

# The Role of Foreign Technical and Professional Services in Learning by Exporting

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## Abstract

Using data from the entire pool of manufacturing plants in Chile from 1990 to 1996, evidence found in this paper for a specific channel through which learning by exporting can happen: domestic exporters gain enhanced access to foreign technical and professional services by virtue of their presence in the foreign market and actively use it to acquire productivity improving capabilities. It is first shown that export experience may help firms to have foreign technical service market access. Using the propensity-score matching technique to control for self-selection firms are matched within narrowly defined industries. Using the difference in difference estimator that removes the effects of aggregate shocks, strong evidence is found for 'learning by exporting' but only among those that have access to foreign technical service markets.

*Keywords:* Productivity; Learning by Exporting; Foreign Technical Service Markets

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# 1 Introduction

Recent evidence shows a self-selection of more productive firms into export markets<sup>1</sup> but we still do not fully know the feedback effects from exporting on the future development in firm productivity. To what extent do firms learn by exporting and what are specific channels through which export may lead to productivity improvement?

Learning by exporting is often thought to happen via the buyer-supplier link that foreign buyers actively or passively channel knowledge to domestic exporters during the course of doing business. Previous empirical studies which look for evidence of this mechanism failed to find strong support of it.<sup>2</sup> More recently Van Biesebroeck (2006) showed evidence of learning for African exporters and De Loecker (2007) showed evidence of learning for exporters in a transition country, Slovenia, suggesting that this channel is more plausible when there are large differences in development between exporters' and buyers' markets.

In a related literature, the complementarities between productivity enhancing investment and firms' exporting status has been in focus as one potential channel of feedback. (See for example Aw, Roberts, and Winston (2005), Bustos (2005) for empirical evidence and Melitz and Constantini (2007), Atkeson and Burstein (2008) for structural foundations on the linkages between technological upgrade and firms exporting decision.) The main argument in this literature is that domestic firms upgrade technology or engage in more innovative activities to make better use of international market opportunities.

In this paper, evidence is sought of a specific channel through which export may lead to productivity gain, namely through the link between domestic exporters and foreign technology and technical service suppliers rather than through the all-inclusive foreign buyer-domestic supplier link. In the paper, it is argued that learning by exporting may happen through

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<sup>1</sup>See for example, Clerides, Lach and Tybout (1998), Bernard and Jensen (1999).

<sup>2</sup>For a review of the literature, see Tybout (2000).

an intentional effort to develop and improve technological capabilities by acquiring foreign assistance, training and licensing.

Exporting firms may improve their productivity levels because they have a better chance of accessing and absorbing foreign technology and information from foreign technical and professional service (FTS) suppliers by virtue of their presence in the foreign markets. Through this channel new technologies diffuse from foreign technical service markets towards domestic firms which consume the services provided by foreign technical and professional service suppliers. These services may include foreign technical training and assistance, technological license purchases, management consulting services, computer and related services, and maintenance and repair of equipment services provided by foreigners. <sup>3</sup>

In this paper, establishment-level panel data from Chile is used, which covers the entire manufacturing sector and has the unique feature of allowing the identification of establishments with foreign technical service market access. The data is used to investigate the linkages between firms' decision to access foreign technical service markets and to export and is used to evaluate the effect of firms' status regarding FTS purchase on the exporters' future total factor productivity trajectory.

The data suggest that FTS access and exporting are strongly correlated. There may be different explanations for the positive association between exporting and FTS access. First of all, to the extent that accessing foreign markets involves sunk costs (Das et al., 2007), it becomes relatively less costly for exporting firms to access foreign technical and professional services. It is also possible that foreign technical service purchase results in future productivity improvement which then results in a higher probability of paying the sunk entry costs

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<sup>3</sup>Recent work examines forward linkages of technological spill-over between manufacturing and service sector. But these spill-overs are considered within a country, and technical and professional services that may have a direct impact on technology transfer are not distinguished from the other service sectors. See for example Arnold et al. (2007).

of exporting. To some extent linkages may also be related to being a foreign affiliate, as foreign affiliates will be provided technology service by the parents. The results presented here suggest that firms find it easier to utilize FTS opportunities through their customers in the foreign market.

The question is then whether exporters' access to foreign technical service markets would be a channel of learning. Investigating whether Chilean exporters learn by exporting, the present analysis does not show strong evidence for learning by exporting after controlling for self selection and common industry and time effects. It is examined then whether we can find evidence of learning by exporting among firms that have foreign technical service market contacts. The results show that among exporters, firms that receive foreign technical services (FTS) are the ones who are 'learning', suggesting that learning by exporting for Chilean exporters comes through foreign service market access.

Section 2 provides description of the data and the preliminary analysis. In Section 3, an analysis of complementarities between exporting and accessing FTS is provided. In Section 4, the preliminary analysis of learning by exporting and the econometric methodology are presented. In section 5, the results are presented and discussed followed by the concluding remarks in Section 6.

## **2 Data and Preliminary Analysis**

### **2.1 Data Description**

The data set analyzed in this paper contains plant-level panel data from Chile from the period 1990 to 1996. The data is from the Annual National Industrial Survey (ENIA), which is prepared by the National Institute of Statistics of Chile (INE). The survey covers the universe of Chilean manufacturing plants with 10 or more workers.

For each plant, the ENIA collects data on production, value added, sales, employment, wages, investment, depreciation, energy and materials usage, domestic service expenditures as well as expenditure on foreign technical service. More specifically, each manufacturing plant in the data set reports its expenditure on foreign technical assistance and license fees. Typical international licensing agreements include technical assistance, managerial assistance, component and equipment supply, patent rights, trademark rights, and buyback of licensee product.<sup>4</sup>

Plant-level output and input variables are deflated using 3-digit industry deflators.<sup>5</sup> Every variable is converted in constant 1980 prices. The capital stock variable which consists of building, machinery and vehicle, is constructed using the perpetual inventory method. Separate deflators are used for buildings, machinery and vehicles.<sup>6</sup>

Table 1 shows the number of plants each year that engage in export and FTS. The visual inspection of the data confirms the positive association between exporting and accessing to FTS. More than 50 percent of plants that purchase FTS are also exporting.<sup>7</sup>

## 2.2 Preliminary Analysis

A preliminary analysis is first performed to analyze the exporters' and FTS receivers' characteristics. To do that, the following OLS regressions are run:

$$x_{ist} = \beta_0^{XP} + \beta_1^{XP} I(XP_{ist}) + \beta_2^{XP} \ln l_{ist} + \sum_t \gamma_t Year_t + \sum_s \eta_s Industry_s + \epsilon_{ist} \quad (1)$$

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<sup>4</sup>See Contractor (1985) for the details of licensing agreements.

<sup>5</sup>I thank Alfonso Irarrazabal for providing 3-digit industry level output and input deflators.

<sup>6</sup>I assume that investment at period  $t$  becomes productive at period  $t+1$ , that is,  $k_{t+1} = (1 - \delta)k_t + i_t$ . Following Liu (1990), rather than using reported book values of annual depreciation for each year, economic depreciation rate of 5% for building, 10% for machinery and equipment and 20% for vehicles are used.

<sup>7</sup>I will use the word firm instead of plant in the remainder of the paper. Note that although the data set does not allow me to see if a plant is a single plant firm or part of a multi-plant firm; the majority of the plants in Chile are single-plant firms (Pavcnik, 2002).

$$x_{ist} = \beta_0^{FTS} + \beta_1^{FTS} I(FTS_{ist}) + \beta_2^{FTS} \ln l_{ist} + \sum_t \gamma_t Year_t + \sum_s \eta_s Industry_s + \epsilon_{ist} \quad (2)$$

$$x_{ist} = \beta_0^{XPF} + \beta_1^{XPF} I(FTS_{ist}) * I(XP_{ist}) + \beta_2^{XPF} \ln l_{ist} + \sum_t \gamma_t Year_t + \sum_s \eta_s Industry_s + \epsilon_{ist} \quad (3)$$

where  $x_{ist}$  denotes characteristics of plant  $i$  at period  $t$  in industry  $s$  (in logarithm),  $l$  is total labor,  $I(XP)$  is an export dummy equal to one when the firm is an exporter and zero otherwise,  $I(FTS)$  is a foreign technical service market access indicator equal to one when the firm purchases foreign technical service and zero otherwise. 2-digit industry and year dummies are also included.

The respective  $\beta_1$  coefficients are reported in Table 2. The first two columns of Table 2 reports the differences between exporters and non-exporters, and FTS receivers and non-FTS receivers, respectively. The third column reports the differences between firms engaging in both activities and firms engaging in none or only one of the activities (FTS and export premium). The coefficient  $\beta_1$  indicates the percentage differences in the relevant firm characteristics controlling for size (measured by the number of employees), industry and time effects.

The results on exporters confirm the general findings of the literature, that on average exporters are bigger, more capital-intensive, they pay higher wages, and they generate higher value-added. FTS access premium on the other hand, is, to my knowledge, not studied in the literature before.

Firms with FTS access have similar characteristics as exporters. They pay higher wages (26.3 %), and invest more (43.7 %). Their technology is relatively more capital intensive (38.2 %) and they have higher labor productivity (44.8 %). Focusing on differences between exporters

and FTS receivers, FTS receivers seem to be smaller than exporters in general. Probably the most striking differences between exporters and FTS receivers are related to the composition of workers'. FTS receivers are significantly more skill-intensive than exporters. This is in line with expectations. If firms invest in foreign technical expertise, they need to have the capacity to absorb these new techniques, so they need to employ high skill people to learn the new ways of doing production, management, etc..Column (c) reveals that firms that engage in both activities have similar characteristics as exporters with the exception of workers' composition. Do exporters build capacity to absorb foreign knowledge via FTS?

Table 2: Differences in Firm Characteristics

|                                                   | (a)                | (b)             | (c)             |
|---------------------------------------------------|--------------------|-----------------|-----------------|
| Firm Characteristics                              | $\beta_1^{XP}$     | $\beta_1^{FTS}$ | $\beta_1^{XPF}$ |
| Value added per worker                            | 0.385              | 0.448           | 0.525           |
| Average Wage                                      | 0.223              | 0.263           | 0.326           |
| Average Blue Collar Wage                          | 0.150              | 0.169           | 0.203           |
| Average White Collar Wage                         | 0.269              | 0.168           | 0.206           |
| Capital per worker                                | 0.631              | 0.382           | 0.532           |
| Investment per worker                             | 0.563              | 0.437           | 0.543           |
| Employment                                        | 1.266              | 1.076           | 1.609           |
| $\frac{Non-ProductionWorkers}{TotalWorkers}$      | 0.035 <sup>n</sup> | 0.460           | 0.549           |
| $\frac{Executives\&Administrators}{TotalWorkers}$ | 0.132              | 0.330           | 0.448           |
| Number of Observations (max/min)                  | 32060/18365        | 32060/18365     | 32060/18365     |

Note: All regressions include log employment except for the employment regression. All monetary variables are deflated by the appropriate 3-digit industry deflator. All coefficients are significant at the 1% level except the coefficients with superscript "n" which indicates that coefficient is not statistically significant.

## 2.3 Productivity Estimation

Plant-level productivity is computed by estimating the production function in the form of:

$$Q_{it} = e^{\mu_{it}} U L_{it}^{\beta_u} S L_{it}^{\beta_s} K_{it}^{\beta_k} \quad (4)$$

where  $Q_{it}$  denotes the output measured by value-added,  $UL_{it}$  denotes the number of unskilled workers,  $SL_{it}$  denotes the number of skilled workers, and  $K_{it}$  denotes the value of capital used by firm  $i$  at period  $t$ .

The semi-parametric estimator developed by Olley and Pakes (1996) is used to estimate the production function. The Olley and Pakes (1996) estimator deals with the simultaneity problem associated with production function estimation which has been well-recognized at least since Marschak and Andrews (1944), by using investment as a proxy to control for unobservable productivity. The estimator also corrects for the selection bias. It is important to control for simultaneity bias, as it will more likely cause a downward bias in the capital coefficient and this will likely cause an over-estimation of exporters' productivity as they are more capital-intensive. Moreover, potential bias due to exporters' and/or firms with FTS access facing different market structures and factor prices is also corrected for. To do that, the investment function that is used as a proxy for unobservable productivity is allowed to be different for firms with different status (exporters, and FTS receivers). The estimator also takes into account firm's status with respect to exporting and FTS access when calculating the survival probabilities to correct for the selection.<sup>8</sup>

The production functions are estimated separately for each 2-digit industry allowing different technologies for each industry.

The productivity measure is then imputed as follows:

$$\mu_{ijt} = (q_{ijt} - \bar{q}_{jt=1990}) - \beta_{uj}(ul_{ijt} - \bar{ul}_{jt=1990}) - \beta_{sj}(sl_{ijt} - \bar{sl}_{jt=1990}) - \beta_{kj}(k_{ijt} - \bar{k}_{jt=1990}) \quad (5)$$

where  $q$ ,  $ul$ ,  $sl$ , and  $k$  denote the logarithm of; value-added, unskilled labor, skilled labor and capital respectively.  $i$  is an index for plant,  $j$  for industry and  $t$  for time. Bar indicates

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<sup>8</sup>Similar approaches have been used by Van Biesebroeck (2006) and De Loecker (2007).

average. So  $\bar{q}_{jt=1990}$  denotes the geometric mean of value added across all other firms in industry  $j$  at year 1990. That is, productivity is expressed relative to the hypothetical firm constructed for each industry separately at year 1990. The coefficients of capital, skilled workers and unskilled workers are found to be 0.16, 0.33 and 0.35 on average across nine 2-digit manufacturing industries.

### 3 Potential Linkages between Exporting and FTS

In this section, the determinants of the decision to purchase FTS and the decision to export are investigated using a probit model. The export decision and purchasing foreign technical service are specified as two binary decisions.

$$\begin{aligned}
I(XP_{it}) = & b_0 + b_1 \log(k_{it}) + b_2 \log(l_{it}) + b_3 \log(wage_{it}) + b_4 skill_{it} + b_5 \mu_{it} + b_6 \log(age) + b_7 I(ForCap_{it}) + \\
& b_8 I(XP_{it-1}) * I(FTS_{it-1}) + b_9 (1 - I(XP_{it-1})) * I(FTS_{it-1}) + b_{10} (1 - I(FTS_{it-1})) * I(XP_{it-1}) + \\
& \sum_t \gamma_t Year_t + \sum_s \eta_s Industry_s + \epsilon_{it}^{XP}
\end{aligned} \tag{6}$$

$$\begin{aligned}
I(FTS_{it}) = & b_0 + b_1 \log(k_{it}) + b_2 \log(l_{it}) + b_3 \log(wage_{it}) + b_4 skill_{it} + b_5 \mu_{it} + b_6 \log(age) + b_7 I(ForCap_{it}) + \\
& b_8 I(XP_{it-1}) * I(FTS_{it-1}) + b_9 (1 - I(XP_{it-1})) * I(FTS_{it-1}) + b_{10} (1 - I(FTS_{it-1})) * I(XP_{it-1}) + \\
& \sum_t \gamma_t Year_t + \sum_s \eta_s Industry_s + \epsilon_{it}^{FTS}
\end{aligned} \tag{7}$$

The right hand side variables are: a constant term, the logarithm of the firm's capital, the logarithm of the firm's labor, the logarithm of the average wage, skill intensity as proxied by the ratio of non-production workers over production workers, the firm's tfp, the logarithm of firm's age, indicator variable showing whether there is any foreign ownership of equity,<sup>9</sup>

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<sup>9</sup>I thank Caroline Paunov for providing me foreign capital information of Chilean firms.

indicator variables about the firm's past choice of: export (XP) and purchase foreign technical service/training (FTS), export only, and purchase foreign technical service/training only. Both equations include year and 3-digit industry dummies to control for aggregate and industry level differences. I allow for contemporaneous correlation between the error terms of the two choices and estimate the two equations jointly as a system by modeling bivariate probit regression. The results of the bivariate probit model of exporting and purchasing foreign technical service/training are reported in Table 2.

Coefficients indicate that the larger the firm both in terms of capital and labor, the higher the chance to engage in either activity. Confirming the preliminary analysis, the association of the size with the probability of engaging in export is stronger than of engaging in FTS. Wages are positively correlated with the probability of engaging in either activity as well as productivity. The higher the fixed costs intensive activities as measured by the ratio of non-production workers over production workers, the more likely a firm will purchase FTS, but this measure does not have any significant effect on the exporting decision. Younger firms are more likely to export which suggest that firms enter the domestic market also in response to international market opportunities.<sup>10</sup> Although only significant at the ten percent level, age coefficient is also found to be significant in decision to engage in FTS. The younger the firm, the more likely it will purchase FTS. Foreign capital seems to be a very important factor in relation to both activities, and marginal values indicate that probability of engaging in both activities increases 6.2 percent for firms with foreign capital.

The coefficients on the lagged choice variables indicate that firms with recent export experience either on its own or in conjunction with FTS experience are more likely to export. The magnitudes indicate that the continuation probability for export is not affected by FTS.

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<sup>10</sup>Age is measured as the number of years survived since 1979. Alvarez and López (2005) also find that younger firms are more likely to export in Chile.

Table 3 presents the same regression with interactions of past choices with the *tfp*. The results show that more productive firms with past FTS experience either on its own or in conjunction with export are more likely to engage in FTS. That is, past experience in FTS affects the probability of engaging in FTS also through the impact of the past experiences on productivity. This is consistent with the hypothesis that FTS is an investment to improve domestic technological capabilities. The estimated value of correlation between the errors is positive but insignificant indicating that the factors that are taken into account in the model are sufficient to explain the links between the two activities.

Overall, the results on the patterns of exporting are in line with the previous literature and support the presence of sunk entry costs to international markets. The results on the interaction between FTS and exporting indicate that firms that are receiving FTS are more likely to continue to receive FTS if they were also exporting. It is also found that past experience in FTS affect firms decision to purchase FTS also through the productivity channel that the more productive the firms the higher the likelihood of continuing to engage in FTS, which is consistent with the view that FTS is an investment in productivity.

### **3.1 Decision to start to Export and to purchase FTS**

Controlling for factors such as *tfp*, age, size, foreign capital etc., past FTS experience alone is not found to be significant in affecting the probability to engage in export. But it is also possible that FTS access makes it easier for firms to find customers in the foreign market. To see if past FTS status affect firms' decision to start exporting, probit regression of starting to export was run on firm-level characteristics and the lagged FTS status of the firm. Time and 3-digit industry dummies are also included. The results are reported in Table 4 and indicate that past FTS status does not have any effect on the decision to enter the export market.

Probit regression was also run of starting to purchase FTS on firm-level characteristics and

past exporting status. The results are presented in Table 5. The coefficient of the lagged export status is found to be significant at the 10 % level supporting the hypothesis that being an exporter in a developing country provides firms an opportunity to utilize (probably more developed and sophisticated) foreign technical and professional services to increase their productivity. On the other hand, the probability of starting to export or starting to purchase FTS seems to be not affected significantly by being a foreign affiliate as the coefficient of foreign capital is found to be insignificant in both of the regressions.

## 4 Learning

Learning by exporting is often thought to happen via the buyer supplier link that foreign buyers actively come to the local market and teach new techniques, and present the specifics of what they want to buy from the local suppliers. A detailed survey conducted by Carlo Pietrobelli among a representative sample of 26 Chilean exporting companies in 1988 shows that foreign buyers supply advice on product design to 81 % of the sample firms and on how to adopt the product to export markets to 12 % of them. Assistance to production technology design and adaptation is also mentioned by 19 % of the companies as the second most important form of assistance.<sup>11</sup> This type of knowledge transfer has often been thought of as a primary channel of learning by exporting. However, empirical studies did not find strong support of the effectiveness of this channel while they test the effect on all exporters. The same survey, though, also reveals that many Chilean exporters buy FTS to improve their in-house capability mainly from Germany, USA, Italy, Japan and Denmark.

If the buyers' know-how is hypothesized as the main channel of learning, knowing the type of customers of manufacturer exporters in the foreign markets can help us to know where to look when we search for the learning effect. Who are the Chilean exporters' customers?

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<sup>11</sup>See Pietrobelli (1998) for the details of the survey.

The very recent availability of the custom data to researchers provide us with a very valuable opportunity in this respect. Using transaction-level international trade data from Denmark, Utar (2010) documents that between 1996 and 2006, on average, wholesale trade firms' and manufacturers' share of imports are 58 % and 30 % respectively while their respective shares of export are 33 % and 52 %. Similar conclusions regarding the heavy presence of wholesale trade companies also emerge from Bernard et al (2010), Ahn et al.(2010), and others.

Table 3 presents the number of Danish customers within firm types (manufacturer, wholesale and retail trade) between the period 1993 and 2004. The majority of the customers of Chilean firms are indeed trade firms, mostly wholesale trade firms. Trade firms are not the type of firms that we imagine that 'teach' new techniques, production or marketing skills to their customers. Since, in the survey study mentioned above, Denmark was also identified as a technology provider for Chilean exporters, business lines are identified of those service firms that conduct trade with Chilean firms. FTS does not require goods exchange between firms, yet looking into imports and exports activities (with Chile) of those firms that provide technical services may give us an idea of the type of services that Chilean exporters receive through FTS.<sup>12</sup> The business lines of Danish service firms which conduct import and export with Chilean firms includes research and experimental development on engineering, engineering consultancy activities related to construction and civil engineering, engineering consultancy activities related to industrial and mechanical engineering, software consultancy, business and management consultancy activities, environmental measures and analysis, and other technical consultancy.

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<sup>12</sup>In the plant-level data set of Chile, the variable recorded as foreign technical and professional expenses including license fees do not contain any itemized information.

Table 3: Distribution of Danish Buyers across Types

| Year | Number of Wholesale Trade Firms | Number of Retail Trade Firms | Number of Manufacturer Firms | Total Number of Firms |
|------|---------------------------------|------------------------------|------------------------------|-----------------------|
| 1993 | 44                              | 6                            | 18                           | 81 (74)               |
| 1994 | 42                              | 5                            | 24                           | 86 (77)               |
| 1995 | 53                              | 4                            | 24                           | 89 (85)               |
| 1996 | 48                              | 8                            | 27                           | 88 (85)               |
| 1997 | 49                              | 11                           | 20                           | 89 (85)               |
| 1998 | 55                              | 6                            | 29                           | 97 (94)               |
| 1999 | 59                              | 6                            | 24                           | 100 (95)              |
| 2000 | 59                              | 5                            | 26                           | 106 (100)             |
| 2001 | 73                              | 7                            | 36                           | 130 (126)             |
| 2002 | 83                              | 11                           | 71                           | 204 (196)             |
| 2003 | 111                             | 11                           | 63                           | 209 (201)             |
| 2004 | 117                             | 20                           | 69                           | 246 (239)             |

Note: Author's calculation using the Danish custom transaction data, firm accounting data, and domestic transaction data. The last column presents the total number of firms importing from Chile. The numbers in parentheses are the numbers of those firms with identified industry affiliation. Note that Danish custom data does not provide industry affiliation of Danish firms. One needs to match custom data with other sources of data-sets (Firm Accounting, Domestic Sales) in order to identify the firms' types. The percentage shares do not sum up to 100 because there are also service firms conducting trade.

The potential role of the foreign technology and service suppliers in learning by exporting is explored below, and to what degree learning by exporting can happen through an intentional effort to develop and improve domestic technological capabilities from the foreign technology and service suppliers via assistance, training and licensing.

#### 4.1 Productivity Trajectories

Figure 1 presents a visual inspection of the productivity trajectories of exporters that start exporting during the sample period across their types (whether they establish FTS link while exporting). On the horizontal axis is a time scale which is zero for the period where firms enter the export market. It is 0 at the time when firms start exporting, it is 1 after one year of exporting, etc..<sup>13</sup> The vertical axis plots average productivity for three groups in

<sup>13</sup>Since the data is annual and since export revenue recorded once the transaction is conducted, time 0 refers to the year that the first export transaction is completed/realized.

the 2-digit chemicals industry<sup>14</sup>: Firms that start to export, starters with at least once FTS expenditure when exporting but not before exporting, and starters with no FTS expenditure when exporting. The learning by exporting hypothesis is related to change in slope on the right hand side of the graph for the starters. Visual inspection confirms that the average productivity of firms that start exporting increases strongly among the group of FTS receivers.

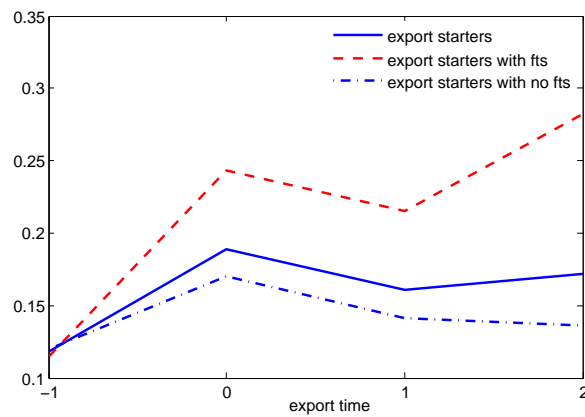


Figure 1: Productivity Trajectory for Different Groups

In the next section, using matching estimator, and controlling for differences between productivity level before starting to export as well as other characteristics, a learning effect is sought among firms that start exporting with or without accompanying FTS.

<sup>14</sup>The productivity index is calculated relative to reference plant  $r$  in the industry. Reference plant is defined as a plant with average output and input measures in 1990. Chemicals industry is chosen because FTS is the most common.

## 4.2 Econometric Model

The purpose of this section is to assess the role of FTS access on the feedback effect of exporting on firms' productivity. In this section, the propensity-score based matching procedure and difference in difference estimator used to assess the learning effect is described.

The average effect of exporting on firms' productivity can be described as follows:

$$E(\mu_{it}^1 - \mu_{it}^0 | STARTXP_i = 1) = E(\mu_{it}^1) - E(\mu_{it}^0) \quad (8)$$

In this equation  $\mu_{it}^1$  denotes the productivity of firm  $i$ ,  $t$  periods after starting to export and  $\mu_{it}^0$  denotes the productivity of firm  $i$  at the same period if the firm should have not started to export. The obvious problem is that we do not observe  $\mu_{it}^0$ . Strong empirical evidence on self-selection to exporting makes the problem even more complicated. We cannot treat the firms that start exporting as a random group.

We proceed with the matching estimator presented by Heckman, Ichimura and Todd (1997) to assess the role of learning by exporting while controlling for self-selection. The basic idea is to construct a counterfactual (if the firm should have not started to export) based on the characteristics of firms which choose to start exporting. Rosenbaum and Rubin (1983) suggest to use the propensity-score to construct a matched sample instead of matching firms directly by their covariates. Assuming a binary action  $X$  (in our case  $STARTXP$ ), and an arbitrary set  $S$  of measured covariates, the propensity score  $P(s)$  is the probability that action  $X=1$  will be chosen by a participant with characteristics  $S=s$ . Rosenbaum and Rubin show that given  $P(s)$ ,  $X$  and  $S$  are independent, so all participants that have the same value of  $P(s)$  are comparable or "balanced".

In the present case, the propensity-score estimation is based on an underlying structure where firms decide to choose to export or not based on their state variables; age, productivity, capital

stock, skill-intensity, lag foreign capital status, and lag FTS status.<sup>15</sup> If we consider firms which choose to start exporting, lag export status can be disregarded as a state variable. For each 2-digit industry, the probit model,

$$Pr(STARTXP_{i,0}) = \phi(h(age_{i,-1}, \mu_{i,-1}, k_{i,-1}, FTS_{i,-1}, Foreign_{i,-1}, Skill_{i,-1})) \quad (9)$$

is estimated where  $\phi$  denotes the normal c.d.f. and  $h()$  is a starting specification which includes all the covariates as linear terms without interactions or higher order terms. 3-digit industry dummies and year dummies are also included. The balancing hypothesis according to the algorithm as described in Becker and Ichino (2002) is tested for.

Once the propensity score is estimated, firms within each 2-digit SIC industry and within each time period are matched to remove any industry-wide and aggregate effects from the estimation results. Common support is imposed in order to improve the matching and control for self-selection (for a given propensity score, the sample of firms which choose to start exporting is random, so that treated and control units are on average observationally equivalent), meaning that observations whose propensity score is higher than the maximum or less than the minimum of the propensity score of the control variables are dropped. For each export starter firm  $i$  in the common support, a set of control firms  $C(i)$ , that consists of  $N^{C(i)}$  firms with propensity scores closest to that of firm  $i$ , is constructed.<sup>16</sup>

Difference in difference estimators are then constructed as follows:

$$\beta_{XP}^t = \frac{1}{N_t^{XP}} \sum_{i \in XP} (\mu_{it}^1 - \sum_{j \in C(i)} w_{ji} \mu_{ij}) \quad (10)$$

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<sup>15</sup>Propensity-score is also estimated without using past FTS status, but the main results are not affected.

<sup>16</sup>I use 3 nearest-neighbor method, but the results are robust to different number of neighbors in the range of 1 to 5. I also impose a maximum distance which equals to 0.001 between the propensity scores of the treated and the control variables for a matching to be feasible.

$$\beta_{XPF}^t = \frac{1}{N_t^{XPF}} \sum_{i \in XPF} (\mu_{it}^1 - \sum_{j \in C(i)} w_{ji} \mu_{ij}) \quad (11)$$

$$\beta_{XPNF}^t = \frac{1}{N_t^{XPNF}} \sum_{i \in XPNF} (\mu_{it}^1 - \sum_{j \in C(i)} w_{ji} \mu_{ij}) \quad (12)$$

where  $XP$  is a set of firms that start exporting,  $XPF$  is a set of firms that start exporting and purchasing FTS once exporting and  $XPNF$  is a set of firms that start exporting with no FTS access established after exporting.  $w_{ji}$  denote the weighting of the matched observation.<sup>17</sup> Time superscript  $t$  indicates time relative to the time when firms start exporting, that is,  $t=0,1,2,..T$  where 0 indicates the time when firms start exporting.  $N_t^{XP}$ ,  $N_t^{XPF}$  and  $N_t^{XPNF}$  denote the number of firms  $t$  periods after starting to export in the sets  $XP$ ,  $XPF$  and  $XPNF$  respectively. So in this way, we construct the productivity premium of exporters relative to the weighted average of productivity of matched firms separately for each group of firms. Previous learning by exporting literature is concerned with the estimator  $\beta_{XP}^t$ . Here  $\beta_{XP}^t$  is decomposed to explore the degree of learning among firms with FTS link versus firms with no FTS.

## 5 Empirical Findings

Table 6 presents the results from the matching estimator. Exporting firms are on average 0.8 % more productive than non-exporters after one, and 5.5 % more productive than non-

<sup>17</sup>I define the weights such that  $w_{ji} = \frac{MaxPDistance + \varepsilon - PDiff_{ji}}{\sum_{j \in C(i)} (MaxPDistance + \varepsilon - PDiff_{ji})}$ , where  $MaxPDistance$  equals 0.001,  $\varepsilon$  is a small number (0.0001),  $PDiff_{ji}$  is the probability distance (difference between the propensity scores) between the matched pair. In this way, I give higher weight to an observation in the control group of firm  $i$  that are 'closer' to the firm  $i$  in comparison to the other firms in the control group. Note that the maximum distance allowed between a matched pair is 0.001. I also use equal weights, i.e.  $w_{ji} = \frac{1}{N^{C(i)}}$ , the results are not critical to these two different weighting scheme.

exporters after three years of exporting but they are not statistically significant. The 14 % difference after four years of exporting is found to be significant at the 10 % level. So concentrating on what is looked at or analyzed in the literature ( $\beta_{XP}^t$ ), the results are in line with the general finding of the empirical literature on learning by exporting: some, but weak, evidence of learning. Let us now investigate the learning by exporting effect among different groups. It is interesting to observe a striking difference in productivity improvement of exporters compared to non-exporters among two different groups: firms with FTS access versus those with no FTS access.

When we look at the productivity effect of starting to export among firms with FTS access,  $\beta_{XPF}^t$ , results show that exporting firms with FTS access are 28.6 % more productive in the first year, and they are 41.4 % more productive on average than non-exporters after four years of exporting. These numbers are remarkable and the results are statistically significant. Thus the learning effect is strongly present in firms with FTS access.

The productivity effect of starting to export among firms with FTS access,  $\beta_{XPNF}^t$ , show that there is no positive productivity effect of starting to export among Chilean exporters if firms do not have access to FTS after exporting. Although significant only at the 10 percent level, exporting firms with no FTS link are found to be 6.9 percent less productive than non-exporting firms with similar characteristics. However, since there are many firms that export only once and these leave the sample quickly, it may be more reliable to look at the coefficient after 3 or 4 years of exporting. The results show if firms do not establish FTS link after exporting, exporters on average are found to be only about 2 percent more productive than non-exporters but this difference is not statistically significant. Notice that this group consists of firms that start exporting but did not establish FTS link *after* exporting. Thus it also consists of firms starting to export with previous FTS experience.

Overall the results presented in Table 6 shows that Chilean exporters learn, but only those

who establish FTS link after their exporting decision.

Table 7 shows the results when labor productivity is used as an outcome variable. After four years of exporting, average labor productivity of exporting firms are found to be 14.1 percent higher than non-exporters after controlling for self-selection. This is statistically significant at the 10 % level. But when we look at the decomposition, we see that this positive effect is due to firms with FTS link, confirming the conclusion that only some Chilean exporters learn and they are the ones with the foreign technical service link.

Another way of examining for learning effect, is to look at whether exporters' productivity grow faster with respect to their pre-export productivity level than non-exporters'. Table 8 presents the results for the three sets of firms when the outcome variable is productivity growth relative to the productivity before exporting,  $\mu_t - \mu_{-1}$ . Firms that start exporting experience productivity growth which is on average 5.9 % higher than non-exporters after the first year of exporting and it is significant at the 10 % level. Notice that  $\beta_{XPF}^1$  in this case also captures the complementarities between technology upgrading and exporting as shown by Yeaple (2005) and found by Bustos (2007) and others. After four years of exporting, exporters' productivity growth is also found to be 5.9 % higher but this difference is not significant. Decomposition of the sample between firms with FTS link and not reveals significant contrast again.

Table 9 presents the results when output variable is output growth,  $q_t - q_{-1}$ . The results are similar in that, except the first year, most of the positive effect observed in output growth is due to firms with FTS link, as the outputs of exporters with no FTS link do not grow significantly faster than non-exporters' output.

## 6 Summary and Concluding Remarks

Using data from the entire pool of manufacturing plants in Chile from 1990 to 1996 with the unique feature of reporting establishment-level expenditure on foreign technical assistance and license fees, firms' contacting with foreign technical and professional service markets is found to be positively associated with exporting and that export experience helps firms to gain access to foreign technical and professional service markets. Unfortunately the data does not provide information on the nature of foreign technical service and assistance. However, the analysis shows that controlling for firm characteristics that may affect exporting decision, there exists a weak evidence of learning by exporting, confirming previous literature. However, once the effect is decomposed into different components, we see that all learning by exporters in Chile during the sample period can be attributed to the firms with FTS link. The results presented here suggest that in order to improve our understanding of feedback effects of exporting, we need to look into particular learning channels.

Although not considered in this paper, foreign financial markets may be another channel through which developing country exporters can benefit. Recently, the emphasis has been on the impact of domestic financial constraints on firms' exporting decision. The findings in this paper suggest that it may also be worth it to assess the impact of exporting on firms' ability to access foreign creditors. When analyzing the impact of financial constraints on exporting decisions we may need to pay attention to reverse causality: that it is also possible that once firms become exporters, they may become less financially constrained through their foreign contacts.

Finally, the results also lend support to the view that service market liberalization which opens up domestic markets to foreign service providers may have an important productivity spill-over into manufacturing.

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## 7 Tables and Graphs

Table 1: Number of Plants which Export  
(XP) and/or purchase FTS

| Year | XP   | FTS | XP & FTS | All  |
|------|------|-----|----------|------|
| 1990 | 708  | 209 | 104      | 4105 |
| 1991 | 856  | 240 | 132      | 4318 |
| 1992 | 930  | 245 | 126      | 4484 |
| 1993 | 1004 | 269 | 150      | 4615 |
| 1994 | 1059 | 254 | 141      | 4692 |
| 1995 | 1087 | 266 | 154      | 4784 |
| 1996 | 1122 | 308 | 175      | 5158 |

Table 2: Bivariate Probit Estimates

| Variables                                             | Exporting |            | FTS    |            |
|-------------------------------------------------------|-----------|------------|--------|------------|
| Log(Capital)                                          | 0.111     | (0.014)*** | 0.050  | (0.016)**  |
| Log(Labor)                                            | 0.270     | (0.022)*** | 0.136  | (0.026)*** |
| Log(Average Wage)                                     | 0.188     | (0.038)*** | 0.175  | (0.046)*** |
| $\frac{Non-productionWorkers}{ProductionWorkers}$     | -0.017    | (0.010)    | 0.009  | (0.004)*   |
| Productivity ( $\mu$ )                                | 0.059     | (0.021)**  | 0.060  | (0.026)*   |
| Log (Age)                                             | -0.145    | (0.018)*** | -0.012 | (0.021)*   |
| $I(ForCapit)$                                         | 0.229     | (0.064)*** | 0.246  | (0.058)*** |
| $I(XP_{it-1}) * I(FTS_{it-1})$                        | 2.208     | (0.084)*** | 2.058  | (0.071)*** |
| $I(XP_{it-1}) * (1 - I(FTS_{it-1}))$                  | 2.192     | (0.037)*** | -0.061 | (0.046)    |
| $I(FTS_{it-1}) * (1 - I(XP_{it-1}))$                  | 0.038     | (0.086)    | 1.644  | (0.070)*** |
| 3-Digit Industry Dummies                              |           | ✓          |        | ✓          |
| Year Dummies                                          |           | ✓          |        | ✓          |
| $Corr(\varepsilon_{it}^{XP}, \varepsilon_{it}^{FTS})$ | 0.034     | (0.032)    |        |            |
| N                                                     | 22478     |            |        |            |
| Log PseudoLikelihood                                  | -8562.587 |            |        |            |

Absolute values of robust standard errors are in parentheses. Standard errors are adjusted for repeated observations on plants. Intercept is included but not reported. \*, \*\* and \*\*\* indicate significance at the 10 %, 5% and 1% levels respectively.

Table 3: Bivariate Probit Estimates with Interaction Terms

| Variables                                             | Exporting     |            | FTS    |            |
|-------------------------------------------------------|---------------|------------|--------|------------|
| Log(Capital)                                          | 0.112         | (0.014)*** | 0.047  | (0.016)**  |
| Log(Labor)                                            | 0.271         | (0.022)*** | 0.136  | (0.026)*** |
| Log(Average Wage)                                     | 0.190         | (0.038)*** | 0.165  | (0.047)*** |
| $\frac{Non-productionWorkers}{ProductionWorkers}$     | -0.017        | (0.010)    | 0.010  | (0.004)*   |
| Productivity ( $\mu$ )                                | 0.041         | (0.027)    | 0.003  | (0.033)    |
| Log (Age)                                             | -0.145        | (0.018)*** | -0.017 | (0.021)*   |
| $I(ForCap_{it})$                                      | 0.233         | (0.064)*** | 0.233  | (0.057)*** |
| $I(XP_{it-1}) * I(FTS_{it-1})$                        | 2.306         | (0.125)*** | 1.924  | (0.103)*** |
| $I(XP_{it-1}) * (1 - I(FTS_{it-1}))$                  | 2.152         | (0.042)*** | -0.018 | (0.056)    |
| $I(FTS_{it-1}) * (1 - I(XP_{it-1}))$                  | 0.146         | (0.106)    | 1.282  | (0.097)*** |
| $\mu_{it} * I(XP_{it-1}) * I(FTS_{it-1})$             | -0.093        | (0.092)    | 0.174  | (0.074)*   |
| $\mu_{it} * I(XP_{it-1}) * (1 - I(FTS_{it-1}))$       | 0.074         | (0.040)    | 0.000  | (0.048)    |
| $\mu_{it} * I(FTS_{it-1}) * (1 - I(XP_{it-1}))$       | -0.104        | (0.090)    | 0.526  | (0.101)*** |
| 3-Digit Industry Dummies                              |               | ✓          |        | ✓          |
| Year Dummies                                          |               | ✓          |        | ✓          |
| $Corr(\varepsilon_{it}^{XP}, \varepsilon_{it}^{FTS})$ | 0.039 (0.032) |            |        |            |
| N                                                     | 22478         |            |        |            |
| Log PseudoLikelihood                                  | -8529.245     |            |        |            |

Absolute values of robust standard errors are in parentheses. Standard errors are adjusted for repeated observations on plants. Intercept is included but not reported.

\*, \*\* and \*\*\* indicate significance at the 10 %, 5% and 1% levels respectively.

Table 4: Probit Estimates: Starting to Export

| Variables                                                | STARTXP              |
|----------------------------------------------------------|----------------------|
| Lagged Log Capital                                       | 0.140<br>(0.011)***  |
| Lagged Productivity                                      | 1.012<br>(0.142)***  |
| Lagged Log Capital *Lagged Productivity                  | -0.075<br>(0.010)*** |
| Lagged Log Age                                           | -0.074<br>(0.020)*** |
| Lagged $\frac{Non-productionWorkers}{ProductionWorkers}$ | -0.006<br>(0.008)    |
| $I(FTS_{it-1})$                                          | 0.081<br>(0.099)     |
| $\mu_{it-1} * I(FTS_{it-1})$                             | -0.055<br>(0.080)    |
| $I(ForCap_{it-1})$                                       | -0.026<br>(0.065)    |
| 3-digit Industry Dummies                                 | ✓                    |
| Year Dummies                                             | ✓                    |
| N                                                        | 21168                |
| Pseudo $R^2$                                             | 0.064                |

Absolute values of robust standard errors are in parentheses. Standard errors are adjusted for repeated observations on plants. Intercept is included but not reported. \*, \*\* and \*\*\* indicate significance at the 10 %, 5% and 1% levels respectively.

Table 5: Probit Estimates: Starting to purchase FTS

| Variables                                                | STARTFTS            |
|----------------------------------------------------------|---------------------|
| Lagged Log Capital                                       | 0.075<br>(0.013)*** |
| Lagged Productivity                                      | 0.081<br>(0.032)*   |
| Lagged Log Age                                           | -0.007<br>(0.025)   |
| Lagged $\frac{Non-productionWorkers}{ProductionWorkers}$ | 0.003<br>(0.004)    |
| $I(XP_{it-1})$                                           | 0.108<br>(0.054)*   |
| $\mu_{it-1} * I(XP_{it-1})$                              | -0.046<br>(0.043)   |
| $I(ForCap_{it-1})$                                       | -0.026<br>(0.079)   |
| 3-digit Industry Dummies                                 | ✓                   |
| Year Dummies                                             | ✓                   |
| N                                                        | 21156               |
| Pseudo $R^2$                                             | 0.036               |

Absolute values of robust standard errors are in parentheses. Standard errors are adjusted for repeated observations on plants. Intercept is included but not reported. \*, \*\* and \*\*\* indicate significance at the 10 %, 5% and 1% levels respectively.

Table 6: The Impact of FTS Access on Learning by Exporting

| Outcome: Productivity |                     |                    |                    |                    |
|-----------------------|---------------------|--------------------|--------------------|--------------------|
| Time                  | 1                   | 2                  | 3                  | 4                  |
| $\beta_{XP}$          | 0.008<br>(0.032)    | 0.012<br>(0.046)   | 0.055<br>(0.058)   | 0.139<br>(0.067)*  |
| N                     | 740                 | 406                | 306                | 217                |
| $N^C$                 | 1977                | 1036               | 755                | 520                |
| $\beta_{XPF}$         | 0.286<br>(0.076)*** | 0.304<br>(0.102)** | 0.370<br>(0.115)** | 0.414<br>(0.133)** |
| N                     | 161                 | 98                 | 85                 | 66                 |
| $N^C$                 | 422                 | 242                | 202                | 149                |
| $\beta_{XPNF}$        | -0.069<br>(0.034)*  | -0.081<br>(0.050)  | -0.066<br>(0.065)  | 0.019<br>(0.076)   |
| N                     | 579                 | 308                | 220                | 151                |
| $N^C$                 | 1555                | 794                | 553                | 371                |

Note: Robust standard errors reported in parentheses. \*, \*\* and \*\*\* indicate significance at the 10 %, 5% and 1% levels respectively.

Table 7: The Impact of FTS Access on Learning by Exporting

| Outcome: Labor Productivity |                    |                    |                    |                    |
|-----------------------------|--------------------|--------------------|--------------------|--------------------|
| Time                        | 1                  | 2                  | 3                  | 4                  |
| $\beta_{XP}$                | 0.009<br>(0.034)   | -0.006<br>(0.052)  | 0.043<br>(0.063)   | 0.141<br>(0.071)*  |
| N                           | 754                | 412                | 316                | 227                |
| $N^C$                       | 2003               | 1053               | 789                | 539                |
| $\beta_{XPF}$               | 0.273<br>(0.081)** | 0.312<br>(0.115)** | 0.389<br>(0.126)** | 0.443<br>(0.135)** |
| N                           | 161                | 98                 | 87                 | 68                 |
| $N^C$                       | 419                | 243                | 216                | 153                |
| $\beta_{XPNF}$              | -0.063<br>(0.036)  | -0.105<br>(0.057)  | -0.089<br>(0.070)  | 0.012<br>(0.081)   |
| N                           | 593                | 314                | 229                | 159                |
| $N^C$                       | 1584               | 810                | 573                | 386                |

Note: Robust standard errors are reported in parentheses. \*, \*\* and \*\*\* indicate significance at the 10 %, 5% and 1% levels respectively.

Table 8: The Impact of FTS Access on Learning by Exporting

| Outcome: Productivity Growth |                   |                   |                  |                   |
|------------------------------|-------------------|-------------------|------------------|-------------------|
| Time                         | 1                 | 2                 | 3                | 4                 |
| $\beta_{XP}$                 | 0.059<br>(0.023)* | 0.048<br>(0.036)  | 0.047<br>(0.044) | 0.059<br>(0.052)  |
| N                            | 738               | 406               | 306              | 217               |
| $N^C$                        | 1971              | 1036              | 755              | 520               |
| $\beta_{XPF}$                | 0.087<br>(0.043)  | 0.149<br>(0.062)* | 0.145<br>(0.070) | 0.250<br>(0.107)* |
| N                            | 161               | 98                | 85               | 66                |
| $N^C$                        | 422               | 242               | 202              | 149               |
| $\beta_{XPNF}$               | 0.051<br>(0.027)  | 0.015<br>(0.045)  | 0.010<br>(0.055) | -0.024<br>(0.064) |
| N                            | 577               | 308               | 220              | 151               |
| $N^C$                        | 1549              | 794               | 553              | 371               |

Note: Robust standard errors reported in parentheses. \*, \*\* and \*\*\* indicate significance at the 10 %, 5% and 1% levels respectively.

Table 9: The Impact of FTS Access on Learning by Exporting

| Outcome: Output Growth |                     |                    |                    |                    |
|------------------------|---------------------|--------------------|--------------------|--------------------|
| Time                   | 1                   | 2                  | 3                  | 4                  |
| $\beta_{XP}$           | 0.089<br>(0.024)*** | 0.087<br>(0.041)*  | 0.137<br>(0.049)** | 0.169<br>(0.057)** |
| N                      | 751                 | 412                | 316                | 227                |
| $N^C$                  | 1995                | 1053               | 789                | 539                |
| $\beta_{XPF}$          | 0.088<br>(0.047)    | 0.202<br>(0.067)** | 0.233<br>(0.078)** | 0.286<br>(0.089)** |
| N                      | 161                 | 98                 | 87                 | 68                 |
| $N^C$                  | 419                 | 243                | 216                | 153                |
| $\beta_{XPNF}$         | 0.090<br>(0.028)**  | 0.051<br>(0.050)   | 0.100<br>(0.060)   | 0.119<br>(0.072)   |
| N                      | 590                 | 314                | 229                | 159                |
| $N^C$                  | 1576                | 810                | 573                | 386                |

Note: Robust standard errors reported in parentheses. \*, \*\* and \*\*\* indicate significance at the 10 %, 5% and 1% levels respectively.