses why exporting may generate productivity spillovers. Section 3 describes the data and the empirical approach. Section 4 presents the main results and robustness checks. Section 5 concludes.

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. Consider a firm entering into a new market or developing a new product for foreign markets; it faces several costs such as promotional investments, establishing contacts with new clients, and technological innovation expenditures. Once the firm achieves its objective, however, other firms may learn from this pioneering firm and be able to enter these markets or to imitate the new product without paying the full investment or entry cost (Westphal 1990). This is not to say that sunk costs of exporting are inexistent, which have been shown to exist extensively, but it is possible that early entrants to exporting may reduce the costs of entry to other potential exporters. A similar idea is formalized in Hausmann and Rodrik (2001), in which a high degree of uncertainty about what a country can produce profitably may generate information spillovers from innovators to other firms when discoveries can be easily imitated. These positive information externalities suggest that investments in opening new markets and developing new products may be lower than the socially optimal level.

Other authors argue that exporters tend to adopt more efficient and competitive management styles, and training of a higher quality of labor that may benefit firms in other sectors (Keesing 1967; Feder 1982; Edwards 1993).[5] The existence of these externalities and the role for export promotion are, however, controversial. Advocates of active export promotion policies have used such justifications to support government intervention. Lall (2002), for example, argues that the evidence suggests that export promotion policies have been effective for improving export performance in newly industrialized economies. But skeptics argue that these policies distort competition and undermine the multilateral free trade system.[6]

Therefore, empirical evidence on this issue is crucial to evaluate whether these policies are justified or not. Table 1 shows a list of studies that examine the existence of spillovers from exporting. Most of these papers explore

Table 1: *Previous Studies on Exporting Spillovers*

	Probability of exporting and/or export intensity	Productivity	
		From foreign-owned exporters	From domestic exporters
Horizontal	AHH[a], CLT, BGS, GK, S, GSW, BJ, RS, KK, KP	CLT, GGP, GH	CLT
Backward	KP	J, GGP	None
Forward	KP	GGP	None

[a] Study deals with endogeneity of industry/region export shares.

Source: AHH: Aitken, Hanson and Harrison (1997); CLT: Clerides, Lach and Tybout (1998); BGS: Barrios, Görg and Strobl (2003); GK: Greenaway and Kneller (2008); S: Sjöholmm (2003); GSW: Greenaway, Sousa and Wakelin (2004); BJ: Bernard and Jensen (2004b); RS: Ruane and Sutherland (2005); KK: Karpaty and Kneller (2005); KP: Kneller and Pisu (2007); GGP: Girma, Görg and Pisu (2008); GH: Görg and Hijzen (2004); J: Javorcik (2004).

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5 Unfortunately, most of these arguments have not been formalized in theoretical models. This contrasts with models looking at multinationals as source of productivity spillovers. See, for example, Rodriguez-Clare (1996), Markusen and Venables (1999), Lin and Saggi (2005), and Markusen and Trofimenko (2007).

6 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.

potential technological or information spillovers from exporters on other firms' export performance. They analyze how export concentration affects the probability of exporting and/or export intensity (the exports 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 and exports by multinational corporations. These studies either do not find evidence that export activity increases the probability of exporting (Clerides et al. 1998; Barrios et al. 2003; Bernard and Jensen 2004b) or find that only multinational exporters generate spillovers (Aitken et al. 1997; Greenaway et al. 2004; Ruane and Sutherland 2005). The effect of exporting activity on export intensity of exporters is not clear either. While some studies find a positive effect of exporting activity by multinationals on export intensity (Greenaway et al. 2004), others find a negative effect (Ruane and Sutherland 2005).

Table 1 also shows a list of studies that look 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 horizontal productivity spillovers from domestic exporting but the results do not provide support for their existence. Using Colombian plant level data they find that high export activity is not, in general, associated with 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.

The emphasis of this paper is on productivity spillovers from exporting activity and not on information spillovers that may improve export performance directly. The idea is that exporters may introduce new technologies and products that can improve productivity of firms in the same industry or of those in vertically related. This is the case of traditional technological spillovers based on the idea than new knowledge is not fully appropriable by firms. Note that productivity and information spillovers are not mutually exclusive. In fact, export spillovers might result from productivity spillovers. A larger presence of exporters in a given industry may increase technological capabilities and productivity of non-exporters and some of these firms may become exporters later. It may also be the case that, due to fixed and variable trade costs, information spillovers are not enough for some firms to become exporters.

We focus on three types of spillovers from exporting activity: horizontal, backward, and forward. Horizontal spillovers refer to the fact that exporting activity in a given industry may increase the productivity of firms in the same industry, even for those that do not export. The literature suggests several mechanisms through which these spillovers may be present. First, exporters are usually exposed to superior technologies or to more exigent external clients and may find ways to improve their products or production processes. This could not only raise the productivity of exporters but also the productivity of other firms through information spillovers about new technologies. Second, exporters may also increase competition in the domestic market. This higher competition may force other firms to increase productivity in order to survive in the local market.

There are several ways by which exporters may affect the productivity of 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.[7] Case studies show that exporters provide technical assistance to domestic suppliers in order to improve quality of the final good. Perez-Aleman (2002: 46), for example, explains how this was the case in the Chilean agro-industry: "Frequent field visits by the plant's technical personnel (at least once a week) to suppliers allowed for timely correction responses to deficiencies to meet the buyer firms quality standards." Interestingly, the knowledge that was transmitted to suppliers was, in some cases, obtained from foreign customers: "as some firms established contracts with world-class customers that had expertise in quality control techniques, they acquired new skills to better manage relations with their suppliers, particularly in the area of quality control." (Perez-Aleman 2002: 46).

There are also arguments favoring the existence of forward export spillovers. This would be the case when downstream industries become more productive as a result of gaining access to new, improved, or less costly intermediate inputs. Although these spillovers have been commonly associated with the presence of multinationals,[8] 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 a raw material in the production of juice, canned fruit, and other more elaborated products. It is reasonable that technological advances in industries produc-

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[7] 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.

[8] See Blomström and Kokko (1998).

ing the input or the introduction of a new variety (raw fruit) can have an important effect on downstream industries (juice, canned fruit).

There are two important aspects regarding the identification of these spillovers effects. First, our main interest is to identify spillovers that are specific to exporting. Given that exporters are more productive than non-exporters, we run the risk of capturing the positive effects from the presence of high-productivity firms and not from exporting activity. We acknowledge that it is difficult to separate both effects and we try to alleviate this problem by distinguishing between the effect of foreign-owned and domestically owned exporters. If spillovers are generated by high-productivity firms and foreign-owned firms are more productive than domestic firms, we should then expect a larger effect on productivity from a larger presence of foreign-owned exporters. As a further robustness check, we include the average productivity of the sector and in other sectors (upstream and downstream) in our basic regressions. As we show in the following sections, the results tend to be consistent with the idea of export spillovers.

Second, the arguments presented in this section refer to positive spillovers. Theoretical considerations, however, prevent us from being too optimistic. On the one hand, horizontal spillovers may be unobserved in practice because firms may have incentives to prevent information flows to competitors. On the other hand, 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.[9]

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 throughout 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 single-plant firms (Pavcnik 2002). The INE updates the survey annually by

[9] This negative effect has been denominated "congestion." Evidence on this has been found by Karpaty and Kneller (2005) for the entry of multinationals in Sweden.

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 technology 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.[10]

3.2 Econometric Strategy

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

$$\begin{aligned} y_{ijrt} &= \alpha_0 + \alpha_1 k_{ijrt} + \alpha_2 l^{NP}_{ijrt} + \alpha_3 l^{P}_{ijrt} + \beta_1 \ln(Horizontal_{jt}) \\ &\quad + \beta_2 \ln(Backward_{jt}) + \beta_3 \ln(Forward_{jt}) + \varepsilon_{ijrt}\,, \end{aligned} \tag{1}$$

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^{NP}_{ijrt} and l^{P}_{ijrt} are the logs of non-production and production labor. *Horizontal*, *Backward*, and *Forward* are variables measuring the potential spillovers from exporters in the same industry and vertically related industries.

The horizontal variable for a given industry, say j, is defined as the exports to sales ratio of that industry:

$$Horizontal_{jt} = \frac{\sum_{i \in j} Exports_{ijt}}{\sum_{i \in j} Sales_{ijt}}\,. \tag{2}$$

It is assumed 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

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[10] For the majority of plants, an initial value of the capital stock was available. This initial value was used to construct the capital stock data by adding investment and subtracting depreciation for each type of capital (machinery and equipment; buildings; and vehicles). For a small group of plants it was not possible to construct the stock of capital, so they were dropped from the data set.

the export orientation of industries that are supplied by industry *j*:

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

where α_{jk} is the proportion of sector *j*'s output supplied to sector *k*. These coefficients are calculated 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*:

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

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 of the horizontal variable at the 3-digit sector level for the period 1990–1999. The most export-oriented sectors are basic chemicals (ISIC 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 low fraction of their output.

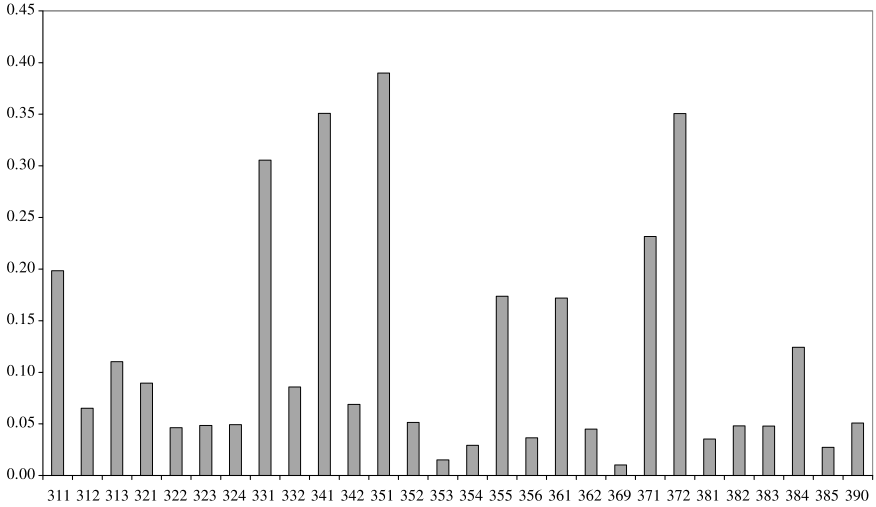
Figures 2 and 3 show the backward and the forward variables. There are important differences across industries. The backward variable is high in ceramics and glass (361, 362), plastic (356), and basic chemicals (351), but close to zero for transport equipment (384), footwear (324), and rubber products (355). The forward variable 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 (1):

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

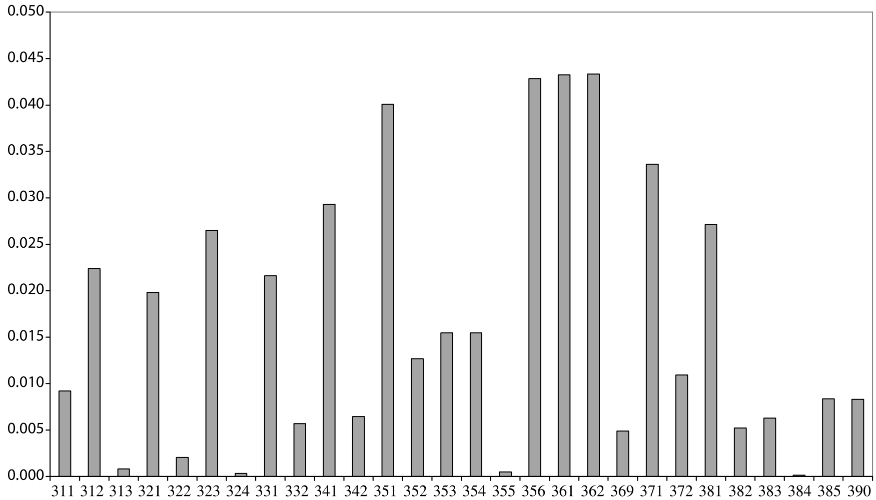
The left-hand side of this equation is the traditional measure of the log of total factor productivity (TFP) at the plant level. To measure TFP we estimate a Cobb–Douglas production function for each 3-digit ISIC indus-

Figure 1: *Horizontal Spillover Variable, 1990–1999*



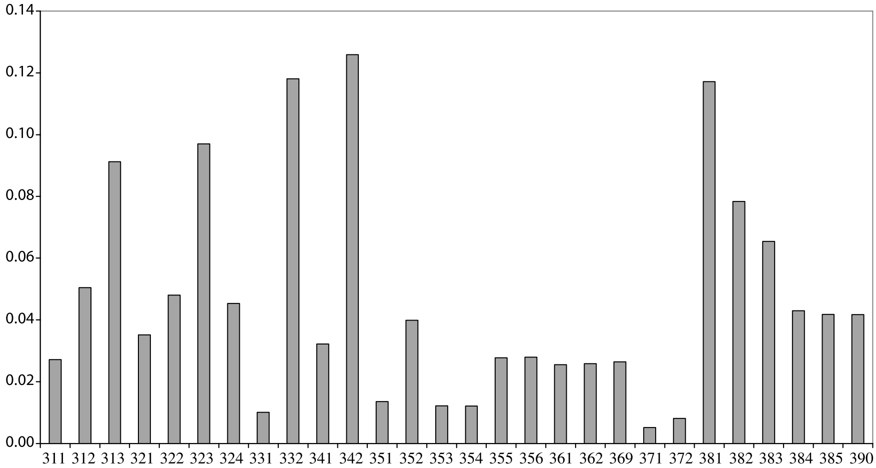
Source: Own elaboration based on data from ENIA.

Figure 2: *Backward Spillover Variable, 1990–1999*



Source: Own elaboration based on data from ENIA.

Figure 3: *Forward Spillover Variable, 1990–1999*



Source: Own elaboration based on data from ENIA.

try using the method proposed by Olley and Pakes (1996), 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. The estimated residuals of these regressions correspond to our measure of productivity.[11] Once TFP has been measured, we estimate the following equation:

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

There are several estimation issues that need discussion. First of all, there may be unobserved plant characteristics, which may make some plants more productive. In that case the error term in (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. After adding a vector of year dummy variables (6) becomes:

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

[11] For a discussion of the Olley and Pakes technique and its strengths see Van Biesebroeck (2007). As a robustness check, we also estimate TFP using the technique proposed by Levinsohn and Petrin (2003). This method, which was recently criticized by Ackerberg et al. (2006), has only minor effect on the results.

We treat c_i as fixed effects and use OLS to estimate the parameters of the within transformation of (7). In all the estimations we control for the plant export status and foreign ownership. Both variables have been found to be positively correlated with plant productivity in the Chilean case (Alvarez and López 2005). In addition, we also estimate the model for a sample of domestic non-exporting plants. This helps to analyze if the impact of spillovers are different for less productive domestic exporters.[12]

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.[13] 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 its 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:[14]

$$\text{Sector-Region Concentration}_{rjt} = \frac{\left(\mathit{Gross\ Ouput}_{rjt} / \mathit{Gross\ Output}_{jt}\right)}{\left(\mathit{Gross\ Output}_{rt} / \mathit{Gross\ Output}_{t}\right)}.$$

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.

Table 2: *Descriptive Statistics*

	Number of observations	Mean	Std. dev.	Min.	Max.
ln(TFP)	40,476	6.55	1.22	−3.67	30.66
ln(Horizontal)	40,476	−2.46	0.96	−5.70	−0.61
ln(Backward)	40,476	−4.77	1.32	−9.60	−2.90
ln(Forward)	40,476	−3.29	0.74	−5.62	−1.82
ln(Sector-region concentration)	40,476	0.16	0.92	−8.11	3.65
Export dummy	40,476	0.23	0.42	0	1
Foreign ownership dummy	40,476	0.06	0.23	0	1

Source: Own elaboration based on data from ENIA.

12 In general, as shown in the next section, our results are similar for both groups of plants. This indicates that domestic non-exporters can also absorb spillovers form exporting plants.

13 See Head and Mayer (2004) for a survey on agglomeration and trade.

14 We also use a concentration variable based on employment data. This is generally insignificant and does not affect the sign and significance of our other estimates.

4 Results

4.1 Basic Results

Table 3 reports the basic results of estimating (7). Columns (1) and (2) show the results using all plants in the sample, while columns (3) and (4) are based on the sample of domestically owned non-exporting plants only. As seen in columns (1) and (2) both the dummy for exporters and the dummy for plants with foreign ownership are positive but only the export dummy is significant. For the spillover variables we find that in all the different specifications the coefficient on backward is positive and statistically significant. The estimate in column (1) suggests that a 1 percent increase in the ratio exports/sales in downstream industries increases productivity of plants in upstream industries by 0.114 percent, on average. Thus, sectors with higher exports increase the productivity of plants that provide inputs to those sectors. The estimates for forward and horizontal are both positive

Table 3: *Productivity Spillovers from Exporting—Basic Results*

	All plants		Domestic non-exporters	
	(1)	(2)	(3)	(4)
Backward	0.114 (3.29)***	0.114 (3.27)***	0.146 (3.48)***	0.146 (3.48)***
Forward	0.021 (0.72)	0.019 (0.68)	0.015 (0.52)	0.014 (0.48)
Horizontal	0.037 (1.80)*	0.037 (1.78)*	0.028 (1.22)	0.028 (1.22)
Export dummy	0.042 (3.24)***	0.042 (3.29)***	—	—
Foreign ownership dummy	0.031 (0.90)	0.030 (0.89)	—	—
Sector-region concentration	—	0.065 (3.94)***	—	0.042 (2.83)***
Number of observations	40,476	40,476	30,136	30,136
R-squared (within)	0.114	0.114	0.146	0.146

Note: Absolute value of robust t-statistics in parentheses. Standard errors were clustered at the industry level. Year dummy variables were included but not reported. * and *** significant at the level of 10 and 1 percent, respectively. All variables in logs. Dependent variable: log(TFP).

but in general not significant. The estimate for horizontal is significant at the 10 percent level only when all plants are included. In order to control for positive effects of agglomeration that are not linked to exporting or multinationals activity, columns (2) and (4) present the estimates including the variable capturing industry and region concentration of economic activity. The estimate for this variable is positive and statistically significant suggesting that there are indeed positive agglomeration externalities. More importantly, the coefficients for the spillover variables remain unchanged once this control variable is included. In summary, the estimates suggest the existence of backward productivity spillovers from exporting, but there is no evidence of forward spillovers.

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:

$$Horizontal\text{-}Foreign_{jt} = \frac{\sum_{i \in j} F_{ijt} Exports_{ijt}}{\sum_{i \in j} Sales_{ijt}}, \qquad (8)$$

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 a similar 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 (3) and (4).

Table 4 shows the results of estimating (7) splitting the exporting spillover variables between domestic and foreign-owned plants. Columns (1) and (2) refer to the entire sample, while (3) and (4) correspond to domestic non-exporter plants. We find, in general, evidence of backward spillovers from both domestic and foreign exporters, especially for the case of domestic plants. As seen in columns (3) and (4), exports from domestic as well as foreign-owned plants in downstream sectors generate increases in productivity of plants in upstream sectors of the same magnitude; we test if both

Table 4: *Productivity Spillovers from Exporting: Foreign-Owned Plants' Exports vs. Domestic Plants' Exports*

	All plants		Domestic non-exporters	
	(1)	(2)	(3)	(4)
Backward-Foreign	0.052	0.052	0.077	0.076
	(1.64)	(1.66)	(2.23)**	(2.22)**
Backward-Domestic	0.067	0.068	0.075	0.076
	(1.94)*	(1.97)*	(1.95)*	(1.97)*
Forward-Foreign	−0.011	−0.011	−0.006	−0.006
	(0.46)	(0.47)	(0.20)	(0.20)
Forward-Domestic	0.018	0.017	0.016	0.015
	(0.70)	(0.66)	(0.58)	(0.55)
Horizontal-Foreign	0.057	0.057	0.064	0.063
	(2.55)**	(2.60)**	(2.12)**	(2.12)**
Horizontal-Domestic	0.021	0.021	0.014	0.014
	(1.59)	(1.59)	(0.98)	(0.98)
Export dummy	0.043	0.043	—	—
	(3.29)***	(3.35)***		
Foreign ownership dummy	0.030	0.029	—	—
	(0.88)	(0.87)		
Sector-region concentration	—	0.065	—	0.042
		(3.98)***		(2.84)***
No. of observations	40,476	40,476	30,136	30,136
R-squared (within)	0.253	0.254	0.218	0.219
Back-For = Back-Dom (F-Stat)	0.07	0.07	0.00	0.00
Forw-For = Forw-Dom (F-Stat)	1.54	1.47	0.73	0.66
Hor-For = Hor-Dom (F-Stat)	2.15	2.29	2.22	2.23

Note: Absolute value of robust t-statistics in parentheses. Standard errors were clustered at the industry level. Year dummy variables were included but not reported. *, **, *** significant at the level of 10, 5, and 1 percent, respectively. All variables in logs. Dependent variable: log(TFP).

coefficient are the same (Backward-Foreign = Backward-Domestic), and the null hypothesis cannot be rejected (the F-test is between 0.00 and 0.07 across the different specifications). The estimates for the forward spillover variable tend to be positive for those originated by domestic plants and negative for those originated by foreign-owned plants, but both are not statistically significant. Finally, we find that when we distinguish between exports by domestic plants and exports by foreign affiliates, there is clear evidence of horizontal spillovers from foreign-owned exporting plants. Therefore, our basic results are robust to distinguishing between domestic and foreign exporting spillovers. Both domestic and foreign-owned exporters generate backward spillover effects. We find that forward spillovers are not significant, and there is some evidence of positive horizontal spillovers from foreign-owned exporters.

4.3 Robustness Checks

It has been argued in this paper that exporters may be a potential source of productivity gains for other plants, but most of the previous literature has focused on overall multinationals spillovers (Aiken et al. 1997; Javorcik 2004). It is possible, however, that the positive association between exporting and TFP may be also reflecting the effect of productivity spillovers from foreign-owned plants. There are two reasons for this. First, foreign-owned plants are more productive than domestic plants. In Table 5 we show the effect of being a foreign-owned plant on TFP. Column (1), which includes sector, region, and year dummy variables, shows that foreign-owned plants are 33.6 percent more productive than domestic plants. As seen in columns (2) and (3), foreign-owned plants are more productive than domestic plants even when controls for plant size and export status are included. The second reason to suspect that foreign-owned plants may affect the results is that they produce a significant fraction of the manufacturing output and use

Table 5: *Differences in TFP between Foreign-Owned Plants and Domestic Plants*

	(1)	(2)	(3)
Foreign ownership dummy	0.336	0.149	0.121
	(8.80)***	(4.08)***	(3.31)***
Log(Employment)	—	0.263	0.234
		(31.73)***	(26.26)***
Export dummy	—	—	0.160
			(8.05)***
Constant	27.648	26.330	26.361
	(16.84)***	(17.90)***	(18.02)***
No. of observations	40,476	40,476	40,476
R-squared	0.565	0.613	0.615

Note: Absolute value of robust t- statistics in parentheses. Standard errors were clustered at the plant level. 3-digit sector, year, and region dummy variables were included but not reported. *** significant at the level of 1 percent. Dependent variable: log(TFP).

a large amount of resources. For example, in 1999 foreign-owned plants accounted for 32 percent of all value added of the manufacturing industry and almost 17 percent of the labor force employed in the manufacturing sector. They also accounted for 34 percent of the capital stock and 38 percent of the exports of the entire manufacturing sector.

For these reasons we check how robust our results are after controlling for the importance of foreign-owned plants independently if they are exporters or not. Our basic and extended regressions in Tables 3 and 4 are replicated in Tables 6 and 7 but including three measures of the importance of non-exporting foreign-owned plants in the same sector (Horizontal FDI) and vertically related sectors (Backward FDI and Forward FDI).[15] As seen in Table 6, the estimates for Horizontal FDI and Backward FDI are positive and in some cases statistically significant. Consistent with Javorcik (2004), we find evidence of backward productivity spillovers from FDI on domestic plants. Table 6 also shows that the existence of backward spillovers from exporting is robust to the inclusion of these additional control variables. Moreover, the estimate for the horizontal variable becomes significant in most of the cases. In Table 7 the estimates for FDI are not statistically significant and the estimates for the spillover variables remain similar than those without controls. The coefficient for backward-domestic is positive and significant, while the estimate for horizontal-foreign remains positive and significant.

As a further robustness check, we include the average productivity of the sector and in other sectors (upstream and downstream) in our basic regressions. If our measures of exporting spillovers were capturing the effect of firms learning from more productive firms then the coefficient of these variables should turn out to be not significant. As we show in Table 8 the evidence seems to confirm the existence of exporting spillovers. The parameters for the average productivity in the same sector as well as in upstream and downstream sectors are positive but not statistically significant. Moreover, the inclusion of these variables has only minor effects on the estimated coefficients of the spillovers variables and does not affect their statistical significance.

A final estimation issue is a possible endogeneity of the spillover variables. Suppose, for instance, that some sectors export more because plants

[15] These variables reflect the share of non-exporting foreign-owned plants in the output of the same industry (Horizontal FDI) as well as in downstream (Backward FDI) and upstream sectors (Forward FDI).

Table 6: *Productivity Spillovers from Exporting with Controls for FDI*

	All plants		Domestic non-exporters	
	(1)	(2)	(3)	(4)
Backward	0.097	0.097	0.127	0.127
	(2.65)**	(2.63)**	(2.97)***	(2.97)***
Forward	0.013	0.012	0.005	0.004
	(0.52)	(0.48)	(0.19)	(0.15)
Horizontal	0.047	0.047	0.041	0.041
	(2.35)**	(2.34)**	(1.92)*	(1.93)*
Export dummy	0.044	0.045	—	—
	(3.31)***	(3.36)***		
Foreign ownership dummy	0.028	0.028	—	—
	(0.83)	(0.82)		
Horizontal FDI	0.023	0.022	0.016	0.016
	(2.01)*	(2.01)*	(1.12)	(1.12)
Backward FDI	0.025	0.025	0.033	0.033
	(1.72)*	(1.72)*	(2.12)**	(2.11)**
Forward FDI	−0.027	−0.026	−0.039	−0.039
	(1.50)	(1.49)	(1.68)	(1.68)
Sector-region concentration	—	0.064	—	0.042
		(3.90)***		(2.78)***
No. of observations	40,476	40,476	30,136	30,136
R-squared (within)	0.254	0.254	0.219	0.219

Note: Absolute value of robust t-statistics in parentheses. Standard errors were clustered at the industry level. Year dummy variables were included but not reported. *, **, *** significant at the level of 10, 5, and 1 percent, respectively. All variables in logs. Dependent variable: log(TFP).

that operate in that sector are more productive. Furthermore, some plants may increase their productivity with the purpose of becoming exporters (Hallward-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 (7), u_{ijrt}, will be correlated with the spillover variables, so that the OLS estimates will be inconsistent. This suggests the use of instrumental variables estimation techniques.

Unfortunately, it is difficult to find appropriate instruments for the spillover variables. In the context of our problem, we need to find variables

Table 7: *Productivity Spillovers from Exporting: Foreign-Owned Plants' Exports vs. Domestic Plants' Exports with Controls for FDI*

	All plants		Domestic non-exporters	
	(1)	(2)	(3)	(4)
Backward-Foreign	0.035	0.035	0.061	0.060
	(0.87)	(0.88)	(1.30)	(1.29)
Backward-Domestic	0.071	0.071	0.083	0.083
	(2.30)**	(2.33)**	(2.40)**	(2.43)**
Forward-Foreign	−0.009	−0.009	−0.009	−0.009
	(0.43)	(0.45)	(0.35)	(0.35)
Forward-Domestic	0.010	0.009	0.007	0.006
	(0.43)	(0.38)	(0.28)	(0.24)
Horizontal-Foreign	0.055	0.055	0.062	0.062
	(2.08)**	(2.12)**	(1.79)*	(1.80)*
Horizontal-Domestic	0.025	0.025	0.020	0.020
	(2.00)*	(2.01)**	(1.41)	(1.43)
Export dummy	0.045	0.045	—	—
	(3.36)***	(3.41)***		
Foreign ownership dummy	0.028	0.027	—	—
	(0.81)	(0.80)		
Horizontal FDI	0.020	0.020	0.013	0.013
	(1.62)	(1.63)	(0.85)	(0.85)
Backward FDI	0.015	0.015	0.017	0.017
	(0.79)	(0.80)	(0.80)	(0.80)
Forward FDI	−0.024	−0.023	−0.032	−0.032
	(1.52)	(1.51)	(1.67)	(1.66)
Sector-region concentration	—	0.065	—	0.042
		(3.95)***		(2.81)***
No. of observations	40,476	40,476	30,136	30,136
R-squared (within)	0.254	0.255	0.219	0.219
Back-For = Back-Dom (F-Stat)	0.34	0.36	0.11	0.12
Forw-For = Forw-Dom (F-Stat)	0.59	0.55	0.33	0.29
Hor-For = Hor-Dom (F-Stat)	1.09	1.17	1.28	1.29

Note: Absolute value of robust t-statistics in parentheses. Standard errors were clustered at the industry level. Year dummy variables were included but not reported. *, **, *** significant at the level of 10, 5, and 1 percent, respectively. All variables in logs. Dependent variable: log(TFP).

Table 8: *Productivity Spillovers from Exporting – Basic Results with Sector Level TFP*

	All plants		Domestic non-exporters	
	(1)	(2)	(3)	(4)
Backward	0.118	0.118	0.147	0.146
	(3.38)***	(3.37)***	(3.56)***	(3.56)***
Forward	0.023	0.022	0.016	0.015
	(0.73)	(0.69)	(0.49)	(0.46)
Horizontal	0.039	0.038	0.030	0.030
	(1.88)*	(1.86)*	(1.33)	(1.34)
Export Dummy	0.043	0.043	—	—
	(3.26)***	(3.32)***		
Foreign ownership dummy	0.030	0.030	—	—
	(0.89)	(0.88)		
TFP same sector	0.017	0.017	0.008	0.008
	(0.92)	(0.93)	(0.39)	(0.40)
TFP downstream sectors	0.001	0.001	0.001	0.001
	(0.25)	(0.35)	(0.39)	(0.43)
TFP upstream sectors	0.010	0.010	0.012	0.012
	(1.03)	(1.06)	(1.06)	(1.08)
Sector-region concentration	—	0.065	—	0.043
		(3.95)***		(2.87)***
No. of observations	40,476	40,476	30,136	30,136
R-squared (within)	0.253	0.254	0.218	0.218

Note: Absolute value of robust t-statistics in parentheses. Standard errors were clustered at the industry level. Year dummy variables were included but not reported. * and *** significant at the level of 10 and 1 percent, respectively. All variables in logs. Dependent variable: log(TFP).

that are correlated with the export performance of sectors (upstream and downstream) but uncorrelated with the error term in (7). We use as instrument the level of foreign income relevant for the sector. The idea is that an increase in foreign income increases the demand for Chilean exports, augmenting the export share of the manufacturing sectors. Using information on export destinations, we construct a weighted average of the income level of each of the 15 main destination countries of Chile for each 3-digit sector. In addition, we construct a level of foreign income relevant for plants in upstream sectors and a foreign income relevant for plants in downstream sectors.[16]

[16] See Appendix for an explanation on how these variables were constructed.

There are two concerns with instrumental variables: validity and weakness (Murray 2006). The validity of this instrument could be justified by recent evidence in Bernard and Jensen (2004a) showing that increases in foreign income (a proxy for demand in external markets) increase the export share of US plants in the manufacturing sector.[17] Then, controlling for firm characteristics, demand pull factors are expected to increase export shares. In order to debilitate the validity of our instrument, foreign income should be correlated with unobservable factors affecting firm productivity. It is possible that highly productive firms self-select into high-income or growing income markets, but this could be a serious concern only if we do not control, as we do, for other firm characteristics such as export status and foreign ownership. In sum, even though we cannot test directly the validity of the instrument, we believe it is reasonable to assume that external demand affects export shares, but not directly firm productivity.

To check that our instruments are not weak, we follow the traditional procedures of looking at the individual t-statistics for the coefficients of the three measures of foreign income, 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 foreign income reveal that these variables are always significant at 1 percent. A more formal test is the Anderson–Rubin test of the significance of the endogenous regressors. 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 percent, confirming the validity of our instruments.

The results of using this method, not presented here, show that the estimate for the backward variable is positive and statistically significant while the estimates for the forward and the horizontal variables are not significant. This is consistent with the results obtained using the within estimator, which gives us confidence that our findings are fairly robust and not driven by simultaneity problems.

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[17] In order to check that this is also true in the Chilean case, we estimated a regression for the export share at the firm level with foreign income as explanatory variable. The estimated coefficient turned out to be positive and statistically significant confirming that this variable is highly correlated with exports.

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. However, empirical evidence on this regard is scant.

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 some evidence that higher exporting activity in a given sector increases the productivity of the plants operating in that domestic sector. We do not find, however, evidence of spillovers from exporters to their buyers of output.

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 and to other plants in the same industry. This is consistent with the perception that foreign firms transfer technologies in developing countries. But this does not mean that domestic exporters do not improve the performance of other plants. We find also support for the existence of backward spillover effects from domestic exporters to their suppliers.

Although we have been able to address several estimation issues that have plagued previous studies such as the identification of spillover effects, and the role of unobserved plant characteristics, we 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 exporters and its suppliers and customers.

Appendix: IV Estimation

To instrument the three spillover variables we construct three measures of foreign income using GDP per capita of the main destination countries of Chilean exports. We first compute the level of foreign income that a given sector j faces at time t ($GDPPC_{jt}$) as a weighted average of the real per capita GDP of the 15 main destination countries of the Chilean exports of the industry: $GDPPC_{jt} = \sum_{c=1}^{C} \theta_{cj} GDPPC_{ct}$, where $GDPPC_{ct}$ is the per capita GDP of country c; $C = 15$

is the number of countries; and θ_{cj} is defined as: $\theta_{cj} = (1/T)\sum_{t=1}^{T} Exports_{cjt}/Exports_{jt}$, 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 variable is assumed to be correlated with the export share of the sector (the horizontal variable). Based on this variable, we compute the foreign per capita GDP for exporters in downstream sectors as $GDPPC - Backward_{jt} = \sum_{k,k\neq j} \alpha_{jk} GDPPC_{kt}$, while the foreign income in upstream sectors is calculated as $GDPPC - Forward_{jt} = \sum_{k,k\neq j} \sigma_{jk} GDPPC_{kt}$.

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