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Empirically Revisiting the Learning-by-Exporting Theory Using Data on Chilean Manufacturing Plants

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This paper empirically studies the learning-by-exporting hypothesis based on data of Chilean manufacturing plants from 2001 to 2007. I examine plants' exporting behavior from two aspects: export ratio and exporting experience. Intensive exporting behavior, in terms of higher export ratio or longer exporting experience, consistently and significantly raises the manufacturers' productivity only among those plants with asset innovation investment over 100 million pesos. Otherwise, the plants' exporting behavior cannot effectively improve their productivity; learning-by-exporting hypothesis does not hold under a low-innovation circumstance.

Keywords: Export Ratio, Exporting Experience, Productivity, Innovation, Learning-by-Exporting

JEL Classification: C23, D21, F14, F23, L60

I. Introduction

The positive relationship between exports and productivity growth has been well documented over the years. According to learning-by-exporting theory (Marin, 1992; Ben-David, 1993), firms can grow faster by making substantial exports. Compared to their non-exporting cohorts, exporting firms have access to more advanced skills via *ex post* benefits, especially when these skills are unavailable domestically. Alternatively, exporting firms can have access to more comprehensive market information, both globally and domestically. In other words, firms learn from their foreign business partners in the course of undertaking exporting activities. Theoretically speaking, such a learning process greatly enhances a firm's production efficiency. For example, tips on new manufacturing techniques, or news about an upcoming technological breakthrough, can help a firm make successful transitions vis-à-vis production and sales. As a result, it can grow more quickly than less resourceful domestic firms.

This study examines the reasons as to why the learning-by-exporting effect may not exist under certain circumstances. To undertake an empirical study that garners valid and reliable results, I use data captured through the ENIA (Encuesta Nacional Industrial Anual) survey, an annual industrial survey of Chilean manufacturing plants. I consider the learning-by-exporting hypothesis from two perspectives: the export ratio, which is the ratio between a plant's export value and its total production value, and exporting experience, or how many years a plant has

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continuously operated as an exporter. I then study whether exporting behavior significantly improves productivity.

Based on all the exporting manufacturers observed within the dataset, I find that while a plant's export ratio helps it significantly increase its productivity, exporting experience does not. I then study how innovation influences the learning-by-exporting effect. I use plants' aggregate innovation input on their capital assets (land, buildings, vehicles, and machines). A grouped test based on the plants' innovation investment reveals new findings: the learning-by-exporting effect is consistently significant only among the Chilean manufacturers that make sufficiently large asset innovation investments (i.e., exceeding 100 million Chilean pesos). Thus, a firm's exports can improve its productivity, but only when that firm makes substantial innovation efforts.

This study contributes to the literature by explaining why mixed evidence exists vis-à-vis the learning-by-exporting hypothesis; it does so by studying the latest plant-level survey data from Chilean manufacturers. It examines the learning-by-exporting hypothesis through two types of exporting behavior, and yet it reaches a consistent conclusion: high innovation investment practically guarantees a manufacturing plant's productivity growth, by way of its exports. If a firm wishes to effectively improve its productivity through intensive exports, it must concurrently pay sufficient attention to its research and development (R&D) investment.

To date, empirical tests based on various samples have found both positive and negative evidence for the learning-by-exporting hypothesis, indicating that this theory is very case-sensitive. This conclusion is addressed by Wagner (2007) in his review of the empirical literature on the positive correlation between exports and productivity growth. On one hand, Clerides *et al.* (1998) use plant-level data from Mexico, Colombia, and Morocco and find no evidence that firms' production costs are affected by their previous exporting behaviors. Using data from the Swedish manufacturing industry, Greenaway *et al.* (2005) find no evidence of differences between pre and post-export-market entry in terms of firm-level productivity. On the other hand, studies based on data from Indonesia (Amiti and Konings, 2007; Blalock and Gertler, 2004), Canada (Baldwin and Gu, 2004), the United Kingdom (Girma *et al.* 2003 and 2004), Slovenia (De Loecker 2007 and 2013), Spain (Manjón *et al.* 2013), and Chile (Alvarez and Lopez, 2005) all reach approximately the same finding: manufacturing firms become significantly more productive than their domestic counterparts upon entering the exporting market.

Recently, extensive empirical studies have explained this mixed evidence of the veracity of the learning-by-exporting theory. Among these studies, the role of innovation investment has been put under the spotlight with increased frequency. In their theoretical and empirical works, Hallward-Driemeier *et al.* (2002), Bustos (2011), Aw *et al.* (2008), and Costantini and Melitz (2007) each concludes that firms' exports are related to their R&D investments or their adoption of new technology. The key insights drawn from these studies are that innovation and exportation correlate, and that they both influence a firm's growth.

This paper is organized as follows. Section II describes the data. Section III presents the empirical results and analysis. Section IV provides a discussion, and section V concludes the paper.

II. Data Description

The plant-level data used in this study come from ENIA (Encuesta Nacional Industrial Anual), the Annual National Industrial Survey conducted by the National Statistics Institute of Chile (Instituto Nacional de Estadisticas Chile; INE). The original dataset features comprehensive plant-level information from 1995 to 2007. The survey contains the universe of manufacturing plants in Chile that employ more than 10 workers. More than 5,000 plants are reported per year, so the data contain more than 65,000 plant observations. Through the survey, the INE also captured data on the plants that began operating during the current year, and excluded those that stopped operating for any reason. Each plant is assigned with a specific identification number that allows me to track its activities over time. Note that although a plant is not necessarily a "firm"—since a firm may have several plants concurrently—according to Pavcnik (2002), more than 90 percent of the manufacturing firms of Chile have only one plant. Thus, this plant-level survey data can also be used to address firm-level issues, and the terms are often used interchangeably.

A. Descriptive Statistics of the Observed Plants

The data from before 2001 contain no information on the plants' capital input. Since estimations of productivity require the plants' detailed production information, and because ENIA captured fixed capital input data through the survey only after 2001, I select the manufacturers from 2001 to 2007 and combine them as balanced panel data. These data comprise continuously operating plants, and so I can observe their long-term exporting experience. There are 2,264 plants per year and 15,848 observations in total. Table 1 reports the descriptive statistics of the panel data. Among all the observations, 3,782 (24 percent) plants were exporters during this timeframe, and 12,066 (76 percent) were non-exporters. Nonetheless, exporting behavior among Chilean plants is relatively rare.

Besides exports, I use two other variables that measure plants' business dealings with foreign countries. One is the proportion of the plant's capital that is foreign-owned, and the other is the proportion of the plant's techniques that come from abroad. In panel B, the foreign capital proportion is the ratio of the plant's foreign capital to its total capital input. In comparing exporting and domestic plants, it is clear that high proportions of foreign capital (>50 percent) occur more frequently among the exporters. In all, 10 percent of the exporters are endowed with 100 percent foreign capital; on the other hand, almost all non-exporter capital (97 percent) is completely domestic.

Foreign technical assistance is the value of technical assistance that a plant receives from abroad; in panel C, the "Foreign Tech Assistance Ratio" is the ratio of a firm's foreign technical assistance to its total production revenue. A firm with no foreign capital also receives no foreign technical assistance, and relatively fewer non-exporters receive as much foreign technical support as do exporters.

Panel D indicates the plants' sizes—in other words, the number of workers. The proportion of small (<50 workers) non-exporters is twice as large as that of small exporters. Compared to non-exporters, a much higher proportion of exporters comprise large plants with more than 150 workers each.

Furthermore, the ENIA dataset shows the innovation behavior of plants vis-à-vis their capital assets (i.e., buildings, vehicles, machines, and land). Manufacturing innovation information is not directly reported within the data via their original R&D expenditures; rather, it is indicated indirectly, through the value-added of assets—that is, based on its innovation-related activities, how much value-added has been created with respect to a plant's current capital assets. If a plant shows no signs of increased asset value, then I consider there to be no actual innovation. The more capital value-added the plant has acquired, the greater its innovation-related effort has been, and it is evidenced in real effects. Hereafter, I use the capital value-added as derived from the plants' innovative activities to measure innovation effort. For simplicity, I name this variable "innovation investment."

Panel E, "ASSET INNOVATIONS," reports how many exporters or non-exporters have made innovation investments on a variety of asset types. Under each asset category, the proportion of innovating exporters is almost twice that of innovating non-exporters. Nonetheless, most of the plants—among either the exporters (88 percent) or the non-exporters (95 percent)—do not innovate.

Table 1: Descriptive Statistics of Exporting and Non-Exporting Plants, 2001 to 2007

	Exporters		Non-Exporters	
	Number	Percentage	Number	Percentage
A. TOTAL NUMBER OF PLANTS	3,782	100.00	12,066	100.00
B. CAPITAL PROPORTION				
Foreign Capital Proportion = 0	3,057	80.83	11,770	97.55
Foreign Capital Proportion ∈ (0, 50%)	113	2.99	104	0.86
Foreign Capital Proportion ∈ (50%, 100%)	223	5.90	99	0.82
Foreign Capital Proportion = 100%	389	10.29	93	0.77
C. TECHNICAL ASSISTANCE				
Foreign Tech Assistance Ratio = 0	3,057	80.83	11,770	97.55
Foreign Tech Assistance Ratio ∈ (0, $5.0e^{-6}$)	373	9.86	105	0.87
Foreign Tech Assistance Ratio ∈ ($5.0e^{-6}$, $1.0e^{-5}$)	121	3.20	30	0.25
Foreign Tech Assistance Ratio > $1.0e^{-5}$	231	6.11	161	1.33
D. SIZES				
Small (10-49 Workers)	1,647	44.26	10,715	88.80
Medium (50-149 Workers)	2,034	53.78	1,306	10.82
Large (≥150 Workers)	99	2.62	41	0.34
E. ASSET INNOVATIONS				
Innovators on Buildings > 0	265	7.01	386	3.20
Innovators on Vehicles > 0	33	0.87	55	0.46
Innovators on Machines > 0	251	6.64	294	2.44
Innovators on Land > 0	16	0.42	29	0.24
No Innovation	3,343	88.39	11,448	94.88

Source: ENIA (Annual National Industry Survey) Dataset, National Institute of Statistics of Chile.

B. Exporting Experience vs. Non-Exporting Experience

Table 2 reports the plants' exporting and non-exporting experience. The "exporting experience" of an exporter is the number of years that it has continuously exported goods. For example, if an exporter in 2007 has four years of exporting experience, then it did not export in 2003, but had positive exports from the beginning of 2004 to the end of 2007. If an exporter in 2007 has five years of exporting experience, then it did not export in 2002, but exported from the beginning of 2003 to the end of 2007.

Meanwhile, "non-exporting experience" is an exporter's number of continuous years with zero exports, prior to the current year. For example, if an exporting plant in 2007 has four years of non-exporting experience, then it did not export from 2003 to 2006, but did export in 2002; similarly, for an exporting plant in 2007 with five years of non-exporting experience, it had no exports from 2002 to 2006, but did export in 2001.

Table 2: Exporters' Exporting and Non-Exporting Experience from 2001 to 2007

	Exporting Experience		Non-Exporting Experience	
Number of Years	Number	Percentage	Number	Percentage
7	359	15.86	-	-
6	20	0.88	22	0.97
5	27	1.19	0	0.00
4	30	1.33	1	0.04
3	32	5.79	3	0.13
2	30	1.41	5	0.22
1	42	1.86	11	0.49
0	-	-	359	15.86
Never-Exporting Plants	1,522	67.23		
Total	2,264			

Source: ENIA (Annual National Industry Survey), National Institute of Statistics of Chile.

To study the continuous behavior of the observed plants, I reassemble the balanced panel data into a time-series longitudinal dataset. To preclude redundancy, I consider only those plants in 2007 and their past experience. In total, 2,264 plants continuously operated from 2001 to 2007. From Table 2, one can see that most of the plants (67 percent) never exported goods. Even in today's mature state of globalized business and expanding international trade and cooperation, exporting behavior is still not commonly observed among Chilean plants.

The exporters that exported from 2001 and all the way through 2007 constitute the second-largest group (16 percent). Additionally, most of the current exporters already had previous exporting experience, and very few of them started to export after sustaining a long period of not exporting. Thus, plants are highly likely to have a consistent exporting or non-exporting status;

frequently jumping in and out of the export market is quite rare. Once a plant exports or stops exporting, it tends to retain this status for a considerable time.

C. Distribution of Productivity

Based on a traditional Cobb–Douglas production function[1], I estimate the plants' levels of productivity, based on their outputs, capital inputs, labor inputs, and material costs. Specifically, I use the Olley–Pakes methodology (Olley and Pakes, 1996), which makes use of a semi-parametric algorithm; it effectively removes endogeneity and simultaneity during the estimation of the production coefficients—especially the coefficient of the capital input.

Table 3 reports the productivity distribution among all the observed exporters and non-exporters in the panel data. A_{it} is the estimated total factor of productivity; hereafter, for simplicity, I use $a_{it} = \log A_{it}$ as productivity. As shown in the table, the productivity score of most of the exporters (67 percent) ranges from 1 to 3, while that of most of the non-exporters (59 percent) is between 0.25 and 1. The median of the exporters' productivity (0.96) is much higher than that of the non-exporters (0.37). Additionally, the productivity distribution of the non-exporters is more left-skewed than that of the exporters; an exporter thus faces a greater chance of having a high level of productivity than a non-exporter.

Table 3: Distributions of Productivity

$a_{it} = \log A_{it}$				
	Exporters		Non-Exporters	
	Number	Percentage	Number	Percentage
$a_{it} < 0$	23	0.61	524	4.34
$a_{it} \in (0\ 0.25)$	36	0.95	1,161	9.62
$a_{it} \in (0.25\ 0.5)$	127	3.36	2,239	18.56
$a_{it} \in (0.5\ 1)$	985	26.04	4,964	41.14
$a_{it} \in (1\ 1.5)$	1,327	35.09	2,188	18.13
$a_{it} \in (1.5\ 3)$	1,232	32.58	939	7.78
$a_{it} > 3$	52	1.37	51	0.42
Total	3,782	100.00	12,066	100.00

[1]A traditional Cobb-Douglas production function looks like:

$$Y_{it} = A_{it} L_{it}^{\beta_l} K_{it}^{\beta_k} M_{it}^{\beta_m}$$

where for firm *i* at time *t*, Y_{it} is the total production, A_{it} is the manufacturing productivity, L_{it} is labor input, M_{it} is material cost, and K_{it} is capital input. β_l, β_k, and β_m are the coefficients of L_{it}, M_{it}, and K_{it}, respectively. The estimation of productivity A_{it} is based on the estimates of β_l, β_k, and β_m.

III. Empirical Tests

In this study, the learning-by-exporting effect is examined from two perspectives: first, whether an exporter's relatively high export volume improves its productivity, and second, whether a longer consecutive period of exporting experience leads to higher productivity. Let us explore each of these in greater detail.

A. Export Ratio and the Learning-by-Exporting Hypothesis

The first hypothesis is that to observe a significant learning-by-exporting effect, a larger export volume would need to help bring about a higher level of productivity. To test this theory, I will start with a linear regression of productivity against export ratio, as one of the main explanatory variables. This regression is specified as:

$$a_{it} = \alpha_0 + \alpha_1 \text{Export Ratio}_{it-1} + \alpha'_2 X_{it-1} + \alpha'_3 \text{Plant}_{it-1} + \varepsilon_{it}, \quad (1)$$

where "Export Ratio$_{it}$" is the ratio between plant i's export value and its total production revenue in year t. X_{it} is a vector of the exporting-related activities of plant i in year t. Plant$_{it}$ constitutes the business characteristics of the plant. Note that all the explanatory variables on the right-hand side are lagged by one period; this is to preclude potential simultaneity during estimation.

Aggregate innovation is based on the plant's innovations with respect to four asset types: buildings, machines, vehicles, and land. If a plant exhibits no type of innovation, then its total innovation is 0. If the plant has invested in any type of innovation, its innovation effort is measured as the aggregate of different types of innovation—specifically,

$$\text{Total Innovation}_i = \sum_j^4 \text{Innovation}_{ij}, \quad (2)$$

where $j \in$ {Buildings, Machines, Vehicles, Land}. Total Innovation is the sum of each type of innovation.

To test whether the learning-by-exporting hypothesis holds and how it is influenced by exporting experience and innovation investment, I will focus on α_1. Specifically, α_1 illustrates the effect of export ratio on productivity, and therefore shows whether the learning effect exists with significance. I therefore refer to α_1 as the "learning coefficient." The results are reported in Table 4. Besides foreign capital proportion and technical assistance, I also use other exporting-related explanatory variables (e.g., the plant's expenditure in promoting exports and subsidies received due to exports). The export revenue ratio is the ratio of the plant's export revenue to its total production revenue. Two business characteristics are also included: the value-added ratio, which is the ratio of the plant's value-added to its production value, and the capital depreciation ratio, which is the ratio of the plant's depreciated capital to its total fixed capital.

In column (i) of Table 4, if we do not consider the potential influence of innovation investment, there is significant evidence that the export ratio promotes productivity. A 1 percent increase in export ratio significantly increases productivity (i.e., by 1.1 percent); all the exporting activities and business characteristics also significantly influence productivity. Increased foreign capital, foreign technical support, and export subsidies and expenditures all effectively increase productivity. Greater value-added and capital depreciation also indicate higher productivity. Interestingly, however, higher export revenue decreases productivity; this finding suggests that if a plant were earning more money from exports, it would actually be a less-productive manufacturer. A 1 percent increase in export revenue ratio significantly reduces productivity by 1.25 percent.

Table 4: Correlation Between Productivity and Exports Among Exporters

Dependent Variable: $a_{it} = \log A_{it}$	All Exporters (i)	With Aggregate Innovation in Chilean Pesos (CLP) > $1.0e^{+8}$ (ii)	∈ ($1.5e^{+7}$, $1.0e^{+8}$) (iii)	∈ (0, $1.5e^{+7}$) (iv)	Without Innovation (v)
Export Ratio	1.14***	5.03**	3.65	0.07	0.39
	(0.32)	(2.18)	(2.22)	(2.25)	(0.32)
Foreign Capital Proportion (%)	0.27***	1.42	0.42***	0.03	0.26***
	(0.03)	(0.11)	(0.12)	(0.11)	(0.03)
Foreign Technical Assistance	0.91***	0.51	3.40	9.83**	0.77***
	(0.19)	(0.83)	(3.32)	(4.37)	(0.19)
Export Subsidy	0.12***	0.27***	0.62***	2.94	0.12***
	(0.02)	(0.08)	(0.20)	(2.14)	(0.02)
Export Promotion Expenditure	1.33***	1.22	5.86**	0.08	1.50***
	(0.17)	(0.89)	(2.77)	(3.36)	(0.17)
Export Revenue Ratio	-1.25***	-5.29**	-4.06*	-0.38	-0.54*
	(0.31)	(2.08)	(2.11)	(2.17)	(0.30)
Value Added Ratio	0.39***	0.95***	0.57**	0.11	0.74***
	(0.05)	(0.27)	(0.28)	(0.20)	(0.05)
Capital Depreciation Ratio	0.14***	1.20*	1.33	-0.18	0.23***
	(0.05)	(0.72)	(0.87)	(0.49)	(0.05)
Region FE	Yes	Yes	Yes	Yes	Yes
Size FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.370	0.449	0.302	0.556	0.412
No. of observations	3,242	121	127	130	2,864

Notes: Standard errors are in parentheses. Foreign technical assistance, export subsidy and export promotion are measured in 10^{10} pesos. ***: Significant at or less than 1%; **: Significant at or less than 5%; *: Significant at or less than 10%.

Columns (ii)–(iv) report test results based on the plants that exhibit asset innovation; column (v) reports on plants lacking any innovation. Most of the sampled plants exhibit no innovation effort. Only 378 of 3,242 (11.7 percent) exporters have made innovation efforts vis-à-vis their capital assets; among them, the learning effect is significant only among the plants with the highest levels of innovation. For a plant with an aggregate innovation investment exceeding CLP100 million, a 1 percent increase in export ratio significantly increases its productivity (i.e., by 5 percent). A higher export ratio can significantly improve a plant's productivity; in such cases, the learning effect substantially holds. Besides the export ratio, each of higher export subsidy, value-added, and the capital depreciation rate can increase productivity. Rising export revenue still lowers productivity.

For the plants in column (iii) with innovation investments of CLP15–100 million, the learning coefficient is lower, and no longer significant. Nonetheless, other exporting-related activities (i.e., higher foreign capital ratio, higher value-added ratio, and higher export subsidies and expenditures) all enhance productivity in a very significant manner. The export revenue ratio continues to affect productivity negatively. For the plants in column (iv) with aggregate innovation investments lower than CLP15 million, the learning-by-exporting hypothesis does not hold, either; the learning coefficient is insignificant, but even smaller. Except foreign technical assistance, none of the exporting activities and business characteristics influences productivity anymore.

Meanwhile, for the non-innovating exporters in column (v), the learning coefficient is still small and insignificant. This remains as evidence that runs counter to the learning-by-exporting hypothesis. The learning effect cannot be detected among the non-innovating exporters; however, their exporting activities and business characteristics all regain significance. Higher foreign capital and technical assistance effectively increase productivity; so do export subsidies and expenditures. As previously found in columns (i)–(iii), the export revenue ratio is still found to reduce productivity.

In summary, the learning-by-exporting effect exists only when plants exhibit sufficient innovation effort. On one hand, for manufacturing plants with innovation investments exceeding CLP15 million, more exports can effectively increase their productivity; this finding is consistent with that positive evidence for the learning-by-exporting theory. For example, based on micro-level data from Indonesia (Amiti and Konings, 2007), Canada (Baldwin and Gu, 2004), the United Kingdom (Girma *et al.* 2003 and 2004), and Slovenia (De Loecker, 2007 and 2013), it has been found that firms experience significant productivity growth upon participating in the export market.

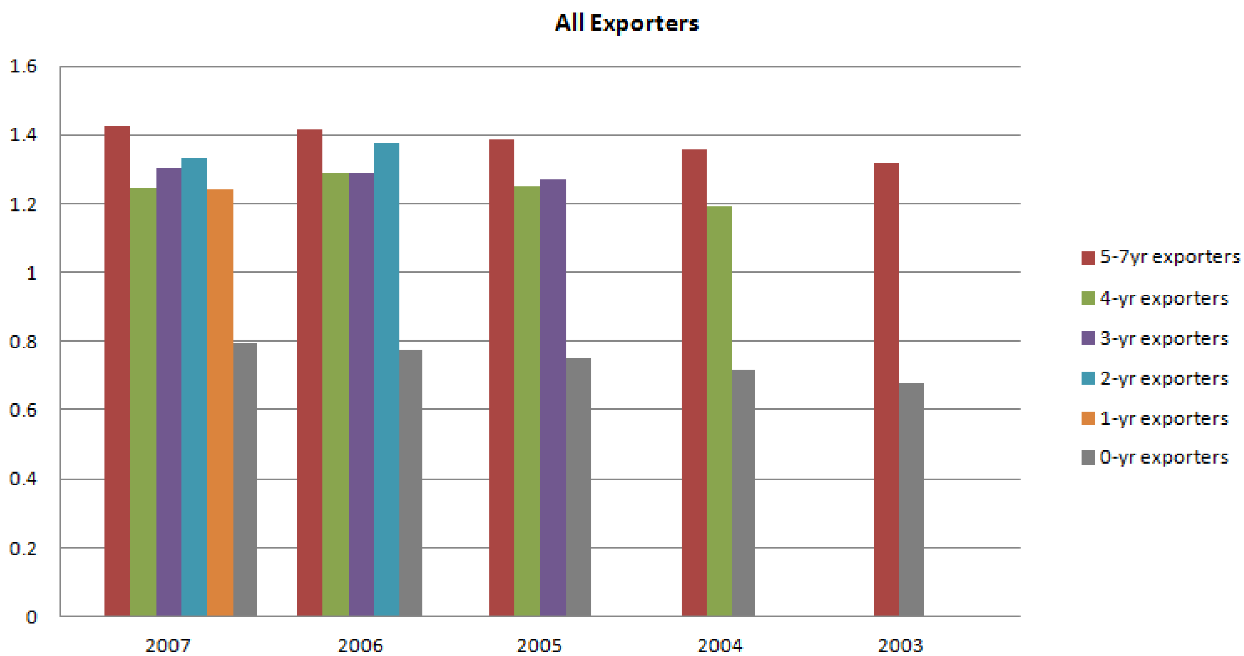
On the other hand, a higher export ratio cannot significantly improve the productivity of a plant whose innovation investment is lower than CLP15 million. This finding is consistent with evidence that runs counter to the learning-by-exporting theory. For example, Clerides *et al.* (1998) and Greenaway *et al.* (2005) each found there to be no production difference among firms' export-market entrants. Therefore, we cannot simply argue that the learning-by-exporting theory itself is right or wrong; there are explanations as to why divergent results exist. Thus far, the current study has already shown that innovation investment is an effective way of reconciling evidence that supports the theory with that which disputes it.

B. Exporting Experience and the Learning-by-Exporting Hypothesis

Next, I examine the learning-by-exporting effect from the second perspective: exporting experience. Let us see how exporters' levels of productivity differ, given their divergent lengths of exporting experience period.

I follow the definition of "exporting experience" described in Section II.B. For example, an exporter in 2007 that has four years of exporting experience had positive exports from 2004 to 2007, but did not export in 2003; a firm with three years of exporting experience had positive exports from 2005 to 2007, but did not export in 2004. Having five to seven years of exporting experience means that the plant has been continuously exporting for at least five years. Figure 1 shows how exporting experience corresponds to the plants' expected productivity, which is based on estimations of their average productivity levels. I examine the plants in 2007, and study their expected productivity levels year by year. The vertical axis refers to the estimated expected productivity, while the horizontal axis refers to the time. I call those plants that have never exported "zero-year exporters."

Figure 1: Exporting Experience and Expected Productivity: Plants in 2007



Each bar in Figure 1 represents the expected productivity of plants that have attained a certain length of exporting experience. For example, red bars represent the expected productivity of exporters with five to seven years of consecutive exporting experience; that labeled "2007" is the expected productivity in 2007. The red bar labeled "2006" is the expected productivity of these exporters in the previous year (2006), and that labeled "2005" is their expected productivity two years previous (2005). The green bars represent the expected productivity of exporters with four years of exporting experience, across various years; the purple bars represent exporters with three years of experience; and blue and yellow bars are exporters with two and one year of experience, respectively. The gray bars indicate the expected productivity of those plants that never exported (i.e., "zero-year exporters") between 2001 and 2007.

First, let us compare expected levels of productivity across exporters that have the same length of exporting experience, but in different years. Except for the exporters with four and two years of experience, all plants—even those with no exports between 2001 and 2007—saw increases in expected productivity year by year. Thus, exporting behavior alone cannot explain productivity growth; exports may improve productivity to a certain extent, but they do not fully decide growth trends vis-à-vis productivity.

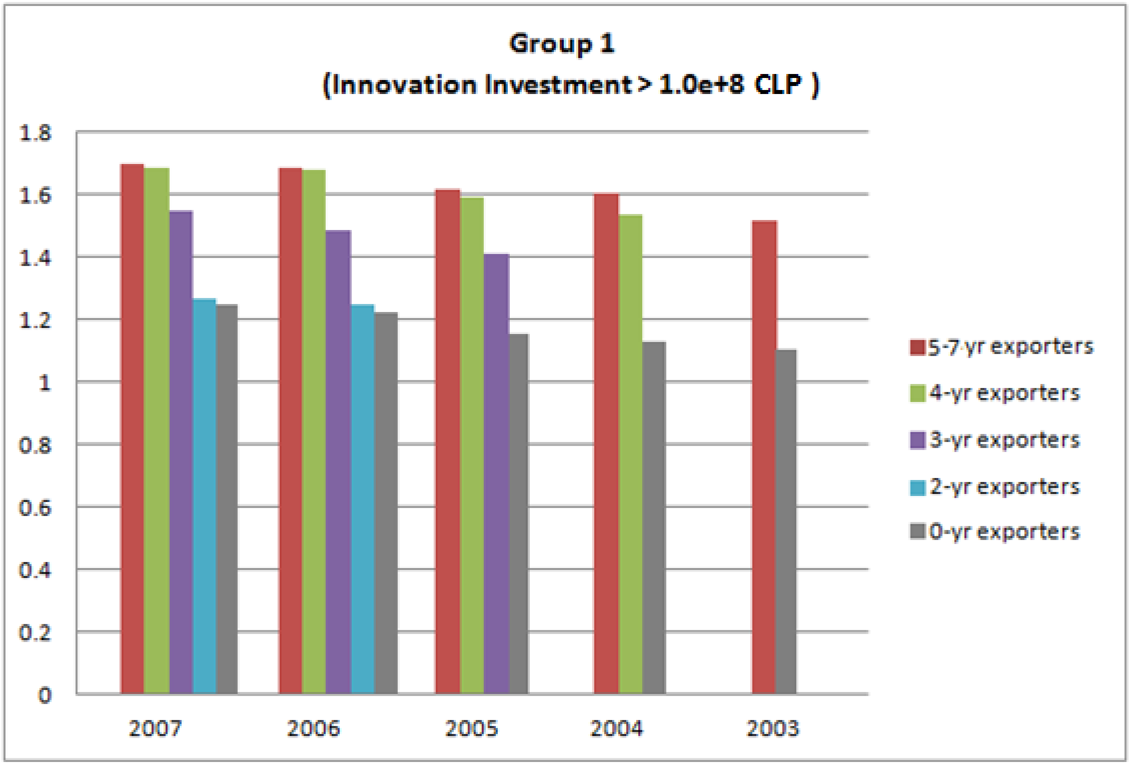
Let us then compare exporters within the same year, but with different consecutive levels of exporting experience: as the exporting experience increases, the expected productivity does not always increase. As expected, the plants that exported every year between 2001 and 2007 show the highest productivity levels. Unsurprisingly, the plants that never exported always show the lowest productivity levels. However, in 2007 and 2006, the plants with two years of exporting experience witnessed the second-highest level of productivity—even higher than that of plants with three and four years of experience. Among all the observed exporters in 2007, the strength of correlation between expected productivity and exporting experience is very ambiguous.

B.1. Exporting Experience, Learning-by-Exporting Effect, and Innovation

Based on the plants' asset innovation investment, I divide the plants observed in 2007 into four groups, in terms of their level of innovation investment: group 1 had the highest investment level (>CLP100 million), group 2 had medium investment (CLP15–100 million), and group 3 had the lowest investment level (<CLP15 million). Group 4 includes all the non-innovating exporters. In each of these groups, let us look again at the relationship between the plants' exporting experience and their expected productivity.

Figures 2 and 3 show how exporting experience influences productivity within each of the various innovation groups. First, let us look at Figure 2. In the high innovation investment group (group 1; >CLP100 million), if we compare vertically within each group across different periods, we find that expected productivity always increases year after year. If we compare horizontally within each year, the plants with five-to-seven years of exporting experience have the highest expected productivity; those with four years of experience have the second-highest expected productivity; those with three years of experience have the third-highest productivity, and so on. The less experience an exporter has, the lower its expected productivity will be; as such, the plants that have never exported have the lowest expected productivity. Therefore, among plants showing the highest level of innovation investment, the learning-by-exporting hypothesis is found to hold significantly. In other words, a longer period of exporting experience leads to higher expected productivity. Higher productivity levels can be rightfully expected among more experienced exporters that each invest more than CLP100 million in asset innovation.

Figure 2: Exporting Experience and Expected Productivity in Different Innovation Groups – Plants in 2007



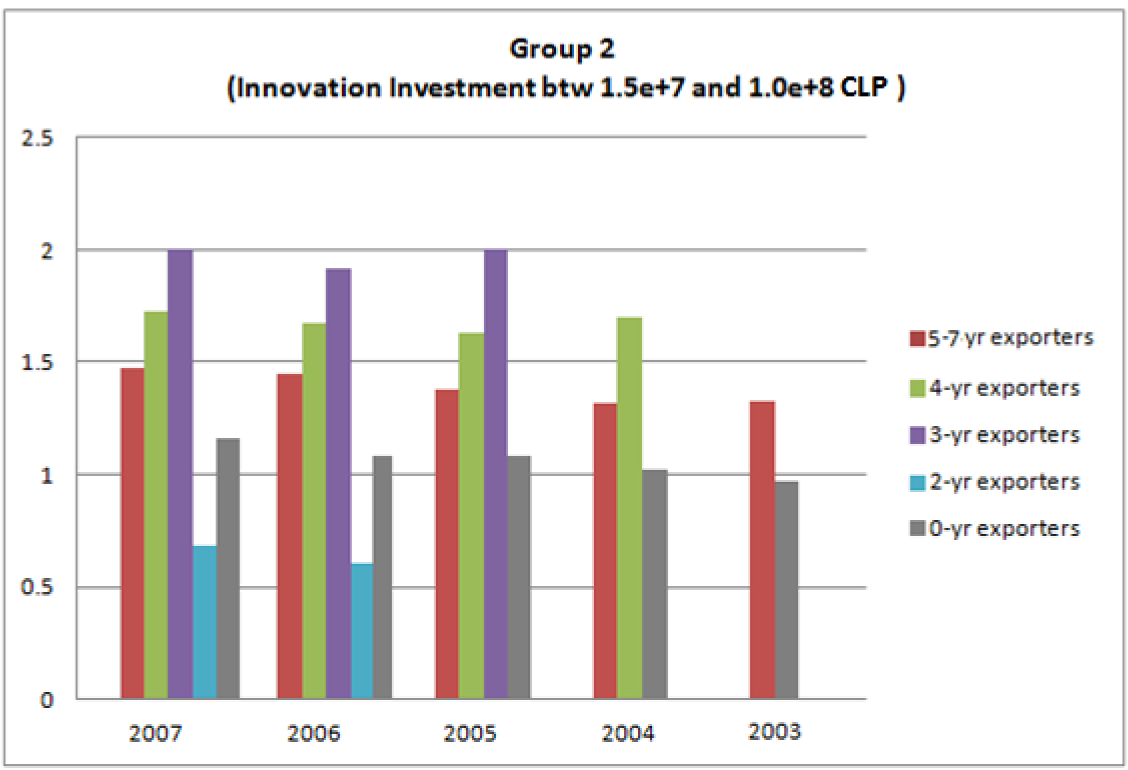
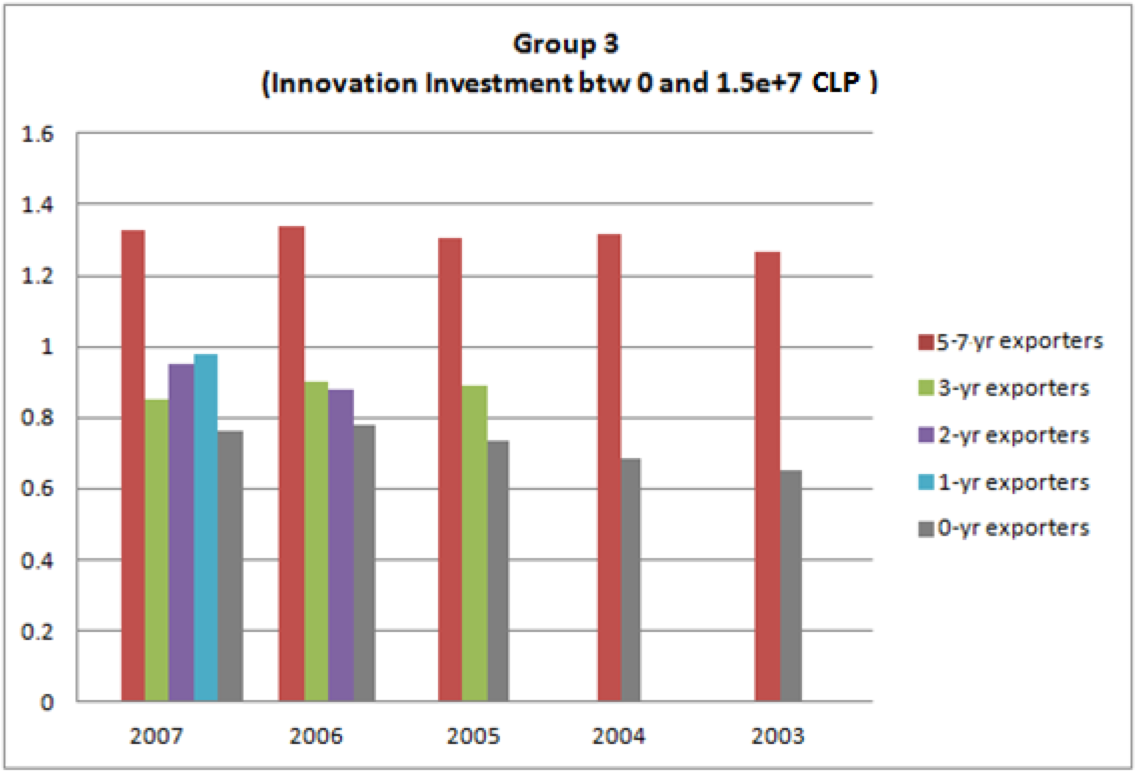
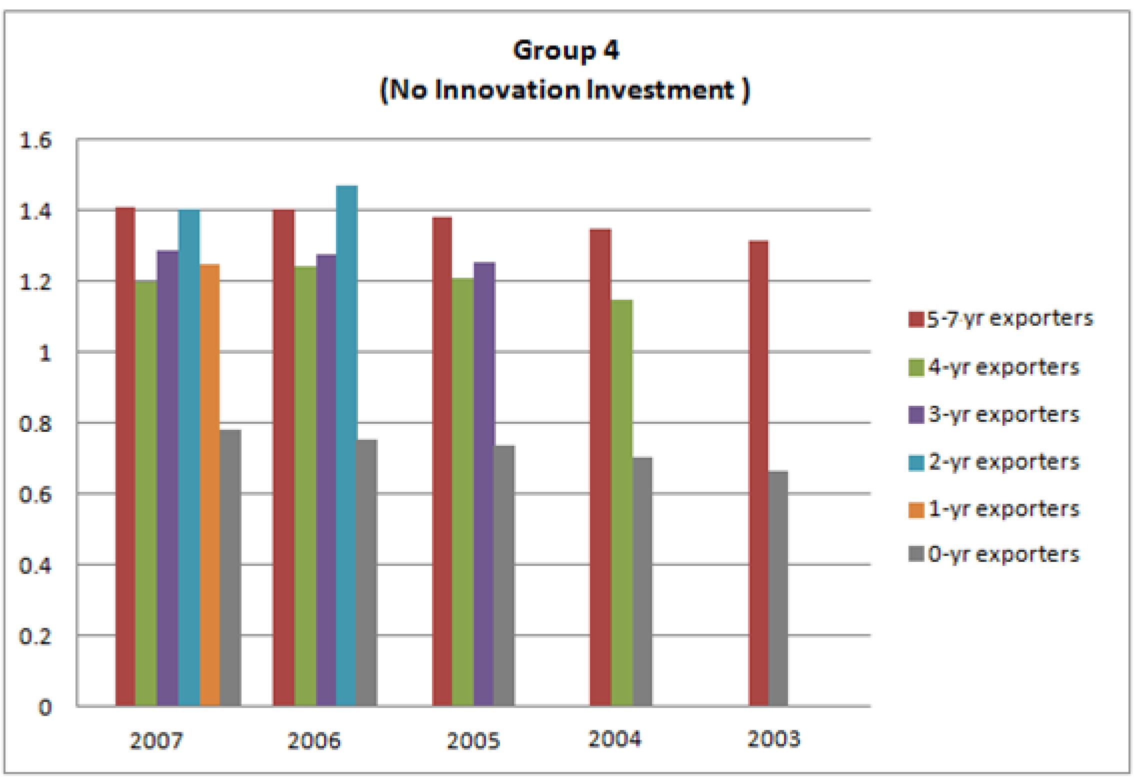


Figure 3: Exporting Experience and Expected Productivity in Different Innovation Groups – Plants in 2007: Continues





However, in group 2, this positive correlation between exporting experience and productivity is dramatically violated: a longer period of exporting experience no longer equates with higher productivity. For example, in 2007, exporters with only two years of exporting experience have the lowest expected productivity—much lower, even, than that of non-exporters with seven years of non-exporting experience. Additionally, exporters with three years of exporting experience have the highest expected productivity. Thus, the learning effect does not exist for the exporters that make a lower innovation investment (CLP15–100 million). Clearly, more exporting experience does not necessarily translate into a higher productivity level.

Figure 3 shows the results of the exporters with the lowest (<CLP15 million) investment levels and of those with no innovation investment. In group 3, the learning-by-exporting hypothesis is strongly violated in 2007. Although the plants with five to seven years of exporting experience have the highest expected productivity, and those that have never exported have the lowest, the second-highest expected productivity is observed among exporters with only one year of exporting experience. The expected productivity of non-exporters with seven years of experience remains the lowest for each year. As for group 4—which comprises plants that showed no asset innovation effort—the strength of the correlation between exporting experience and expected productivity is again ambiguous. In 2007 and 2006, the plants with only two years of experience have the highest productivity—higher even than that of those with the longest period of exporting experience. Thus, the learning effect does not exist for groups 3 and 4, which comprise plants that each spent less than CLP15 million in asset innovation.

IV. Discussion

Although this paper addresses the learning-by-exporting effect by using two different methods—namely, one that uses the export ratio, and another that uses exporting experience—the conclusion is consistent. If I do not consider the potential influence of manufacturing plants' levels of asset innovation investment, but rather target all the observed Chilean exporting plants from 2001 to 2007, the learning effect is found to give rise to inconsistent results. The export ratio significantly increases the plants' productivity, but a longer period of exporting experience does not necessarily result in higher expected productivity.

However, once I divide the plants into groups according to their total innovation investment, interesting and consistent findings are revealed. A significant learning-by-exporting effect can be detected only among plants that invest a sufficiently high amount in asset innovation. Specifically, among Chilean manufacturing plants that each spend more than CLP100 million in asset innovation investment, more exports and a longer period of exporting experience can be expected to effectively increase productivity—otherwise, a plant with lower innovation investment cannot improve its productivity through intensive exporting behavior. My conclusion aligns with the findings of Hallward-Driemeier *et al.* (2002), Bustos (2011), Aw *et al.* (2008), and Costantini and Melitz (2007). Innovation investment is indeed an important decision for plants to make in an open economy, especially when they are deciding to augment productivity by undertaking more intensive exporting activities.

Naturally, the current study has limitations and bias. For example, the sample includes only the manufacturing plants that continuously operated from 2001 to 2007; the use of this inclusion criterion stems from my need to estimate the plants' productivity levels and study their continuous exporting behavior. The selected sample, furthermore, does not represent the entire Chilean economy, and I have little to say about the learning-by-exporting effect on plants that operate sporadically or inconsistently.

V. Conclusion

This study examined the learning-by-exporting hypothesis and whether it holds among Chilean manufacturing plants. It interprets the learning effect from two perspectives. First, with respect to the export ratio, it examined the effect of a plant's exports on its total production. Second, it examined exporting experience—namely, the number of years that a plant maintains an exporter status. I used data captured through the ENIA, an annual industrial survey on Chilean manufacturing plants from 2001 to 2007.

I studied how innovation alters the learning effect. I found that a Chilean plant's exporting behavior can significantly and consistently improve its productivity, but only if it is spending more than CLP100 million in asset innovation. There is a solid, economics-based rationale behind this conclusion: the more an exporting plant innovates, the more its effort will be repaid in terms of improved technology or increased efficiency. As a plant improves its production efficiency, it becomes better able to effectively learn from exporting—and, as a result, its production will increase more quickly than that of exporters with low innovation investment.

This study reconciles both negative and positive evidence of the learning-by-exporting hypothesis, and ultimately concludes that differential investment in innovation gives rise to these mixed findings. Therefore, while it remains a controversial topic, the learning-by-exporting hypothesis is neither absolutely right, nor absolutely wrong. In the real world, we need to consider other specific, micro-level details—for example, innovation behavior—before we can decide the likelihood of the existence of the learning effect.

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