**Innovation-exports behavior at firm-level in developing countries: How this causal relationship changes in acquisition of knowledge or R&D?**

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**Abstract**

With micro-level data from a developing country (Chile), I use an econometric causality test (Granger) to study the relationship between the innovation effort and the exports propensity, distinguishing between knowledge acquisition and R&D expenditures. The results show a difference in the causal direction between innovation and exports according to the type of innovation engaged, where the acquisition of knowledge shows a mutual reinforcement (reciprocal causality); rather than R&D expenditure, where causality is found from exports towards innovation (Learning-by-Exporting) and not in the opposite direction. Both, the former idea and the results, are important given that the main source of technological progress in developing countries is related to technological adoption from developed countries, rather that in-house R&D as in developed countries firms. My results show the relevance of the export information mechanism of foreign knowledge, given that it encourages both knowledge acquisition and R&D. This finding shows that the local markets in developing countries—including a medium size and open-to-international-market such as Chile—are still farm reaching from the technological frontier.

**Keywords:** Exports, Innovation, Learning-by-Exporting, Self-Selection, Mutual Reinforcement, Granger Causality Test, Developing Countries.

# Introduction

The availability of new firm-level detailed data encourages a great amount of research, which studies innovation, exports and firm performance. The main findings are consistent with the idea of a positive relationship between exports, productivity and innovation (Bernard & Jensen, 1999); (Crepón, Duguet, & Mairesse, 1998) and (López Rodríguez & García Rodríguez, 2005)]. Related to innovation activities, while some firms engaged in R&D projects to achieve new technology creation (mainly firms from developed countries), most of them merely imitate or adapt existing production techniques to local conditions (Evenson & Westphal, 1995); (UNCTAD, 1999). This idea is particularly important in developing countries; the main source of technological progress is related to technological adoption from developed economies, rather that in-house R&D in developing countries (Hoekman, Maskus, & Saggi, 2004); (UNCTAD, 2004).

Additionally, the innovation concept has gone far away from the R&D activities in the traditional sense, which imply that not every innovation has a technological source. The last (third) edition of the Oslo Manual (OCDE & Eurostat, 2005) defines innovation as the implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations, where only the first two concepts are related to technological innovations. To be categorized as an innovation, the minimum requirement is that the innovative product, process, marketing method or organizational method must be new (or significantly improved) to the firm.

The acquisition and adaptation of knowledge for catching-up the technology frontier have turned into important factors on economic development, and those factors are the common denominator for successful strategies of development, which were applied to several countries like the Republic of Korea, Finland, Ireland, Singapore, Taiwan, and recently, China and India. This is the main reason why developing countries started looking for strategies to facilitate local firms adapting the knowledge and technology originated in developed countries as their main development strategy (Inter-American Development Bank, 2010). Furthermore, the need to study innovation in a broad definition, and not just restricted to R&D activities, but doing the distinction between knowledge acquisition and R&D, is especially important for developing countries.

How does the innovation-exports causal behaviour in developing countries change when considering R&D or acquisition of knowledge? In order to answer this question, Chile is an interesting, small developing country to study. The country experienced a very successful transformation in the last thirty years, many substantial economic reforms were implemented. For example, measures aimed for boosting competition and becoming open to the global economy. Despite the higher openness, investment in technological innovation in Chile remains small relative to more developed countries. Furthermore, it could be interesting to study other instance of innovations, rather than R&D, as I propose here. And Chile, despite its openness to knowledge from global market, did not have raised R&D innovations.

This paper aims to provide evidence, for developing countries, of the causal relationship between the innovation effort and the export propensity, distinguishing between knowledge acquisition and R&D expenditures. We can see this as a contribution regarding previous papers in two main aspects.

First, there are only a few studies that focus on the firm-level export-innovation relationship in developing countries, and those few studies only take into account R&D expenditure as innovation and they do not consider acquisition of knowledge (Benavente, Ortega-Bravo, & González, 2013); (Álvarez, García, & García, 2008); (Şeker, 2012); (Alvarez & Robertson, 2004) and (Almeida & Fernandes, 2007). In that sense, my paper studies interesting aspects for mainly low-tech firms from developing countries. Firms from developing countries innovate, but not in a sophisticated-disruptive way like those firms from developed economies. They do not have large R&D departments and laboratories; rather, they adapt external knowledge and technology in the form of patents, license, and new machinery for innovation. They perform little improvements to their products in order to achieve new market requirements; they change the shape of their products and not their technical specifications. Furthermore, developing countries firms’ innovations are mainly related to other innovation activities, like acquisition of knowledge, rather than R&D (Hoekman, Maskus, & Saggi, 2004); (UNCTAD, 2004).

Secondly, there is no literature that studies innovation-export causal relationship considering both R&D and acquisition of knowledge separately. On one hand, there is a considerable amount of literature—mainly in developed countries—that study the effects of innovation on firms’ exporting behavior (Barrios, Görg, & Eric, 2003); (Cho & Pucik, 2005); (Díaz-Díaz, Aguiar, & De Saá-Pérez, 2008); (Kyläheiko, Jantunen, & Puumalainen, 2011); (Vila & Kuster, 2007); (Basile, 2001); (Cassiman & Golovko, 2010) and (Wakelin, 1998). However, on the other hand, some literature has examined the reverse relationship—namely, the effect of exports on firms’ technological resources and innovation (Golovko & Valentini, 2011); (Hitt, Hoskisson, & Hicheon, 1997). Internationalized firms are able to maintain their international competitiveness by acquiring more experience and technological knowledge in foreign markets (Zahra, Ireland, & Hitt, 2000). These papers examine only a single causal direction of innovation-export relationship (Cho & Pucik, 2005); (Damijan, Kostevc, & Polanec, 2010); (Kyläheiko, Jantunen, & Puumalainen, 2011), and have not considered the double relationship (Kumar & Saqib, 1996); (Salomon & Shaver, 2005); (Zahra, Ireland, & Hitt, 2000). There are a few notable expectations (Filatotchev & Piesse, 2009); (Golovko & Valentini, 2011); (Monreal-Pérez, Aragón-Sánchez, & Sánchez-Marín, 2012), which jointly examine innovations and exports without defining the causality relation previously. Their study complements that of (Filatotchev & Piesse, 2009) by examining the joint effect of innovation and exports over small and medium-sized enterprises’ growth.

(Filipescu, Prashantham, Rialp, & Rialp, 2013) Filipescu et.al. (2015) studies the double causal effect between a firm’s export and innovation activities, which has been overlooked insofar as they have typically been related to one another unidirectionaly (Pla-Barber & Alegre, 2007); (Vila & Kuster, 2007).

None of these study the relationship between the innovation effort and the exports propensity in developing countries, considering how this causal relationship change under technological adoption or R&D expenditures.

# Literature review

Endogenous growth models give a central role to technological change (Grossman & Helpman, 1991), where entrepreneurs generate ideas related with R&D (innovations) in order to achieve profit from monopoly power. In that sense, growth is sustained through the development of new products, expanding the capital knowledge and lowering innovation cost. Although this is how innovation activities occur in firms from developed countries, this is not accurate in developing countries.

Firms from developing countries innovate, but not in a sophisticated-disruptive way like those firms from developed economies. They do not have large R&D departments and laboratories; rather, they adapt external knowledge and technology in the form of patents, license, and new machinery for innovation. They performs little improvements to their products in order to achieve new market requirements; they change the shape of their products and not their technical specifications. Furthermore, developing countries firms’ innovations are mainly related to other innovation activities, like acquisition of knowledge, rather than R&D (Hoekman, Maskus, & Saggi, 2004); (UNCTAD, 2004).

New disruptive products, achieved by R&D activities and produced in developed countries, transmit their embodied knowledge through international trade to other countries, frequently in developing countries. That knowledge is acquired and management uses this knowledge to produce innovations.

This paper aims to provide evidence, for developing countries, of the causal relationship between the innovation effort and the export propensity, distinguishing between knowledge acquisition and R&D expenditures.

## Innovation

Originally, researchers defined innovation as a creative destruction process at firm level (Schumpeter, 1942). Later, under what we can name as an applied idea approach, Urabe (1988) defines innovation as the generation of a new idea and its implementation in productive activities (Urabe, 1998). In that sense, Urabe’s definition leaves innovation covering a wide range of activities. In contrast, Afuah (1998) defines innovation as a new knowledge incorporated into productive activities. Afurah’s point of view focuses on the importance of knowledge, rather than just the idea, in innovation activities (Afuah, 1998). In fact, a great number of researchers has considered knowledge as the origins of innovation (e.g. (Alegre & Chiva, 2008); (Nonaka & Takeuchi, 1995), focusing the innovation activity as a learning process that aims to pursue new and improved methods of production. Innovation seems to depend on the company’s capability to learn, and through these companies, new knowledge is created, spread and used.

The Oslo Manual (OCDE & Eurostat, 2005) identifies four widely accepted types of innovation: product, process, marketing and organizational innovation. Product innovation is defined as ‘the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses’; process innovation as ‘the implementation of a new or significantly improved production or delivery method’; marketing innovation as ‘the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing’; and organizational innovation as ‘the implementation of a new organizational method in the firm’s business practices, workplace organization or external relations’. These four types of innovation could have different degrees of novelty, and therefore could be incremental or radical, that is, based on exploitative or explorative learning (Jansen, Van Den Bosch, & Volberda, 2006). Pavitt (1991) describes radical innovations as revolutionary or discontinuous changes, while incremental innovations are conventional or simple extensions in a line of historical improvements (Pavitt, What makes basic research economically useful?, 1991). Most literature (e.g. Dewar and Dutton, 1986) considers that technology is essential in radical innovations. Dewar and Dutton (1986) believe that radical innovations are fundamental changes that represent revolutionary changes in technology (Dewar & Dutton, 1986). However, Verganti (2008) introduced *meaning* as another dimension aside from technology (Verganti, Design, meanings and radical innovation: a meta-model and a research agenda, 2008). He argues that some innovations might represent a fundamental change in meaning, rather than in technology. These are radical design-driven innovations, which are radical innovations of a product’s meaning. Radical design-driven innovation is defined by Verganti (2003) as an innovation where novelty of meaning and design language is significant and prevalent compared with novelty of functionality and technology (Verganti, Design as brokering of languages: the role of designers in the innovation strategy of Italian firms, 2003).

## Innovation in developing countries

In developing countries, the main source of technological progress is related to technological adoption from developed economies, rather that in-house R&D (Hoekman, Maskus, & Saggi, 2004); (UNCTAD, 2004). Firms in these economies carry out innovation activities mainly by technology acquisition, adapting existing methods to local circumstances (Evenson & Westphal, 1995). This is the mechanism of knowledge diffusion which enable developing economies to catch-up the technology frontier (Grossman & Helpman, 1991) and (Aghion & Howitt, 1998).

Diffusion of knowledge is facilitated by an open trade structure (Saggi, 2002). International Technology Transfer ITT occurs through three main channels: trade in goods and services, foreign direct investment, and direct trade in knowledge via technology licensing (Hoekman, Maskus, & Saggi, 2004). In a firm-level approach, openness can affect productivity by inducing production of new ideas and products, accelerating the adoption of existing technologies, and prompting reorganization due to market effects, such as increased competition (Alvarez & Robertson, 2004).

But openness is not sufficient; there needs to be absorptive capacity and ability to adapt foreign technology, both of which are related to human capital endowments. The further the ‘technological distance’ of a country from the global frontier, the more difficult it is to absorb information effectively into production systems (Keller, 2002). Countries tend to acquire international technology more readily if domestic firms have local R&D programs, there are domestic private and public research laboratories and universities, and there exists a sound basis of technical skills and human capital. All this reduces the costs of imitation, adaptation, and follow-on innovation.

Barriers to technology adoption are a key determinant of international differences in per capita income (Parente & Prescott, 1994). Increased trade openness can increase growth by lowering these barriers. Trade can contribute to ITT by allowing reverse engineering by local firms and by granting firms access to new machinery and equipment.

## Chile: An opened and developing country

Chile is an interesting and small developing country for studying the innovation and exports relationship. The country experienced a very successful transformation in the last thirty years by implementing substantial economic reforms such as boosting competition and entering the global economy. As a consequence, the economic results have been impressive. Chile has been the only middle size country in Latin America that reduced its per capita income gap relative to advanced economies in the past thirty years (Corbo & Gonzalez, 2014).

For instance, Chile augmented trade liberalization with reduced restrictions to capital influctions, especially to foreign direct investment. Both trade and capital liberalization have contributed greatly to increasing the volume of total trade and capital inflows (Alvarez & Robertson, 2004).

Foreign investment has increased significantly since the mid 1980s. Between 1978 and 1985 direct foreign investment represented approximately 1 percent of GDP, growing to 2.3 percent in 1986 and reaching 8.5 percent in 1989. The ratio of foreign investment to GDP decreased to 3–4 percent at the beginning of the 1990s, but then increased to 8 percent by the end of the decade.

Despite the higher openness, investment in technological innovation in Chile remains small relative to more developed countries. The total expenditure in R&D reaches nearly 0.65 percent of GDP in Chile. When separating expenditure financed by private and public sector, the evidence indicates that the private sector finances less than 16 percent. The government finances nearly all of the remainder. In contrast, more than 50 per cent of investment in R&D in developed countries is made by private sector.

Furthermore, it could be interesting to study other instances of innovations, rather than R&D, as my paper proposes.

## Effects of innovation on firms’ exporting behavior

There is empirical evidence that exporting companies are bigger, more productive, more capital-intensive, posess greater human capital, pay higher wages and invest more on technology (for instance acquisition of knowledge) and R&D (Bernard & Jensen, 1999). My focus is the innovation-export causal relatioship in developing countries, distinguishing between technology acquisition and R&D expenditures.

Bernard and Jensen (1999) and Wagner J. (2008) argue that firms that have access to global markets must have previously improved their performance, particularly their productivity (Bernard & Jensen, 1999) and (Wagner J. , 2008). Firms with better performance in terms of their productivity may access and continue participating in global markets. This hypothesis, which states that only firms with certain characteristics will access export activities, is called self-selection and may be linked to certain entrance expenses (such as those regarding transportation, distribution, skilled personnel to handle the international network, information asymmetries regarding quality, etc.), expenses that would only allow firms that have innovated and increased their productivity to have access to the competitive export markets.

Innovation can serve as a source of sustainable competitive advantage both domestically and abroad (Filipescu, Rialp, & Rialp, 2009); (Pla-Barber & Alegre, 2007). The development of a certain innovative capacity may indeed facilitate a firm’s export engagement and subsequent export growth. In general, the literature reports a positive relationship between firm technological innovation and internationalization (Bianchi, 2009); (Filipescu, Rialp, & Rialp, 2009); (López Rodríguez & García Rodríguez, 2005). There are, however, some controversial findings regarding this expected positive relationship (Lefebvre, Lefebvre, & Bourgault, 1998); (Vila & Kuster, 2007).

In the context of export behavior research in particular, empirical studies widely support the idea that innovation induces firms to increase exports, with technological resources having a positive and significant effect on firms’ export activities (Basile, 2001); (Cho & Pucik, 2005). The early consensus in the literature indicates that innovation acts as an important driver for exports, thus suggesting that the direction of causality runs from undertaking innovation activities to exports (Harris & Li, 2009). In this sense, international markets may represent an area in which firms can exploit their innovations and thereby enhance their economic performance (Filipescu, Rialp, & Rialp, 2009); (Hortinha, Lages, & Lages, 2011); (Love & Mansury, 2009). Accordingly, innovative firms will have a greater tendency to enter foreign markets to increase sales volume and spread the fixed costs of innovation over a larger number of markets (Pla-Barber & Alegre, 2007); (Zahra, Ireland, & Hitt, 2000). Investments in technological resources enhance organizational knowledge and learning capabilities, which in turn, are important antecedent factors of a firm’s capability to develop cost-/differentiation-based international competitive advantages and, consequently, pursue international expansion by engaging in exporting and/or increasing its activities in foreign markets (Eriksson, Johanson, Majkgard, & Sharma, 1997); (Filatotchev & Piesse, 2009); (López Rodríguez & García Rodríguez, 2005). Thus, innovative firms have strong incentives to subsequently expand their activities into markets beyond their domestic ones to earn higher returns from their technological investments (Bianchi, 2009).

Furthermore, some authors identify R&D intensity as an important determinant of firms’ exports (Barrios, Görg, & Eric, 2003) because firms with a technological, R&D-based advantage can expand into new oversea markets at little or no marginal cost over the cost of developing this advantage in the domestic market (Davis & Harveston, 2000). In addition, as exporting expands the potential customer base, investments performed in activities whose costs are largely fixed (e.g., R&D) may be recovered through greater sales volume (Love & Mansury, 2009). However, Lefebvre, Lefebvre, and Bourgault (1998) do not find a significant influence of R&D expenditures on firms’ export intensity (Lefebvre, Lefebvre, & Bourgault, 1998).

Product and process innovations (outputs) may also have a positive effect on a firm’s exports, as well as R&D intensity (input). Technological innovations, in the form of either product or process innovations, also generate competitive advantages based on cost and/or differentiation, which provide the firm with a greater competitive capacity at home and also opportunities in foreign markets (Eriksson, Johanson, Majkgard, & Sharma, 1997); (López Rodríguez & García Rodríguez, 2005). Ganotakis and Love (2011) argue that the ability to compete in international markets is ultimately influenced by the firm’s capacity to successfully market new and improved products that attract foreign customers, rather than merely being based on its R&D investments (Ganotakis & Love, 2011). This holds especially true for small and medium-sized enterprises, whose formal R&D measures heavily underreport research activity and degree of innovativeness (Kleinknecht, 1987). In a similar sense, a firm’s international presence and export success, usually measured in terms of export intensity, depends on distinct strategic factors linked to superior new product development and/or process innovations (Eriksson, Johanson, Majkgard, & Sharma, 1997); (Pla-Barber & Alegre, 2007).

## Effects of exports on firms’ innovation behavior

Under firms’ growth process, sooner or later a firm will have to deal with internationalization. In particular, for developing smaller countries with small markets. The literature argues that there are significant differences between domestic growth and internationalization (Buckley, 1993; Buckley and Casson, 1998). Exporting firms could take advantage of the diverse knowledge by being internationally exposed to a richer source of knowledge often not available in their home markets and take advantage of new market opportunities through rapid new product developments (Salomon & Shaver, 2005). This hypothesis is called Learning-by-Exporting. Greenaway and Kneller (2007) approach to Learning-by-Exporting by defining at least three causality mechanisms (Greenaway & Kneller, 2007):

1. The knowledge and technology that firms absorb in international markets, which non-exporting companies do not have access to, will increase exporting firms’ performance and, consequently, their productivity.
2. Exporting firms have access to a global market that is bigger than the local market, and so their production will benefit from economies of scale.
3. Firms participating in global markets are subject to a greater competition level, which will force them to invest in innovation in order to reach greater efficiency levels.

De Loecker (2007) finds evidence of a positive effect on new entrants’ productivity after they have begun their exporting activities. Through a data sample from Slovenia, he also concludes that the destination of exports is an important factor in determining learning-by-exporting (De Loecker, 2007).

Several studies analyze the relevance of innovation at the firm level and found that the development of abilities to innovate, which are endogenous to firms, is one of the main incentives that allow firms to export (Leonidou, Katsikeas, Palihawadana, & Spyropoulou, 2007). Most of these studies suggest that innovation positively affects the development of exports by showing that innovation can set a firm apart and therefore constitute a source of competitive advantages in international markets (López Rodríguez & García Rodríguez, 2005), due to the fact that innovation acts as a source of competitive advantages that are hard to imitate. A firm’s ability to innovate represents a combination of the organization’s resources that have been developed throughout the firm’s existence. To imitate innovations is difficult, given that competitors may not possess the necessary resources to exploit these abilities (Miller & Shamsie, 1996). In turn, firms that have developed a certain innovation will have incentives to exploit said innovation in larger markets to improve their economic performance (Pla-Barber & Alegre, 2007). Furthermore, previous studies argued that the high competition level in global markets forces firms to constantly update their products and adapt to these markets’ new conditions. Salomon and Shaver (2005) studied Spanish firms and found that gained knowledge from international markets allows firms to register an even higher amount of patents and to develop more innovative products in general. The authors emphasize the importance of studying how long it takes for Learning-by-Exporting to have an effect, given that this effect may not be immediate. They find that Learning-by-Exporting first affects product innovation two years after the firm has begun exporting and that the amount of patent filings increases with a much greater lag (Salomon & Shaver, 2005). On the other hand, Silva and Leitão (2007), in a study conducted about Portuguese manufacturing firms, come to the conclusion that firms with higher export levels are less able to innovate. The authors argue that most companies with high export intensity outsource services and adopt a low-price strategy, which does not correspond with product innovation (Silva & Leitão, 2007).

A more recent study conducted by Filipescu et al. (2013) investigates how innovation (R&D intensity, product and process innovation) on the one hand and exports (breadth and depth) on the other hand can mutually influence each other (Filipescu, Prashantham, Rialp, & Rialp, 2013). The causality between both effects is examined by means of a panel of 696 Spanish manufacturing firms during the 1994-2005 period. There is evidence of a reciprocal relationship between technological innovation and exports (mutual causality). In turn, the authors find positive, but not significant, connections between product innovation and exports, as well as between export depth and process innovation. The authors argue that these results are consistent with most existing international studies on this topic. This relationship of reciprocal causality could be centered on the relevance of resources and learning based on the development and use of intangible resources. As companies develop export activities, they gain knowledge and abilities that help them develop new technological innovations, which in turn allow exporting firms to increase their export intensity and diversify the global markets in which they participate (Filipescu, Prashantham, Rialp, & Rialp, 2013).

## Exports-innovation relationship in developing countries

There is an overwhelming amount of evidence that study R&D and exports relationship in developed countries. (Ito & Pucik, 1993) check that R&D expenditures that cause export in Japan (Lefebvre, Lefebvre, & Bourgault, 1998) do the same for Canada; (Becchetti & Rossi, 2000) argues the similar for Italy; (Smith, Strojer Madsen , & Dilling-Hansen, 2002) do the same in Denmark; (Cassiman, Golovko, & Martínez-Ros, 2010) in Spain; (Lachenmaier & Wöbmann, 2006) and (Arnold & Hussinger, 2005) study data for Germany; (Girma, Görg, & Hanley, 2008) in UK. Also, there is lots of studies that check the hypothesis of exports causing R&D, (Salomon & Shaver, 2005) for the case of Spain; (Aw, Roberts, & Winston, 2005) in Taiwan and (Girma, Görg, & Hanley, 2008) in the UK.

In contrast, research in developing countries that study exports-innovation relationships on a firm-level is hard to find, in particular, those which whose main focus is studying the causal relationship. Papers that study this topic can be grouped by those that study innovation-exports relationship (and measured innovation by R&D expenditures), and those who considered the relevance of openness as a channel of international technology transfer (IIT) from developed to developing countries. In the first group, Alvarez et al. (using firm-level data from Chile) studies the relationship between exports, productivity and technological productivity. Using R&D measures, authors find evidence of causality from innovation to exports (Álvarez, García, & García, 2008). Benavente et al. study the relationship between R&D expenditure, exports and productivity in Chile. Findings are companies that invest in R&D are considerably more prone to export, but exporting activities do not encourage R&D investment (Benavente, Ortega-Bravo, & González, 2013).

There has been some efforts to study how oppeness afects local firms performance in developing countries. Literature identifies three mechanisms that potentially link openness and firms performance: selling to export markets that demand higher technology (Gereffi, 1999), foreign direct investment (Aitken and Harrison, 1999; Feenstra and Hanson, 1997), and trade in intermediate inputs (Keller, 2002).

Alvarez & Robertson (2004) study the relationship between exposure to foreign markets and specific innovations (product design, investment in technology, and innovation in products and processes) and also research and development. Using firm-level data from México and Chile, their results suggest that exposure to foreign markets is positively related to most types of those innovations (Alvarez & Robertson, 2004). Şeker (2012) use a detailed firm-level dataset from 43 developing countries, showing that there are persistent differences in firm evolution related with their trade orientation as: two-way traders (both importing and exporting), only exporters, only importers, and non-traders. His main results show that globally engaged firms are larger, more productive, and grow faster than non-traders; and two-way traders are the fastest growing (Şeker, 2012). Finally, Almeida & Fernandes (2007) examines international technology transfers using firm-level data across 43 developing countries. Their findings show that exporting and importing activities are important channels for the transfer of technology (Almeida & Fernandes, 2007). Using aggregate data, Iscan (1998) finds a positive relationship between trade liberalization and productivity growth in Mexico (Iscan, 1998). Tybout et al. (1991) do not find large technical improvements in Chile after liberalization (Tybout, de Melo, & Corbo, 1991). Clerides et al. (1998) use firm-level data from Colombia, Mexico, and Morocco and find that more productive firms enter the export market in Colombia and Morocco but do not make similar conclusions for Mexico (Clerides, Lach, & Tybout, 1998).

None of these studies considered expenditures on acquisition of knowledge as a measure of innovation. Which is a more informative measure of innovative activities for developing countries, given the importance of technology acquisition in developing economies.

# Data and descriptive statistics

I used the data source Technological Innovation Survey (EIT, for its acronym in Spanish) conducted by the National Statistics Institute of Chile (INE, for its acronym in Spanish) to study innovative activities in Chile at the firm-level. EIT Survey covers more than 6.300 firm-level observations with data from 1995 until 2012.[[2]](#footnote-2) Given that public authorities carry out the survey—; therefore, secure a high level of participation—and the quality of the information collected—given that INE accomplish the survey— ensure the suitable of EIT for this research in terms of validity and consistency (Monreal-Pérez, Aragón-Sánchez, & Sánchez-Marín, 2012) and (Dorling & Simpson, 1999). This survey includes a questionnaire that follows the guidelines set forth by the Frascati Manual regarding innovation, which was published by the OECD. Our study takes into account the eight innovation surveys during the period 1995-2012.

The studied data contains more than 6,300 observations. I considered a wider range of activities that seek productive improvements inside the firm. **Table 1** shows the variable definitions

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Table 1: Definition of variables

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|  |  |  |
| **R&D** | Research & Development | [thousands of CLP] |
| **know** | Acquisition of External Knowledge for Innovation. | Patents, Licenses, Know-How, etc [thousands of CLP] |
| **l** | Work (input) | total amount of workers |
| **prod** | Productivity | Labor productivity: |
| **g1** | Innovation expenditure effort [know] |  |
| **g2** | Innovation expenditure effort [R&D] |  |
| **exp** | Export intensity |  |
| **K** | Foreign Property | Categorical variable: 1 if part of the property is foreign-owned; or if not. |
| **A** | Year & Sub-sector | Categorical variables by year and sub-sector |

Source: Author’s elaboration.

**Innovation**

In this study, innovation is defined as a new knowledge incorporated into products, processes and services (Afuah, 1998), in contrast to others that defined innovation as technological, which is treated as a subgroup of R&D activities (Monreal-Pérez, Aragón-Sánchez, & Sánchez-Marín, 2012) and (Wakelin, 1998). Under this knowledge-innovation definition, I recede the technological-innovation approach which is restricted only to radical innovations (Dewar & Dutton, 1986). Rather, I consider a wide definition that allows incorporating the lowest degree of novelty than the radical innovations related to R&D. I define two types of innovations. The first innovation is measured by the total cost of R&D investment per worker (as a proxy of the size of the firm) and the second innovation is the total cost of acquisition of knowledge per worker. Other works take into account the critics of Greenhalgh, Taylor, & Wilson, (1994) that states the weakness of consider only expenditures as innovation, and do not consider innovation outputs as new products and processes (Greenhalgh, Taylor, & Wilson, 1994). Some of these works are: (Wakelin, 1998); (Filipescu, Prashantham, Rialp, & Rialp, 2013) and (Monreal-Pérez, Aragón-Sánchez, & Sánchez-Marín, 2012). However, I do not consider innovation outputs because of the relevance of non-radical and technological innovations in developing countries. My innovation definition does not have technological constrains in terms of product and processes, so it could be that main purpose of innovation efforts (R&D or acquisition of knowledge) does not have radical innovation, as their purpose states (like new product or processes), but instead, achieving an incremental innovation (Pavitt, What makes basic research economically useful?, 1991). The former could be a design-driven innovation not necessarily related to functionality or novelty (Verganti, Design as brokering of languages: the role of designers in the innovation strategy of Italian firms, 2003) and (Verganti, Design, meanings and radical innovation: a meta-model and a research agenda, 2008). Using inputs of innovation, (like innovation expenditures) rather than output, (new products and process) could be suitable given the source of information. Surveys use categorical variables for output: new products and processes, which are less informative than level values of expenditures. Finally, this does not guarantee innovation effort and does not give information about heterogeneity of those efforts, in particular, information of the sophistication level of those innovation efforts. Studying innovation expenditures allows analysis for the innovation-export relationship in a case-by-case approach of sophistication level of those innovation efforts.

**Export Intensity**

The empirical model measures the firm’s export activity by assessing the firm’s export intensity (exp), which expresses the exports as a percentage of total sales.

**Productivity**

I measure this variable as the amount of output per unit of input (e.g., labor). In this study, I follow the OECD definition and define productivity as labor productivity, which is defined as the average output per worker-hour (OCDE & Eurostat, 2005).

**Foreign Property**

I measure the ownership of the signing of foreign capital in the period FDI basis i, t-1. It is a variable that allows to evaluate the contribution of multinational companies that make development local technology.

**Labour**

This variable seeks to capture the existence scale effects that promote both the decision to innovate and in the export decision. In this sense, the expected present value of an innovation project can be predicted as an increasing function of number of units on which this innovation will be affected and, if so, large companies will be more likely to spend on innovation and increase spending. On the other hand, larger firms could afford costs related with export activity like, for instance, sunk costs.

**Fix Effects**

I use the year of the survey and the subsector industry as control variables, I used these fix effects (FE) to control for unobserved firm heterogeneities in order to achieve the main goal (i.e., to study the relationships among innovation and export activity).

**Table 2** shows descriptive statistics, where we can observe the percentage of companies that carry out some sort innovation expenditure (generally speaking), companies that export, companies that carry out both activities simultaneously, and lastly, companies whose property is partly owned by foreigners.

We can notice that the amount of firms that innovate[[3]](#footnote-3) is close to 40%, which is similar to the amount of firms that export. However, if we take into account both firms that innovate and export at the same time, we see that they make up 22% of the sample, so we can reach the conclusion that approximately half of exporting firms innovate. The same situation happens with innovative companies; that is, half of them export. Finally, 11% of firms have foreign property.

Table 2: Innovation and Export

|  |  |
| --- | --- |
|  | % |
| Export. | 38.0 |
| Innov. Expend. [general] | 39.4 |
| Innov. [general] and Export. | 22.1 |
| Foreign Property | 11.0 |
| Observations | 6374 |

Source: Author’s elaboration based on information from the EIT and ENIA.

In order to study the innovation-export relationship more thoroughly, **Table 3** shows a Mean Test of innovation expenditure effort for exporting and non-exporting companies. To carry out this test, innovation effort is defined as the innovation expenditure per worker.[[4]](#footnote-4) We can see that there are statistically significant differences between both groups of firms if the whole sample is considered at the aggregate level, where exporting companies have a higher innovation effort level than non-exporting companies. This evidence is coherent with previous studies, and I am able to confirm that exporting companies have a (statistically significant) better innovation performance than non-exporting companies. We can observe a statistically significant difference (difference between means) of more than 750 and a proportion between means[[5]](#footnote-5) (ratio) that is more than double. So, exporters expenditure has expanded more than double in innovation in comparison with local firms (non-exporters).

Table 3: Mean Test Innovation Effort of exporters and non-exporters firms

|  |  |
| --- | --- |
|  | Mean |
| gl |  |
| no-export | 632 |
| export | 1,395 |
| Prob> t | 0.01 |
| dif. of means | 763.9 |
| ratio | 2.21 |
| N | 6,374 |
| non-Exp. | 3,966 |
| Export | 2,408 |

Source: Author's elaboration based on information from the EIT and ENIA.

In order to study the export intensity relationship between innovative and non-innovative firms, we carried out a Mean Test regarding exporting propensity, measured as the proportion of sales intended for foreign markets. The results are shown in **Table 4**. We can see statistically significant differences between both groups of firms if the whole sample is considered, where innovative companies, on average, have a higher export intensity level than non-innovative firms, with a 7% difference (dif) and a proportion between means[[6]](#footnote-6) (ratio) of almost 2 (1.8). That is, the percentage of exported sales of innovative firms is almost twice that of non-innovative firms, which is also significant at the sub-sector level, reaching ratios between 1.3 and 3. This relationship is coherent with previous studies, and thus we can prove that exporting companies pursue a higher innovation efforts than non-exporting companies.

Table 4: Mean Test Export Intensity of innovators and non-innovators

|  |  |
| --- | --- |
|  | Mean |
| ev |  |
| no-Innov | 0.093 |
| Innov | 0.165 |
| Prob> t | 0.00 |
| dif. of means | 0.072 |
| ratio | 1.78 |
| N | 6,374 |
| non-Innov. | 4,016 |
| Innov. | 2,358 |

Source: Author's elaboration based on information from the EIT and ENIA.

# The Model

Following the recommendations of Filipescu et al. (2009), I lagged variables related to innovation by one time period to account for the delay between the R&D investments and the results of these investments. Filipescu et al. (2009) indicated that lagging the innovation variables for longer periods does not significantly influence the results (Filipescu, Rialp, & Rialp, 2009).

However, because expected impacts between innovations and exports and vice versa may not be immediate, we do not expect them to necessarily occur simultaneously (Filipescu, Rialp, & Rialp, 2009), I analyzed their respective effects lagged in one time. Thus, I followed Salomon and Shaver’s (2005) advice to introduce lags into the analysis to reduce possible simultaneity problems (Salomon & Shaver, 2005). Similarly, Baum (2006) considers lags important to improve prospects of valid causal inference. In addition, I include year and subsector dummies for both analyses. This is different, for two primary reasons, from Filipescu, Prashantham, Rialp, & Rialp, (2013) because they consider two lags. First, in their work, they focus on the relation of technological innovations and exports. In my work, I do not consider 2 lags because my innovation definition does not have a technological constrain, so it could be that the purpose of innovation do not have a radical innovation as their purpose (like new product or processes), but achieving an incremental innovation (Pavitt, What makes basic research economically useful?, 1991). Furthermore, one lag could be enough to measure the expected impacts between innovations and exports and vice versa, rather than the two lags for technological innovations. Secondly, there is a data constrains of the survey. INE do not offer a time series panel database. The survey used was constructed with waves of 1 years lagged data, so I have only one lag to construct the granger causality test.

I completed this study by using a pooled cross-sectional data, estimating a Granger test based on one lag. Considering the manufacturing sub-sectors , the model specification was established in the following manner for every sub-sector:

Where:

|  |
| --- |
|  |
|  |
|  |
|  |
|  |
|  |

These innovation and export equations are estimated by means of a Tobit model (Amemiya, 1973), considering that both exporting firms and firms that carry out innovation efforts are censured samples.

The variables are calculated in the following manner: the different amounts of innovation expenditure are calculated according to the aforementioned definition, and afterwards the amount of innovation expenditure per worker is calculated, which is called innovation effort. Exports are considered to be the real value of total exports. This value is divided by the total sales, and the result is the company’s export intensity. Finally, labor productivity is measured by means of the number of sales per worker.[[7]](#footnote-7) I used categorical variables () to capture the variance stemming from the year of observation, which is relevant to capture exogenous effects in the model.

# Main Results

Given that the focus of this paper is to study the existing causality between exports and innovation, and following the definition of the Granger Causality Test, I report the F-statistics of the variables.

In **Table 6**, we can see that there is statistically significant Granger causality from exports towards innovation[[8]](#footnote-8) for both R&D and knowledge acquisition where there is a positive relationship.

Table 6: F-statistics, Granger Causality Test: Innovation Effort

|  |  |  |
| --- | --- | --- |
|  | Acquisition of Knowledge | R&D |
| model |  |  |
|  | + | + |
| Year dummies | Yes | Yes |
| Sector dummies | Yes | Yes |
| F-stat. | 9.43 | 42.29 |
| Prob> F | 0.00 | 0.00 |
| Obs. | 4,942 | 5,127 |
| Obs. Uncensored | 287 | 1,297 |
| Obs. Censored | 4,655 | 3,830 |
| Estimation | tobit | tobit |

Source: Author's elaboration based on information from the EIT and ENIA.

Control Variables: Labor Productivity, Labor, Foreign Property.

Furthermore, in **Table 7** we observe that there is no statistically significant Granger causality from innovation towards exports in the case of R&D. In that sense, innovation expenditure may not have a relevant causal effect on export intensity. The results of the estimations for knowledge acquisition show that there exist causality from innovation towards exports

Table 7: F-statistics, Granger Causality Test: Export Intensity

|  |  |  |
| --- | --- | --- |
|  | Acquisition of Knowledge | R&D |
| model |  |  |
|  | + | + |
| Year dummies | Yes | Yes |
| Sector dummies | Yes | Yes |
| F-stat. | 5.89 | 2.40 |
| Prob> F | 0.02 | 0.12 |
| Obs. | 4,942 | 5,127 |
| Obs. Uncensored | 1,618 | 1,995 |
| Obs. Censored | 3,324 | 3,132 |
| Estimation | tobit | tobit |

Source: Author's elaboration based on information from the EIT and ENIA.

Control Variables: Labor Productivity, Labor, Foreign Property.

Consequently, the evidence that I find points first towards a difference in the causal direction between innovation and exports according to the type of innovation effort that was carried out. When considering all R&D expenditures, we see causality from exports towards innovation (Learning-by-Exporting) and not in the opposite direction. However, when considering innovations related to the acquisition of knowledge, there is mutual reinforcement, as there is statistical significance in both directions (reciprocal causality).

# Discussion and conclusion

In this paper, I consider an econometric causality test (Granger) to study the relationship between the innovation effort and the exports propensity, distinguishing between knowledge acquisition and R&D expenditures. In order to achieve conclusions of forms from developing countries, I use data from Chile, given its favorable conditions of opened economy and middle size developing country that make it perfect to achieve knowledge diffusion from technology adaptation.

The results show a difference in the causal direction between innovation and exports according to the type of innovation engaged, where the acquisition of knowledge shows a mutual reinforcement (reciprocal causality); rather than R&D expenditure, where causality is found from exports towards innovation (Learning-by-Exporting) and not in the opposite direction.

These findings take into account that exporting activities act as an information channel by which firms can access foreign knowledge and; therefore, assimilate them by innovation (Salomon & Shaver, 2005). Results that are in line with previous studies (Filipescu, Prashantham, Rialp, & Rialp, 2013) (Hitt, Hoskisson, and Kim 1997; Vila and Kuster 2007; Zahra, Ireland, and Hitt 2000). In particular, this export to innovation causal-relation sustains for both R&D and knowledge acquisition.

Exporters firms’ assimilate new knowledge to participate and grow in new global markets for them, so they have to adapt their products to local market conditions, offer customized applications; therefore, from a resource-based perspective, exporting firms could take advantage of the diverse knowledge inputs by being internationally exposed to a richer source of knowledge often not available in their home markets and take advantage of new market opportunities through rapid new product developments (Salomon and Shaver 2005) Autio, Sapienza, and Almeida 2000; Zahra, Ireland, and Hitt 2000. Also, firms first need to innovate and gain competitive advantages to compete successfully in international markets, which, in turn, can favor access to foreign knowledge sources that can firms’ technological advantages.

My results account for the idea that innovations provide competitive advantages that give firms the possibility of increasing exports and participate in global markets. First, firms need to innovate and gain competitive advantages to compete successfully in international markets (Bernard & Jensen, 1999); (Wagner J. , 2008); (Filipescu, Rialp, & Rialp, 2009) and (Pla-Barber & Alegre, 2007). These results are in line with the idea that innovation can serve as a source of improvement their productivity and access to global markets. In that sense, only firms with higher performance will access export activities (self-selection) and may be linked to certain entrance expenses (such as those regarding transportation, distribution, skilled personnel to handle the international network, information asymmetries regarding quality, etc.), expenses that would only allow firms that have innovated and increased their productivity to have access to the competitive export markets. This innovation to export causal relationship sustains only for knowledge acquisition, and not for R&D.

This difference between acquisition of knowledge and R&D in their causal relationship with exports is the main finding of my paper. On one side, knowledge acquisition shows a mutual reinforcing behavior, where innovation and exports have a reciprocal relationship. However, on the other side, R&D shows only an export to innovation causal relationship. These findings open a research focus on the behavior of innovation-exports causal relation in developing countries.

My results show the relevance of the export information mechanism of foreign knowledge for developed countries, given that they encourage both the knowledge acquisition and R&D. This finding shows the local markets in developing countries—even a medium-sized and open to international market as Chile—are at a reasonably distance from the technological frontier. The current knowledge located in local markets, while are enough to entail knowledge acquisition effort, are not sufficient to encourage more R&D expenditures. Although more studies are necessary to confirm and support the hypotheses that are studied in this paper, I suggest that these findings be considered when making public-private decisions.

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2. The data provided by EIT corresponds to eight waves of information, each one with one lag. That is the main data constraint that restrict the number of lags in the specification of the Granger Causality test of my econometric model. [↑](#footnote-ref-2)
3. In order to make reading this paper easier, we will write ‘Innovation’ interchangeably to refer to ‘Innovation Expenditure.’ In turn, we will write ‘Technological Innovation’ interchangeably to refer to ‘Technological Innovation Expenditure.’ This terminology flexibility is possible due to the fact that this work does not mention nor study Innovation Outputs, Product Innovation, Process Innovation, Management Innovation, etc., and so it should not be confusing. However, please keep in mind that under no circumstances have we made the assumption that innovation expenditure will necessarily lead to innovation (Output), nor that Technological Innovation Expenditure will necessarily induce technological innovation (Output), although they are intrinsically related. [↑](#footnote-ref-3)
4. This is carried out according to existing literature. Both innovation effort and export intensity allow for corrections based on factors relative to plants and fixed effects per industry. At the same time, both innovation expenditure values and export values are calculated at real value. [↑](#footnote-ref-4)
5. The mean ratio is measured as the innovation effort mean of exporting firms divided by the innovation effort mean of non-exporting firms. [↑](#footnote-ref-5)
6. The mean ratio is measured as the innovation effort mean of exporting firms divided by the innovation effort mean of non-exporting firms. [↑](#footnote-ref-6)
7. Innovation effort, export intensity and labor productivity were calculated with values at constant prices. [↑](#footnote-ref-7)
8. From this point onward, the terms innovation and exports will be used to refer to innovation effort and export intensity respectively. [↑](#footnote-ref-8)