

Learning by Exporting through Access to Foreign Technical Service Markets

Håle Utar*

University of Colorado at Boulder

May 2009

Abstract

Using data from the entire pool of manufacturing plants in Chile from 1990 to 1996, I find evidence 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.

I first show that there are complementarities between exporting and foreign technical service markets access either to receive training or to use foreign technology. Using the propensity-score matching technique to control for self-selection I match firms within narrowly defined industries. Using the difference in difference estimator that removes the effects of aggregate shocks, I find strong evidence that access to foreign technical service markets is an important channel for the firms to learn by exporting.

JEL Classification: F10; D2; L25

*Department of Economics University of Colorado at Boulder 256 UCB Boulder, Colorado 80309, USA
email: utar@colorado.edu

1 Introduction

Recent evidence shows a self-selection of more productive firms into export markets¹ 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.² 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, I look for evidence 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. I argue that learning by exporting happens through an intentional effort to

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

²For a review of the literature, see Tybout (2000).

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. ³

In this paper, I use establishment-level panel data from Chile that covers the entire manufacturing sector and has the unique feature to allow the identification of establishments with foreign technical service market access.⁴ 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 two decisions' effect on the firms' future total factor productivity trajectory.

The empirical results suggest that there are strong linkages between firms' exporting status and FTS access. 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

³Recent 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).

⁴I thank Jim Tybout for providing me with the data set.

of paying the sunk entry costs of exporting. To some extent complementarities 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, and so lend support to the first of these three explanations.

The question is then whether domestic firms' access to foreign technical service markets would be a channel of learning. Investigating whether Chilean exporters learn by exporting, I do not find strong evidence for learning by exporting after controlling for self selection and common industry and time effects. I then investigate 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.⁵

Plant-level output and input variables are deflated using 3-digit industry deflators.⁶ Every variable is converted in constant 1980 prices. I also construct the capital stock variable which consists of building, machinery and vehicle, using the perpetual inventory method. I use separate deflators for buildings, machinery and vehicles.⁷

In Table 4 on page 28, I present the number of plants each year that engage in export and FTS. The visual inspection of the data confirms the complementarity between exporting and accessing to FTS. More than 50 percent of plants that purchase FTS are also exporting.⁸

⁵See Contractor (1985) for the details of licensing agreements.

⁶I thank Alfonso Irarrazabal for providing 3-digit industry level output and input deflators.

⁷I 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.

⁸I 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

2.2 Preliminary Analysis

I first perform a preliminary analysis to analyze the exporters' and FTS receivers' characteristics. To do that, I run the following OLS regressions:

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

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

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

where x_{ist} denotes characteristics of plant i at period t in industry s , 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. I also include 2-digit industry and year dummies.

I report the respective β_1 coefficients in Table 1. The first two columns of Table 1 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 β_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 plants in Chile are single-plant firms (Pavcnik, 2002).

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 seems not as big as exporters. Probably the most striking differences between exporters and FTS receivers are related to the workers' composition. 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 the export premium is strengthened when it is complemented with FTS in terms of labor productivity. There are also important distinctions between export premium and export premium when it is complemented with FTS in terms of workers' composition. Exporters build capacity to absorb foreign knowledge via FTS. Could then FTS access be a channel of learning for exporters?

Table 1: Differences in Firm Characteristics

	(a)	(b)	(c)
Firm Characteristics	β_1^{XP}	β_1^{FTS}	β_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 ⁿ	0.460	0.549
$\frac{Executives\&Administrators}{TotalWorkers}$	0.132	0.330	0.448
Number of Observations (min/max)	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:

$$Q_{it} = e^{\mu_{it}} WC_{it}^{\beta_w} BC_{it}^{\beta_b} K_{it}^{\beta_k} \quad (4)$$

where Q_{it} denotes the output measured by value-added, WC_{it} denotes the number of white-collar workers, BC_{it} denotes the number of blue-collar workers, and K_{it} denotes the value of capital used by firm i at period t .

I use the semi-parametric estimator developed by Olley and Pakes (1996) 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.⁹ 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, I also correct for potential bias due to exporters' facing different market structures and factor prices. To do that, I allow the investment function that is used as a proxy for unobservable productivity to be different for exporters and non-exporters. The estimator also takes into account whether firms export or not when calculating the survival probabilities to correct for the selection.¹⁰

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

I then impute the productivity measure as follows:

$$\mu_{ijt} = q_{ijt} - \beta_{wj}wc_{ijt} - \beta_{bj}bc_{ijt} - \beta_{kj}k_{ijt} \quad (5)$$

where q , wc , bc , and k denote the logarithm of; value-added, white-collar labor, blue-collar labor and capital respectively. i is an index for plant, j for industry and t for time.

⁹I also use Levinsohn-Petrin (2001) methodology and control for the unobservable productivity using materials as a proxy. The empirical analysis carried in the paper is robust to the productivity estimates by Levinsohn and Petrin methodology.

¹⁰Similar approaches have been used by Van Biesebroeck (2006) and De Loecker (2007).

3 Potential Linkages between Exporting and FTS

In this section, I investigate potential complementarities between the decision to purchase FTS and the decision to export using a probit model. The export decision and purchasing foreign technical service are specified as two binary decisions.

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

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

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 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 5.

Coefficients indicate that the larger the firm both in terms of capital and labor, the higher the chance to engage in either activity. Being big in size seems to be a more important

determinant of exporting than of engaging in FTS. One percent increase in capital increases the probability of exporting by 2.4 percent and it increases the probability of engaging in FTS by about 0.3 percent.

Wages are positively correlated with the probability of engaging in either activity. The higher the skill-intensity the more likely a firm will purchase FTS, but skill-intensity does not have any significant effect on the exporting decision. This is consistent with the hypothesis that FTS purchase is an investment in productivity of a firm, so that firms which choose to access FTS will need an absorbing capacity to utilize this investment. Younger firms are more likely to export which suggest that firms enter the domestic market also in response to international market opportunities.¹¹ Although only significant at the five percent level, age coefficient also affects decision to engage in FTS. The younger the firm, the more likely it will purchase FTS.

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. However, recent experience in FTS alone does not affect firms' probability to export and vice versa. The importance of the interaction effect between past exporting and FTS purchase is consistent with the argument that the return to exporting is bigger for firms that invest to acquire in-house capabilities to assimilate foreign knowledge through assistance, training and licensing (FTS).

I also run the same regression with interactions of past choices with the *tfp*. The results are presented in Table 6 and 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 mainly through the impact of the past experiences on productivity. This is also consistent with the hypothesis that FTS

¹¹Age 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.

is an investment to improve domestic technological capabilities. Once interaction terms are added, the impact of experience in FTS on the probability of engaging in FTS loses its significance and changes its sign. This may be due to the fact that firms who do not find their foreign assistance/training effective (i.e. they do not see any effect on their productivity) stop receiving FTS.

For the export decision, interaction terms do not decrease the importance of experience itself, which may be the indication of sunk costs of exporting. However, it is interesting to observe that experience in both activities increases the probability of engaging in export for less productive firms, but this coefficient is significant only in ten percent. This still could be due to the sunk costs as more productive firms are more likely to respond to a negative profitability shock in the foreign markets and exit, while less productive firms will be more constrained by the hysteresis band.

The estimated value of correlation between the errors is positive, indicating that shocks that lead a firm to participate in one activity tend to lead it to participate in both, however not statistically significant.

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 are novel. I find strong linkages between exporting and purchasing foreign technical service, that is firms that are exporting are more likely to continue to export if export was complemented with foreign technical assistance/training or licensing and vice versa. I also find that past experience in FTS and export mainly affect firms decision to purchase FTS through the productivity channel which is consistent with the view that FTS is an investment in productivity.

3.1 Decision to start to Export and to purchase FTS

One potential explanation for the positive associations between export and FTS is that exporters have better access to foreign technical service market through their customers located in the foreign market. 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, I run probit regressions of starting to export on firm-level characteristics and the lagged FTS status of the firm. I also included time and 3-digit industry dummies. The results are reported in Table 7 indicate that past FTS status does not have any effect on the decision to enter the export market. I also run probit regression of starting to purchase FTS on firm-level characteristics and past exporting status. The results in Table 8 support 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.¹²

It is possible that some of the exporters who purchase FTS are foreign affiliates, and they receive training or purchase technology from their partner companies directly. Although the data I have does not allow me to observe foreign ownership, Alvarez and López (2005) reports that more than 95 % of Chilean plants are domestic plants; among exporters, they identify about 13% of plants with 10% or more foreign share. So although foreign ownership might contribute to the complementarities between FTS and export, it cannot be the only explanation since more than 50 % of exporters have experience in FTS in the data set.

Having established complementarities between FTS access and exporting decisions, I now move to a discussion of the learning effect.

¹²I use 2-digit industry dummies in this regression mainly because the number of firms starting to engage in FTS is relatively few per 3-digit industry.

4 Learning

Learning by exporting is often thought to happen via the buyer supplier link that foreign buyers actively come to 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.¹³ 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 on this channel. 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.

Here I explore to what degree learning by exporting happens 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 learning by exporting through FTS. On the horizontal axis I plot a time scale which is zero for the period where firms enter the export market. It is 1 after one year of exporting, etc.. On the vertical axis I plot average productivity for three groups in the 2-digit chemicals industry¹⁴: Firms that start to export, starters with

¹³See Pietrobelli (1998) for the details of the survey.

¹⁴The 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

at least once FTS expenditure when exporting, and starters with no FTS expenditure when exporting. The vertical dotted line indicates the time of export start. 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. It is also worth noting that FTS receivers-exporters have a much higher productivity on average than exporters with no accompanied FTS experience.¹⁵

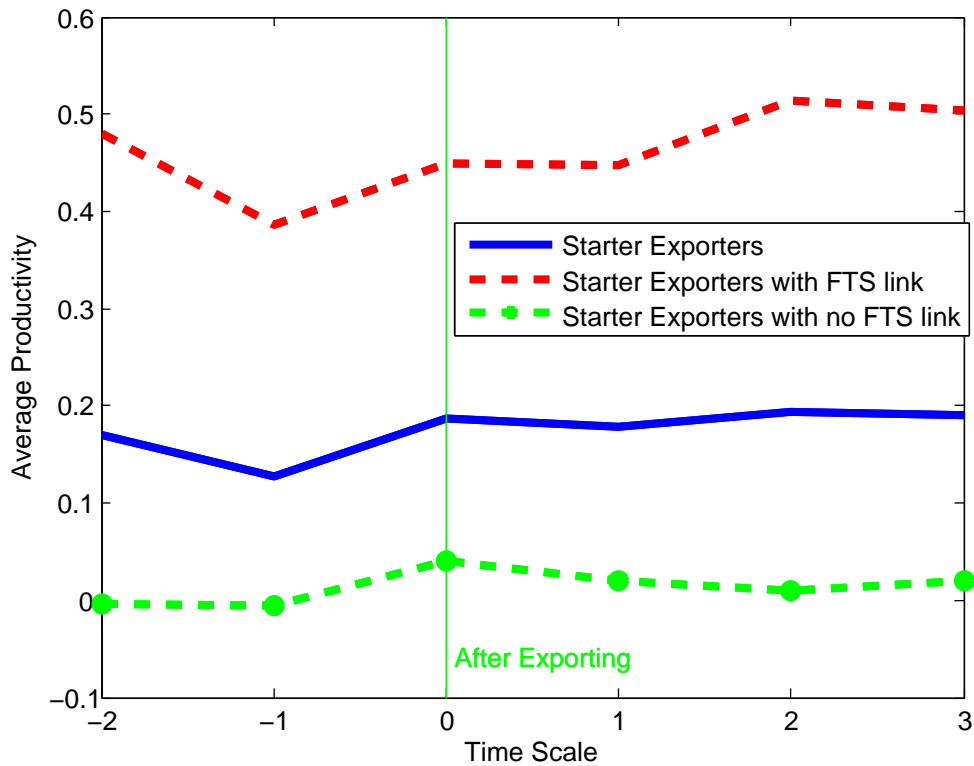


Figure 1: Productivity Trajectory for Different Groups

most common.

¹⁵In the matching estimator, I do control for the productivity level before starting to export.

4.2 The Impact of Export and FTS on the Evolution of Plant Productivity

I then did a preliminary analysis of potential roles of export and FTS on the evolution of the future productivity: I assume that firm-specific productivity evolves over time as a first order Markov process. Learning-by-exporting indicates a link between firms' exporting status and their productivity. Learning through receiving foreign technical service also imply a link between firms' FTS status and their productivity. I run the following regression:

$$\begin{aligned} \mu_{it+1} = & \rho_0 + \rho_1\mu_{it} + \rho_2I(FTS_{it}) * (1 - I(XP_{it})) + \rho_3(1 - I(FTS_{it})) * I(XP_{it}) + \\ & \rho_4I(FTS_{it}) * I(XP_{it}) + \sum_t \gamma_t Year_t + \sum_s \eta_s Industry_s + \epsilon_{it}^\mu \end{aligned} \quad (8)$$

Since μ_{it+1} is only observed for firms surviving into next period, I use Heckman's sample selection model to correct for possible selection bias. In addition to parameters in evolution equation, the selection equation includes logarithm of capital, and firms' age. The results are presented in Table 9. The coefficient of the productivity variable indicates that the productivity process is persistent over time. The coefficients on the firm's export only and FTS only status indicate that they both affect firms' future productivity positively. Wald tests reveal that coefficient on the interaction is significantly higher than both FTS only and export only coefficients. So the preliminary findings without controlling for self-selection hypothesis suggest that both FTS and export can be a source of learning. But more importantly, they suggest FTS and export have complementary effects on firms' productivity. I now move to a discussion of the formal econometric model that I use to identify learning by exporting through foreign technical service access.

4.3 Econometric Model

Given that I find an evidence on complementarities between exporting and FTS access, my purpose is to asses the role of FTS access on the feedback effect of exporting on firms' productivity.

In this section, I describe the propensity-score based matching procedure and difference in difference estimator that I use to asses the learning effect.

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

$$E(\mu_{it}^1 - \mu_{it}^0 | STARTXP_i = 1) = E(\mu_{it}^1) - E(\mu_{it}^0) \quad (9)$$

In this equation μ_{it}^1 denotes the productivity of firm i, t periods after starting to export and μ_{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 μ_{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.

I proceed with the matching estimator (Heckman, Ichimura and Todd (1997)) to asses 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 and capital stock. I consider firms which choose to start exporting so that lag export status can be disregarded as a state variable. For each 2-digit industry, I estimate the logit model,

$$Pr(STARTXP_{i,0}) = \phi(h(age_{i,-1}, \mu_{i,-1}, k_{i,-1})) \quad (10)$$

where ϕ denotes the logistic c.d.f. and $h()$ is a starting specification which includes all the covariates as linear terms without interactions or higher order terms. I also include 3-digit industry dummies and year dummies. I test for the balancing hypothesis according to the algorithm as described in Becker and Ichino (2002).

Once the propensity score is estimated, I match firms within each 2-digit SIC industry and within each time period to remove any industry-wide and aggregate effects from the estimation results. I impose common support in order to improve the matching, meaning that I drop observations whose propensity score is higher than the maximum or less than the minimum of the propensity score of the control variables, so that I make sure, I 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). For each export starter firm i in the common support, I construct a set of control firms $C(i)$ that consists of $N^{C(i)}$ firms with propensity scores closest to that of firm i .¹⁶

I then construct difference in difference estimators as follows:

¹⁶I use 3 nearest-neighbor method, but my 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.

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

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

$$\beta_{XPNF}^t = \frac{1}{N_t^{XPNF}} \sum_{i \in XPNF} (\mu_{it}^1 - \sum_{j \in C(i)} \frac{1}{N^{C(i)}} \mu_{ij}) \quad (13)$$

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.¹⁷ 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, I 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 β_{XP}^t . I do decompose β_{XP}^t to identify a specific mechanism through which exporters learn.

5 Empirical Findings

Table 2 presents the results from the matching estimator. Exporting firms are on average more productive than non-exporters after one, three and four years of exporting; however there is no statistically significant difference between exporters and non-exporters after controlling

¹⁷I only consider firms that have FTS access after starting to export. I also do a robustness check for firms having FTS access before or after exporting.

for self-selection. This is in line with the general finding of the empirical literature on learning by exporting.

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, β_{XPF}^t , results show that exporting firms with FTS access are 32 % more productive in the first year, and they are 45 % more productive on average than non-exporters after four years of exporting. These numbers are remarkably high and the results are statistically significant. Thus the learning effect is strongly present in firms with FTS access.

The results of the estimator β_{XPNF}^t , show that there is no productivity effect of starting to export among Chilean exporters if firms do not have access to FTS after exporting. 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 2 shows that Chilean exporters learn, but only those who establish FTS link after exporting decision.

Table 2: The Impact of FTS Access on Learning by Exporting

Outcome: Productivity				
Time	1	2	3	4
β_{XP}	0.027	-0.007	0.079	0.103
	(0.031)	(0.037)	(0.049)	(0.058)
N	782	641	517	388
N^C	2091	1672	1309	951
β_{XPF}	0.316	0.238	0.496	0.451
	(0.069)***	(0.083)**	(0.110)***	(0.125)***
N	183	150	126	98
N^C	472	373	308	222
β_{XPNF}	-0.061	-0.082	-0.055	-0.015
	(0.033)	(0.040)*	(0.052)	(-0.063)
N	599	491	391	290
N^C	1619	1299	1001	729

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

I also examine whether exporters' productivity grows faster with respect to their pre-export productivity level than non-exporters'. Table 3 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 7 % higher than non-exporters after the first year of exporting and it is statistically significant at the 5 % level. Notice that β_{XPF}^1 in this case also captures the complementarities between technology upgrading or R&D and exporting as shown by Yeaple (2005) and found by Bustos (2007) and others. After two years of exporting the statistical significance disappears although the difference is still positive. This may be because after a major upgrading of

technology in response to exporting, firms slow down investments in their productivity in the following years.

The productivity growth is 13.4 % higher after one year of exporting and 20 % higher after 4 years of exporting for the exporting firms with FTS link compared to non-exporters.

On the other hand, firms that export without accompanied FTS link do not show higher productivity growth than non-exporters after four years of exporting. The productivity growth shows a clear decreasing trend through time for the firms with no FTS link. Exporting itself does not cause faster productivity growth if not accompanied with FTS. However, probably exporting cause firms to improve their productivity in preparation of exporting which is captured by β_{XPNF}^1 .

Although not reported, results on the matching estimators are robust to productivity estimates resulted from standard Olley-Pakes estimator as well as fixed effect estimator. I also checked the results when I use labor productivity as an outcome variable, the results presented in Table 10 confirm the conclusion that Chilean exporters learn through the foreign technical service link.

Table 3: The Impact of FTS Access on Learning by Exporting

Outcome: Productivity Growth				
Time	1	2	3	4
β_{XP}	0.071	0.043	0.074	0.057
	(0.023)**	(0.029)	(0.037)*	(0.043)
N	782	641	517	388
N^C	2091	1672	1309	951
β_{XPF}	0.134	0.065	0.191	0.202
	(0.045)**	(0.056)	(0.064)**	(0.084)*
N	183	150	126	98
N^C	472	373	308	222
β_{XPNF}	0.052	0.036	0.036	0.009
	(0.027)	(0.034)	(0.044)	(0.050)
N	599	491	391	290
N^C	1619	1299	1001	729

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

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, I first find that firms' contacting with foreign technical and professional service markets is positively associated with exporting. I then find that foreign technical and professional service complements the effect of exporting on productivity. After controlling for self-selection and aggregate shocks, I do not find significant evidence for learning among overall export starters. Analyzing the group of firms with FTS link, I find a strong support for the hypothesis that learning happens through FTS. Moreover, I find that all learning by exporters in Chile during the sample period can be attributed to FTS. 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, my 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 4: Number of Plants which Export (XP) and/or purchase FTS

Year	XP	FTS	XP & FTS	All
1990	930	245	126	4484
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 5: Bivariate Probit Estimates

Variables	Exporting		FTS	
Intercept	-4.901	(0.305)***	-5.573	(0.293)***
Log(Capital)	0.109	(0.013)***	0.052	(0.016)***
Log(Labor)	0.255	(0.021)***	0.129	(0.025)***
Log(Average Wage)	0.156	(0.035)***	0.182	(0.043)***
Skill Intensity	-0.015	(0.010)	0.010	(0.004)*
Productivity (μ)	0.072	(0.020)***	0.053	(0.025)*
Log (Age)	-0.280	(0.016)***	-0.048	(0.020)*
$I(XP_{it-1}) * I(FTS_{it-1})$	2.484	(0.093)***	2.167	(0.072)***
$I(XP_{it-1}) * (1 - I(FTS_{it-1}))$	2.397	(0.041)***	-0.048	(0.046)
$I(FTS_{it-1}) * (1 - I(XP_{it-1}))$	0.117	(0.085)	1.703	(0.071)***
3-Digit Industry Dummies		✓		✓
Year Dummies		✓		✓
$Corr(\varepsilon_{it}^{XP}, \varepsilon_{it}^{FTS})$	0.045	(0.032)		
N	22922		22922	
Log PseudoLikelihood	-8489.594		-8489.594	

Absolute values of robust standard errors are in parentheses. Standard errors are adjusted for repeated observations on plants. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively.

Table 6: Bivariate Probit Estimates with Interaction Terms

Variables	Exporting		FTS	
Intercept	-4.887	(0.296)***	-5.959	(0.311)***
Log(Capital)	0.109	(0.013)***	0.050	(0.015)**
Log(Labor)	0.255	(0.021)***	0.129	(0.025)***
Log(Average Wage)	0.156	(0.035)***	0.179	(0.044)***
Skill Intensity	-0.015	(0.010)	0.010	(0.004)*
Productivity (μ)	0.075	(0.024)**	0.022	(0.029)
Log (Age)	-0.280	(0.016)***	-0.049	(0.020)*
$I(XP_{it-1}) * I(FTS_{it-1})$	3.708	(0.597)***	1.318	(0.433)**
$I(XP_{it-1}) * (1 - I(FTS_{it-1}))$	2.296	(0.237)***	0.101	(0.262)
$I(FTS_{it-1}) * (1 - I(XP_{it-1}))$	0.480	(0.539)	-0.756	(0.536)
$\mu_{it} * I(XP_{it-1}) * I(FTS_{it-1})$	-0.162	(0.078)*	0.117	(0.058)*
$\mu_{it} * I(XP_{it-1}) * (1 - I(FTS_{it-1}))$	0.014	(0.034)	-0.017	(0.037)
$\mu_{it} * I(FTS_{it-1}) * (1 - I(XP_{it-1}))$	-0.049	(0.074)	0.345	(0.075)***
3-Digit Industry Dummies		✓		✓
Year Dummies		✓		✓
$Corr(\varepsilon_{it}^{XP}, \varepsilon_{it}^{FTS})$	0.048	(0.032)		
N	22922		22922	
Log PseudoLikelihood	-8466.163		-8466.163	

Absolute values of robust standard errors are in parentheses. Standard errors are adjusted for repeated observations on plants. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively.

Table 7: Probit Estimates: Starting to Export

Variables	STARTXP
Intercept	-7.896 (0.797)***
Lagged Log Capital	0.566 (0.060)***
Lagged Productivity	0.779 (0.097)***
Lagged Log Capital *Lagged Productivity	-0.068 (0.009)***
Lagged Log Age	-0.066 (0.018)***
Past FTS Status	0.024 (0.063)
3-digit Industry Dummies	✓
Year Dummies	✓
N	21640
Pseudo R^2	0.063

Absolute values of robust standard errors are in parentheses. Standard errors are adjusted for repeated observations on plants. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively.

Table 8: Probit Estimates: Starting to purchase FTS

Variables	STARTFTS
Intercept	-2.958 (0.227)***
Lagged Log Capital	0.067 (0.012)***
Lagged Productivity	0.058 (0.025)*
Lagged Log Age	-0.001 (0.024)
Past Export Status	0.090 (0.045)*
2-digit Industry Dummies	✓
Year Dummies	✓
N	21651
Pseudo R^2	0.028

Absolute values of robust standard errors are in parentheses. Standard errors are adjusted for repeated observations on plants. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively.

Table 9: Productivity Evolution

Variables	μ_{it+1}	
Constant	2.147	(0.083)***
$I(FTS_{it}) * (1 - I(XP_{it}))$	0.104	(0.022)***
$(1 - I(FTS_{it})) * I(XP_{it})$	0.100	(0.010)***
$I(FTS_{it}) * I(XP_{it})$	0.181	(0.019)***
μ_{it}	0.784	(0.007)***
3-Digit Industry Dummies	✓	✓
Year Dummies	✓	✓
$Corr(\epsilon^\mu, \epsilon^s)$	0.097	(0.011)***
N	21219	
LogLikelihood	-17299	

Absolute values of robust standard errors are in parentheses. Standard errors are adjusted for repeated observations on plants. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively. $Corr(\epsilon^\mu, \epsilon^s)$ is the correlation between errors in the productivity evolution ϵ^μ and errors in the survival equation ϵ^s .

Table 10: The Impact of FTS Access on Learning by Exporting

Outcome: Labor Productivity				
Time	1	2	3	4
β_{XP}	0.045	-0.015	0.001	0.038
	(0.033)	(0.039)	(0.047)	(0.055)
N	797	654	538	405
N^C	2130	1730	1408	1034
β_{XPF}	0.301	0.222	0.368	0.360
	(0.080)***	(0.090)*	(0.094)***	(0.119)**
N	185	154	132	101
N^C	478	385	323	240
β_{XPNF}	-0.032	-0.088	-0.118	-0.069
	(0.035)	(0.042)*	(0.053)	(0.060)
N	612	500	406	304
N^C	1652	1345	1085	794

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