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EXTERNAL SOURCES OF TECHNOLOGICAL INNOVATION IN CHILEAN MANUFACTURING INDUSTRY*

ROBERTO ALVAREZ

Abstract

There are several arguments in the literature regarding that more open economies would grow faster in the long term. Nevertheless, the channels through which openness increases growth have not been clearly identified in empirical analysis. In this article, we study if outward orientation variables have a positive impact on technological innovation, which is one of the most important sources of productivity growth. Using microeconomic data for Chilean manufacturing industry, we identify the effect of three main mechanisms of technological absorption: exports, direct foreign investment and purchase of foreign technical licenses. The results suggest that exports increase significantly technological innovation. In addition, we found causality in both ways. Technological innovation increases the probability of exporting. The other two channels; direct foreign investment and technical licenses, would be less important, because they only affect a reduced number of technological innovation indicators.

Resumen

Existen diversos argumentos que aseveran que economías más abiertas debieran crecer más en el largo plazo. Sin embargo, los canales mediante los cuales la apertura aumenta el crecimiento no han sido claramente identificados empíricamente. En este estudio se evalúa si variables de apertura tienen un impacto positivo en innovación tecnológica, que es una de las fuentes más importantes de crecimiento en productividad. Utilizando datos micro para la industria manufacturera chilena, este trabajo identifica los efectos de tres mecanismos de absorción tecnológica: exportaciones, inversión extranjera directa y compra de licencias técnicas extranjeras. Los resultados sugieren que las exportaciones incrementan significativamente la innovación tecnológica, mientras que los otros dos canales son menos importantes porque afectan sólo a un número reducido de indicadores de innovación tecnológica.

JEL Classification: *O33, L60.*

Keywords: *Innovation, technological absorption, productivity.*

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□ Department of Economics of the University of Chile. Diagonal Paraguay 257. e-mail: ralvarez@econ.facea.uchile.cl

1. Introduction

In literature about the determinants of economic growth there are some arguments relative to that openness would allow to reach higher growth rates. Nevertheless, some theoretical models show an ambiguous relationship between both variables. In some cases, as in Lucas (1993), the trade openness is positively related with growth, because allows a higher accumulation of human capital in the way of learning by doing. On the other hand, some models as in Young (1991), conclude that trade openness is negative for developing countries, since these countries would produce goods of a very low learning rate.

In models that emphasize the accumulation of knowledge like a mechanism to generate endogenous growth, the effects of openness depend on the reallocation of resources that this generates. If openness increases production of sectors more intensive in knowledge, the impact will be positive. Otherwise, it will be negative. (Grossman and Helpman, 1991). Rivera Batiz and Romer (1991) obtain similar conclusions. In their model, openness will generate a higher economic growth, only if it reallocates human capital from the sector that produces final goods toward the sector that produces new designs of capital goods.

Many empirical studies have studied this topic, but the evidence is not conclusive. Some authors find that openness increases growth rates (Dollar, 1992; Ben David, 1993; Sachs and Warner, 1995; and Edwards, 1992 and 1998). While others suggest that there is not a significant relation between openness and growth, as it would be the case for Latin American countries, (De Gregorio, 1992; Corbo and Rojas 1992 and 1993). In a recent paper, Rodriguez and Rodrick (1999) revise critically this empirical literature. They argue that "methodological problems with the empirical strategies employed in this literature leave the results open to diverse interpretations. In many cases, openness indicators used by researchers are poor measures of trade barriers or highly correlated to other sources of bad economic performance. In other cases, the methods used to ascertain the link between open trade policies and growth have serious shortcomings". For these reasons, they conclude that there is little evidence that open trade policies, in the sense of lower tariff and non-tariff barriers, are significantly associated with economic growth.

One of the main problems with these studies is that they do not identify the mechanisms through which openness affects economic growth. In this sense, many authors claim that it is necessary to study this relationship using microeconomic data. This article is a contribution in that sense. We argue that openness may impact positively to growth because it encourages a higher technological innovation. This phenomenon is very relevant in a less developed country since they absorb technological advances generated in the developed world. However, unlike Edwards (1998), we consider that technological absorption is not only restricted to trade of goods, but also to long-run capital flows and direct purchase of foreign licenses.

In order to do that, we use plant level data of several ways of technological innovation and different sources of external absorption. Our main objective is to determine if external sources, like direct foreign investment, exports, and acquisition of foreign technical licenses, contribute to a higher technological innovation in Chilean Manufacturing firms. The case of Chile is very interesting because it has experienced a high growth rate during recent decades. In

addition, it has reduced significantly its trade barriers, and direct foreign investment flows have increased dramatically.

The article is structured as follows. Section 2 shows the data source and the evidence of manufacturing firms' technological innovation. It has been found that there is a positive correlation between innovation and international exposure (exports and foreign direct investment). In Section 3, using a wide group of innovation indicators, we estimate econometrically the impact of export orientation, foreign capital and technical licenses. The results suggest that innovation probability is affected mainly by the exports, and that the other two variables affect a reduced number of indicators of technological innovation. This evidence is robust for alternative definitions of innovation variables and in a wide group of indicators of innovative activity. Nevertheless, the impact of export orientation is not lineal. A higher exporting orientation increases innovation for lower ratios of exports to sales, but to some extent the impact is negative. Firms strongly oriented to international markets have a lower probability of carrying out technological innovation. In Section 4, we discuss causality relationship between exports and innovation. The evidence shows that there is causality in both senses; a higher technological innovation increases the probability of entering to the international markets. Finally, in Section 5, conclusions are presented.

2. Technological Innovation in Chilean Manufacturing Industry

Data used in this article comes from the 1st Survey of Technological Innovation in the Manufacturing Industry, carried out by the National Institute of Statistical (INE) in 1995. The survey contains data for 541 industrial plants and researches on innovative activities. We use two groups of variables. The first group includes information about the intensity of the innovation in five aspects: product innovations, process innovations, packing innovations, innovations on organizational administration and innovations on product design. For each one of these innovation types, the intensity in innovation is measured in a scale of 0 (null) to 4 (very high).

The second group deals with expenditure in technological innovation. The survey asks directly for investment in Research and Development (R&D) carried out by the plants in 1995. Using additional information, the expenditure in foreign technical licenses has been added for the period 1993-1995[1].

In Table 1, a general characterization of the innovative activities is shown for the total sample of firms. In general, it can be inferred that a great percentage of firms declare to have carried out innovations, mainly on products, processes, and organizational administration. In relation to expenditure, most of the companies have invested in R&D (70%), but only about 24% have purchased foreign technique licenses.

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[1] Expenditure in licenses and some other characteristics of these plants (value added, capital, exports, foreign capital, etc.) was obtained from the National Survey in Chilean Manufacturing Industry, carried out by the same institution (INE).

TABLE 1
TECHNOLOGICAL INNOVATION IN MANUFACTURING INDUSTRY
(% of Firms)

Type of Innovation	Innovates	Do not innovate
Innovation on Products	79.3	20.7
Innovation on Productive Process	86.7	13.3
Innovation in Packing	54.3	45.7
Innovation in Organizational Administration	76.2	23.8
Innovation in Design of Products	56.9	43.1
Investment in R&D	70.2	29.8
Acquisition of Foreign Technical Licenses	23.7	76.3

In Table 2, technological innovation by exporting and non-exporting firms is presented. In general, It can be observed that exporters tend to be more innovative than non-exporters. For each one of the five aspects above, the percentage of exporters that have innovated is higher to that of the group that does not export. In relation to expenditure in R&D and technical licenses, we can also infer that exporters carry out more technological innovation than the non-exporters. A higher percentage of exporters declare to carry out investments in technology, either spending directly in R&D or buying foreign technical licenses. In fact, only a 19.5% of non-exporters invest in R&D, on the other hand, in exporters this percentage increases to 58.6%. Similarly, only a 7.2% of non-exporters purchases foreign licenses. This is lower than 25% of exporters that is involved in such activities of technological transfer. In addition, if we take the average of the intensity of innovation, we also have evidence in this sense. Exporters show a more innovative behavior for all the considered aspects (Table 3).

In the case of the comparison of technological innovation between firms that have foreign direct investment (FDI) and those that do not, the results go in the same way. As it is shown in the Table 4, although the percentage of firms that innovates in products and processes is relatively similar between both groups of firms, a higher percentage of firms with FDI innovates in packing, organizational administration and product design. In relation to expenditure in R&D and technical licenses, we also have found significant differences between both groups of firms. Only a 25% and 9% of the firms without FDI invest in R&D and buy technical licenses, respectively. On the other hand, these percentages increase to 57% and 42% respectively in firms with foreign property. Also, for each one of the considered types of innovation the average of intensity is higher in the firms with foreign property (Table 5).

According to these comparisons of the innovative activity between firms more and less exposed to external influences, we can conclude that those more guided toward external markets present a higher technological innovation. A deeper analysis of causality between technological innovation and external sources is presented in the next sections.

TABLE 2
TECHNOLOGICAL INNOVATION BY EXPORTERS AND NON-EXPORTERS
(% of Firms)

Type of Innovation	Non-Exporters	Exporters
Innovation on Products	60.9	84.0
Innovation on Productive Process	67.2	86.4
Innovation in Packing	41.7	51.4
Innovation in Organizational Administration	59.0	74.9
Innovation in Design of Products	42.7	64.3
Investment in R&D	19.5	58.6
Acquisition of Foreign Technical Licenses	7.2	24.9

TABLE 3
TECHNOLOGICAL INNOVATION BY EXPORTERS AND NON-EXPORTERS
(Average Intensity in Innovation)

Type of Innovation	Non-Exporters	Exporters
Innovation on Products	0.80	1.27
Innovation on Productive Process	0.90	1.49
Innovation in Packing	1.01	1.30
Innovation in Organizational Administration	1.61	1.95
Innovation in Design of Products	0.88	1.74

TABLE 4
TECHNOLOGICAL INNOVATION BY FIRMS WITH AND WITHOUT
FOREIGN DIRECT INVESTMENT
(% of Firms)

Type of Innovation	Without FDI	With FDI
Innovation on Products	65.1	68.6
Innovation on Productive Process	70.8	70.2
Innovation in Packing	42.8	57.8
Innovation in Organizational Administration	61.7	67.0
Innovation in Design of Products	46.1	56.5
Investment in R&D	25.2	56.9
Acquisition of Foreign Technical Licenses	8.9	42.2

TABLE 5
TECHNOLOGICAL INNOVATION BY FIRMS WITH AND WITHOUT FOREIGN DIRECT INVESTMENT
(Average Intensity in Innovation)

Type of Innovation	Without FDI	With FDI
Innovation on Products	0.87	1.12
Innovation on Productive Process	0.98	1.62
Innovation in Packing	1.03	1.65
Innovation in Organizational Administration	1.67	1.81
Innovation in Design of Products	1.01	1.63

3. Determinants of Technological Innovation

The relationship between international trade and technological innovation is a topic of theoretical and empirical debate. Grossman and Helpman (1991) suggest several ways through which these variables are related. Nevertheless, their model prediction establishes that the impact of trade on innovation (and growth) depends on the changes in relative prices generated by openness. Although many studies have been made to study the relationship between openness and growth, the evidence continues to be discussed. Rodriguez and Rodrick (1999) revise critically the empirical literature about this topic, and conclude that methodological problems leave the results open to several interpretations and, therefore, there is little evidence suggesting that openness would be associated to a higher economic growth rate.

Many authors have outlined the need to explore this relationship using microeconomic evidence. In this paper, we study the relationship between a wide definition of openness and technological innovation. In this case, openness is considered as a way to absorb foreign knowledge through three main mechanisms. Two are indirect sources; trade in goods and participation of foreign capital in property of the firm, and the other is direct; the purchase of technical licenses.

In general, the studies about the determinants of technological innovation have been focused on the relationship between innovation and market structure, and size of the firms, with relatively little emphasis in the potential impact that absorption of external technologies could have on the innovative activity. There is some evidence about positive relationship between external sources and innovation at firm level in Braga and Willmore (1991) for Brazilian firms. These authors find that the probability of innovating is affected positively by the foreign property and the exporting orientation. Cassiman and Veugeleres (1998) obtain similar results for manufacturing firms in Belgium. Their results indicate that a higher ratio of exports to sales increases the probability of innovating. They argue that competitive pressures in international markets could account for the fact that constant innovation is the only way of maintaining the firms' participation in these markets. A complementary argument is given by Pugel (1978), who states that exports, given that increase the market size, rise the return to innovative activities.

In the case of Chile, due to the scarcity of microeconomic data about technological innovation, the empirical analysis in this sense has been practically none. Recent works have been made with data provided by The Survey about Technological Innovation in Manufacturing Industry carried out in 1995. Two studies in this topic are Herrera and Crespi (1998) and Crespi (1999), who using this survey have found evidence that exporting orientation, measured as the ratio of exports to sales, affects positively and significantly on investment in R&D. In addition to these papers, this contributes in two senses. First, rather than aiming at the determinants of investment in R&D, it focuses in the impact on several indicators of technological innovation. Secondly, the effect of other external sources on innovation is explored. A similar approach to this paper is used in Alvarez y Robertson (2001). They compare the effect of international exposure on technological innovation in Chile and Mexico, and conclude that exports is the most significant external source in both countries.

In this article seven variables of technological innovation are used; innovation on products, innovation on processes, innovation on packing, innovation on organizational administration, innovation on product design , investment in R&D, and purchase of foreign technical licenses.

In the first estimate, we use a Probit model, in which the dependent variables are defined as a dummy variable. It takes the value 1 if the firm innovated technologically in the last years, and 0 if it did not. We define that a firm innovates, if it declares that intensity in innovation is higher than 0. In the same way, we define a dummy variable for R&D and licenses. It takes the value 1 if firms invested in R&D or they bought foreign technical licenses and 0 if they did not.

The others innovation variables, except R&D and licenses, are measured in a scale that takes values between 0 and 4, depending on the intensity that these are carried out by the firm. In order to check the robustness of the first estimates, an ordered Probit model is also estimated.

Among the explanatory variables, we analyze three mechanisms through which the companies can absorb technologies and, in that way, increase their innovative activities. The first two mechanisms are exporting orientation of the firms and the participation of foreign direct investment. In both cases, it is expected that they affect positively technological innovation. Another source of absorption of technologies is the purchase of foreign technical licenses. However, we argue that its impact may be ambiguous depending on the license substitutes or complements to domestic innovation.

Besides these variables, it is controlled by other determinants of the innovation suggested by literature, as the size of the firms, age, investment, labor costs, and property (state or private). The size of firms would affect positively in innovation, because large companies can take more advantage from scale economies associated to the innovative processes. The age would impact negatively; older companies would have lower learning possibilities. A higher investment in machinery could increase innovation through the knowledge incorporated in the capital goods and the adaptive characteristic of the technological process. With regard to the importance of the labor costs, its effect on the innovation would be positive, since very high labor costs could encourage more efforts in innovation to reduce costs. In terms of the property of the companies, it would be expected that private companies are more innovative than the State's.

The descriptive statistic of explicative variables is shown in Table 6. In the sample, exports represent 17.4% of sales. In the case of the foreign investment, the average participation of foreign capitals reaches to 9.8 percent of total capital. In respect to size, about 1/3 of the plants is in the medium size range (between 50 and 200 workers) and almost 50% are large plants (more than 200 workers). The rest, approximately 20% are small plants (less than 50 workers). About 9% are state companies. The average age is around 33 years. Investment in new machinery and labor costs represent 5.5% and 13.5% of sales, respectively. Finally, 20% of plants has purchased foreign technical licenses[2].

The results of the estimates for simple Probit model are shown in Table 7. Regarding the exporting orientation, this was statistically significant for all the analyzed variables, except for purchase of foreign technique licenses. A higher ratio of exports to sales increases the probability of spending in R&D and of carrying out innovations in each type. However, as the parameter of this variable to the square was generally negative and significant, it can be infer that the relationship is not lineal. The probability of innovating increases with certain level of exports, but then it starts to decrease.

Using these estimates, it can be calculated that the probability of innovation is maximized when exports are between 35-60% of sales (Table 8). This evidence suggests that differences in innovative efforts are not only explained by the fact of exporting. In addition, more exports are probably to impact innovation on previous stages of international insertion, and these incentives are lower in firms already strongly oriented to the export markets.

According to estimates, foreign capital is not associated with higher innovation. Firms with FDI are neither more likely to invest in R&D nor to buy foreign licenses. Also, FDI is not associated to more innovation on products, processes and organizational administration. The only positive impact is on the probability of innovating on packing and product design. This evidence is valid for alternative specifications of the variable FDI. The same results are found if a dummy variable is included, or FDI to square is added.

TABLE 6
DESCRIPTIVE STATISTICAL OF EXPLICATIVE VARIABLE

Variable	Description	Mean
Exp	Exports to sales ratio	0.174
Fdi	Foreign capital in total capital	0.098
Size1	1 if 50 < Employment < 200	0.333
Size2	1 if Employment 200	0.488
State	1 if firms is State property	0.087
Age	Operation years	32.97
Inv	Investment in machinery on sales	0.055
Labor	Labor costs on sales	0.135
Licenses	1 if firms bought foreign licenses	0.192

[2] Every variable is measured at the beginning of the period, 1993.

TABLE 7
DETERMINANTS OF TECHNOLOGICAL INNOVATION:
PROBIT MODEL

Variable	R&D	Licenses	Innovation Products	Innovation Process	Innovation Administ	Innovation Packing	Innovation Design
Exp	1.32* (2.02)	0.485 (0.34)	3.339* (2.88)	2.487* (2.16)	1.604* (2.63)	1.816* (2.28)	1.702* (2.51)
Exp2	–0.92 (–1.49)	–0.086 (–0.54)	–3.397* (–2.71)	–2.133** (–1.71)	–1.857* (–2.73)	–2.016 (–2.34)	–2.434* (–3.16)
Fdi	0.176 (1.20)	0.021 (0.60)	0.089 (0.59)	0.013 (0.08)	0.263 (1.57)	0.308** (1.95)	0.383* (2.54)
Size1	0.328* (3.08)	0.122* (3.22)	0.312* (2.29)	0.291* (2.23)	0.307* (1.98)	0.262** (1.67)	0.398* (2.76)
Size2	0.320* (2.80)	0.154* (2.77)	0.317* (3.49)	0.247 (2.70)	0.284* (2.08)	0.331* (2.89)	0.483* (4.14)
State	0.106 (0.57)	–	–0.482 (–2.13)*	–0.055 (–0.21)	–0.003 (–0.02)	–0.099 (–0.49)	0.139 (0.54)
Age	0.001 (0.69)	0.0006 (1.57)	0.002 (0.59)	0.002 (0.69)	–0.0001 (–0.03)	0.004 (1.08)	0.003 (1.20)
Inv	0.289 (0.47)	–0.072 (–0.64)	–0.076 (–1.13)	0.196 (0.17)	–0.303 (–0.53)	–0.378 (–0.68)	0.115 (0.21)
Labor	–0.351 (–1.01)	–0.117 (–1.43)	0.784 (1.52)	0.771 (1.48)	1.270* (2.00)	1.021** (1.87)	1.135* (2.16)
Licenses	0.285** (1.94)	0.593* (5.91)	–0.136 (–1.06)	0.144 (0.95)	0.267** (1.92)	–0.129 (–0.98)	0.027 (0.23)
N	437	426	437	437	437	433	437
Pseudo R2	0.29	0.43	0.25	0.27	0.19	0.18	0.27

Robust z-statistics in parentheses.
*Significant at 5%; ** significant at 10%.
Dummies by sector no reported.

TABLE 8
PROBABILITY OF INNOVATING AND EXPORTS

Type of Innovation	Exports to sales ratio (%)
Innovation on Products	49.1
Innovation on Productive Process	58.3
Innovation in Packing	43.2
Innovation in Organizational Administration	45.0
Innovation in Design of Products	35.0

In the case of technical licenses, the results show that it would affect the quantitative variables of innovation. In these two variables, investment in R&D and purchase of licenses, probability of innovation is affected positively by the fact that the firm had previously purchased technical licenses. According to this evidence, there would be a "virtuous circle" in this sense: it is more likely that a firm continues investing in R&D and purchasing licenses in time if it has bought licenses in recent years. In the rest of innovation indicators, the results indicate that licenses affect a reduced number of technological innovation ways. Specifically, licenses have a positive and significant impact on innovation on organizational administration, but it is not relevant for the rest of the indicators.

For the rest of explicative variables, the only relevant impact is that associated to the size of companies. This is positive and significant in all the estimates and is in accordance to the evidence in similar studies; large companies innovate more than small ones.

Since the definition of the innovation variables used in the previous estimate can seem arbitrary, we proceeded to analyze if the results were robust to alternative definitions. Using five indicators of innovation, we estimated an ordered model Probit. The results are shown in Table 9.

In general, it can be concluded that the previous evidence is robust to the definition of the innovation variables. It is confirmed that the exporting orientation of the firms affects positively to every innovation indicator, and that this relationship is of a U-inverted kind. The other mechanisms of technological absorption, direct foreign investment and licenses, affect a reduced number of innovative activities.

4. The Problem of Causality between Exports and Innovation

Evidence in the last section states that controlling for some characteristics of the firms, the ratio of exports to sales affect positively to technological innovation. However, the causality relationship could be in the other sense. If technological innovation increases productivity and competitiveness of the firms, it could be a way of improving exporting performance. Some articles, like Nassimbeni (2001), have found that the propensity to export of a firm is linked to its ability to innovate.

TABLE 9
DETERMINANTS OF TECHNOLOGICAL INNOVATION:
ORDERED PROBIT MODEL

Variable	Innovation Products	Innovation Process	Innovation Administ	Innovation Packing	Innovation Design
Exp	3.949* (2.60)	2.487* (2.16)	1.604* (2.63)	1.816* (2.28)	1.702* (2.51)
Exp2	–3.638* (–2.71)	–2.133** (–1.71)	–1.857* (–2.73)	–2.016* (–2.34)	–2.434* (–3.16)
Fdi	0.389 (1.35)	0.013 (0.08)	0.263 (1.57)	0.308** (1.95)	0.383* (2.54)
Size1	0.964* (3.17)	0.291* (2.23)	0.307* (1.98)	0.262** (1.67)	0.398* (2.76)
Size2	1.125* (3.87)	0.247 (2.70)	0.284* (2.08)*	0.331 (2.89)	0.483* (4.14)
State	–0.482 (–2.13)*	–0.055 (–0.21)	–0.003 (–0.02)	–0.099 (–0.49)	0.139 (0.54)
Age	0.002 (0.59)	0.002 (0.69)	–0.0001 (–0.03)	0.004 (1.08)	0.003 (1.20)
Inv	–0.076 (–1.13)	0.196 (0.17)	–0.303 (–0.53)	–0.378 (–0.68)	0.115 (0.21)
Labor	0.784 (1.52)	0.771 (1.48)	1.270* (2.00)	1.021** (1.87)	1.135* (2.16)
Licenses	–0.136 (–1.06)	0.144 (0.95)	0.267** (1.92)	–0.129 (–0.98)	0.027 (0.23)
N	437	437	437	433	437
Pseudo R2	0.25	0.27	0.19	0.18	0.27

Robust z-statistics in parentheses.
*Significant at 5%; ** significant at 10%.
Dummies by sector no reported.

To analyze the impact of technological innovation on exports, we follow Roberts and Tybout (1997) and Bernard and Jensen (1999), and estimate a model that explains the probability of exporting. The dependent variable, a dummy that defines exporter status (1 = if the firm exports, and 0 = if not), is measured at the end of the period, 1995. In order to controlling for potential simultaneity between exporter status and these variables, the explicative variables are measured at the beginning of the period.

All innovation variables are defined as a dummy; 1 if firms have innovated, 0 if not. The other explanatory variables included in the model are:

(i) A dummy variable if the firm has or has not participation of foreign capital (Fdi)

(ii) The intensity in human capital, measured as a ratio of qualified to non qualified labor (human capital)

(iii) The size of the firm, using total employment (Employment)

(iv) The labor productivity, measured as value added by worker (productivity)

(v) A dummy if the firm exported one year ago (export_1)

(vi) (vi) a dummy, if it exported two years ago (export_2).

The estimate results, shown in Table 10, let infer that none of the technological innovations has a significant influence on the probability of exporting, an exception is the positive impact of purchase of foreign technical licenses in the first specification. However, this parameter is not significant if we add other control variables. The most important explicative variable is the export status in previous years. According to estimates, if a firm has exported in the last year, the probability of exporting increases about 60-70%. Exports in recent two years increases this probability about 40-50%.

In Table 11, we show two additional estimations for probability of exporting. The objective is to check if this evidence is robust to alternative definitions of innovation. We calculate two measurements of technological innovation. The first one is *innova*, defined as 1, if a firm innovates in every type of innovation, 0 if not. The second one is *innova1*, defined as 1, if intensity is higher than 2 in every type of innovation, 0 if not. The results of these estimates are mixed. In the estimate using variable *innova*, we do not find evidence that innovation affects significantly the probability of exporting. In the case of *innova1*, which identifies firms that make higher efforts in technological innovation, its effect is positive and significant.

In summary, we find some evidence that technological innovation may affect the export status. However, this positive impact is only received by firms that are very intensive in technological innovation.

TABLE 10
DETERMINANTS OF PROBABILITY OF EXPORTING

Variable	(1)	(2)	(3)
Innovation on Products	0.12 (0.89)	–0.01 (–0.11)	–0.01 (–0.09)
Innovation on Productive Process	–0.06 (–0.35)	–0.18 (–0.93)	–0.19 (–1.12)
Innovation in Packing	–0.10 (–1.07)	–0.10 (–1.61)	–0.10 (–1.64)
Innovation in Organizational Administration	0.01 (–0.07)	0.06 (0.63)	0.04 (0.43)
Innovation in design of products	0.13 (1.35)	0.08 (0.71)	0.09 (0.82)
Licenses	0.37* (2.56)	–0.01 (–0.19)	–0.04 (–0.57)
Export_1	–	0.70* (4.62)	0.63* (4.11)
Export_2	–	0.49* (2.98)	0.43* (2.57)
Fdi	–	–	–0.08 (–1.27)
Human capital	–	–	0.01 (0.36)
Employment	–	–	0.05 (1.44)
Productivity	–	–	0.04 (1.42)
N	541	541	532
Pseudo R2	0.12	0.63	0.63

Robust z-statistics in parentheses.
*Significant at 5%; ** significant at 10%.
Dummies by sector no reported.

TABLE 11
DETERMINANTS OF PROBABILITY OF EXPORTING

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Innova	–0.07 (–0.11)	–0.08 (–1.16)	–0.09 (–1.18)	–	–	–
Innova1				0.70* (5.69)	0.50* (2.56)	0.38** (1.71)
Licenses	0.37* (2.96)	–0.01 (–0.20)	–0.04 (–0.45)	0.37* (2.91)	–0.02 (–0.21)	–0.05 (–0.77)
Export_1	–	0.72* (4.80)	0.68* (4.43)	–	0.74* (4.95)	0.70* (4.59)
Export_2	–	0.44* (2.86)	0.43* (2.53)	–	0.38* (2.43)	0.36* (2.22)
Fdi	–	–	–0.09 (–1.07)	–	–	–0.09 (–1.12)
Human capital	–	–	0.02 (0.36)	–	–	0.02 (0.33)
Employment	–	–	0.04 (0.93)	–	–	0.03 (0.62)
Productivity	–	–	0.03 (0.69)	–	–	0.05 (1.11)
N	541	541	529	541	541	529
Pseudo R2	0.08	0.62	0.61	0.12	0.62	0.60

Robust z-statistics in parentheses.
*Significant at 5%; ** significant at 10%.
Dummies by sector no reported.

5. Conclusions

During recent decades Chilean economy has experienced a high rate of economic growth. Also it has significantly increased the trade exchange with the rest of the world and facilitated the entrance of direct foreign investment. Several arguments in literature state that there would be a positive impact on productivity growth from this higher insertion in international markets. One of them is the absorption of new technologies from developed countries.

In this article the impact of three mechanisms of technological absorption has been explored; exports, direct foreign investment and purchase of foreign technical licenses. The empirical evidence of this paper suggests that innovation is affected mainly by exports, and that the other two variables of external absorption affect a reduced number of indicators of technological innovation. This evidence is robust to alternative definitions of innovation variables and a wide group of indicators of innovative activity. However, the impact of export orientation is not lineal. For a lower ratio of exports to sales, a higher export orientation increases innovation, but to some extent the impact is negative. Firms strongly oriented to international markets have a lower probability of carrying out technological innovation.

A second important aspect that has been analyzed is the causality relationship between exports and technological innovation. There is evidence that probability for exporting is not associated to low level of innovation. However, very innovative firms have a higher probability of entering to international markets.

This evidence is consistent with some studies on exporting performance in other economies. In those papers, it is found that productivity growth precede the entrance to international markets. In the case of Chilean industry, it seems to be a similar phenomenon, a high intensity in technological innovation is required to export. But the evidence suggests a kind of virtuous circle, since the exports are an important incentive to innovate.

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