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WHEN DOES INNOVATION MATTER FOR EXPORTING?

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Alumna: Micaela Mussini
Mentor: Facundo Albornoz

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When does Innovation Matter for Exporting?[1]

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ABSTRACT

A growing number of studies that look at the relationship between innovation and exports find that more innovation tends to allow firms to export more. But very little is known about the heterogeneous impacts of innovation on exports. Since innovation is not a costless activity, it is relevant to know the specific situations in which a firm most likely needs to innovate to raise its exports. Using data from Chile, we combine information on innovation activities at the firm level with a rich dataset on exports at the transaction level. We find that the firms that engage in innovation tend to export more than other firms because they are able to sell goods and target markets that reward innovation. We show that the goods and markets in which innovative exporters outperform non-innovative exporters are those where innovation can lead to substantial differences in terms of quality. Innovative firms do not have an edge in exporting goods and in targeting markets that do not reward innovation. In particular, innovative firms do not outperform non-innovative firms when exporting goods and penetrating markets in which differentiation in terms of quality is not possible or not relevant.

Universidad de SanAndrés

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[1] This is a full version of a paper written with Juan Blyde (Lead Trade Economist at Inter-American Development Bank, juanbl@iadb.org) and Gonzalo Iberti (Chilean Ministry of Finance).

1. Introduction

There is a growing literature on the relationship between innovation and exports. The empirical analyses that study the relationship between innovation and exports typically find a positive correlation between these two variables, but whether innovation *causes* exports has not always been carefully examined.

Recent contributions to the literature have started to control for the potential estimation biases that reverse causality could create when addressing the relationship between innovation and exports (Lachenmaier and Wößmann, 2006; Aw et al., 2007; Damijan et al., 2008; Van Beveren and Vandenbussche, 2010; Caldera, 2010 and Becker and Egger, 2013). While different techniques have been used to control for this endogeneity issue, most studies find that innovation efforts tend to translate into larger exports. In the particular context of the Chilean economy, for example, Bravo-Ortega et al. (2013) find that firms that invest in R&D are more likely to export, but the reverse is not true.

The common characteristic behind all these studies is their focus on the impact of innovation on a simple measure of export activity, either the total exports of the firm or its export status. But very little is known about the heterogeneous impacts on exports when firms perform innovation. For instance, does innovation increase all the exports of the firm or only the exports of certain goods? Does the increase in exports occur in all the markets that a firm serves or only in particular markets? If the increase in exports occurs only in certain markets, do the exports of all the goods serving those markets increase, or only a subset of those goods? Until now, these questions have remained unanswered because the studies available in the literature have looked at the effect of innovation on crude measures of firm exports, either total exports or the export status. But addressing these questions can provide new insights into why innovation is relevant for exporting. For example, innovation might be important only when a firm seeks to penetrate certain markets, say high income countries. Likewise, exporting certain goods might require more innovative efforts than exporting others. Since innovation is not a costless activity, it is then relevant to analyze in detail the specific situations in which a firm most likely needs to innovate to raise its exports. This is the objective of this paper.

Using data from Chile, we combine information on innovation activities at the firm level with a rich dataset on exports at the transaction level. By merging these two datasets we identify at very disaggregated levels what type of goods innovative firms export and where. Our contribution to the literature it to analyze not only if innovative firms export more than non-innovative firms but also whether there are heterogeneous effects in terms of the type of goods that they export and the destination markets that they serve. The dataset also allows us to examine whether the potential increase in exports is channeled through a price or a quantity effect. This gives us another dimension to delve into the question of why innovation is important to export.

Universidad de San Andrés

We find that innovative firms tend to export more than non-innovative firms and, also, the results found suggest that they do so because they sell goods and target markets that rewards innovation. In particular, innovative firms exhibit better export performances than non-innovative firms in goods for which innovation can lead to substantial increases in quality and in markets that have higher quality-valuations. The data suggests that innovative firms do not export more than non-innovative firms when it comes to goods and markets for which quality differences are not rewarded. The evidence also indicates the existence of important synergy effects for engaging in different types of innovation. In particular, the edge of innovative firms over non-innovative firms is more pronounced when the innovative firms are engaged in both product and process innovation than when they are engaged in only one type of innovation.

These results are robust to a series of tests. We show that the findings hold after controlling for potential reverse causality, after using different specifications of the econometric model, and after employing alternative definitions of the innovation variable.

Our study contributes to two different literatures. First, it extents the current body of analyses that use broad measures of exports (Lachenmaier and Wößmann, 2006; Aw et al., 2007; Damijan et al., 2008; Van Beveren and Vandenbussche, 2010; Caldera, 2010 and Becker and Egger, 2013; Bravo-Ortega et al., 2013) to examine the impact of innovation across detailed dimensions of the export activity. Second, the study contributes to a growing literature that shows the importance of skill acquisition for exporting to high-income countries (Brambilla et al., 2012; Verhoogen, 2008; Matsuyama, 2007). Our analysis extends this notion to the role of innovation.

Universidad de San Andrés

The rest of the paper is divided as follows. Section 2 provides a brief summary of the literature on innovation and trade and explains the contribution of our analysis to this literature. In this section we also introduce the econometric model. Section 3 describes the various datasets that we employ in the study. Section 4 discusses the empirical results while section 5 finalizes with some concluding remarks.

2. Empirical specification

We consider the exports of firms at the product and market destination level and exploit variations in innovation effort across those firms. In other words, we compare the export outcomes of the firms that innovate with that of the firms that do not innovate paying particular attention to the destination markets and the types of goods that they export. We start with the following baseline specification:

$$Y_{ipc} = \beta_0 + \beta_1 \cdot I_i + \beta_2 \cdot L_i + D_p + D_c + D_r + \varepsilon_{ipc} \qquad (1)$$

where Y_{icp} is the exports (in logs) of firm i of product p to destination country c ; I_i is a dummy variable that takes the value of one if the firm engages in innovation and zero otherwise; L_i isthe employment level of the firm (in logs); D_p and D_c are fixed effects for product p and destination country c, respectively; they seek to capture product and country specific factors that might be correlated with the level of exports; D_r is a region fixed effect that controls for potential locational effects like agglomeration or proximity to other firms or markets[2], and ε_{ipc} is an error term that is white noise. In all the regressions, we employ standard errors clustered by the firm level.

The variable L_i seeks to capture firm-level factors -different from innovation- that are correlated with exporting. In the recent literature of trade, for example, firm productivity is the single attribute that determines the firm's ability to export successfully (e.g. Bernard et al., 2003; Melitz, 2003; Chaney, 2008; Arkolakis, 2010). Unfortunately, the information in our dataset precludes us to construct a suitable measure of productivity. Accordingly, we use firm size instead, based on a large body of empirical analyses indicating that productivity and firm size are highly correlated (Bernard and Jensen, 1999a, b; Bernard, Jensen and Schott, 2006; Mayer and Ottaviano, 2007).[3]

The innovation variable in equation (1), I_i, captures both product and process innovations. In other words, the variable is equal to one if the firm engages in either product innovation, process innovation or both. Later in the paper we present specifications in which I_i captures product and process innovations separately. Another characteristic of our innovation measure is that it captures the outcome of innovation rather than the firm's expenditures in R&D. The advantage of using outcome rather than input measures of innovation is that not all the R&D expenditures of a firm necessarily materialize in actual innovations.

While our empirical analysis is a cross-section, I_i measures innovations that occurred one year prior to the exports of the firm.[4] This implies that the estimations will be capturing the short-run impacts of innovation. Being an outcome variable, it is not unreasonable to expect that the innovation completed by the firm in one year might show up in the exports of the following year. It is possible; however, that some innovations might take longer to materialize in foreign markets, but this only increases the bar for finding a significant effect in our analysis.

[2] Chile is divided into 15 regions, the largest administrative division of the country.
[3] In particular, most papers in this literature find that exporting firms are usually both larger and more productive than non-exporting firms.
[4] In the next section, we will describe in more detail the specific time periods of the datasets

A potential problem with equation (1) is the possible existence of endogeneity between the exports and the innovation activity of the firm. As mentioned before, the causality between these two variables can go in either direction and not controlling for this issue could introduce a bias in the estimation of β_1.

On this paper, we discuss one potential way of solving this potential endogeneity problem. Our approach consists on introducing an instrumental-variable (IV) estimation. In particular, we follow Lachenmaier and Wößmann (2006) and Becker and Egger (2013) and use innovation impulses taken from the innovation survey that are significantly correlated with the innovation outcome but not with the exports of the firm. Innovation impulses are considered as specific impulses that boost firms' innovations. These innovation impulses, which we describe in more detail in the next section, are used as instruments for the innovation measure in equation (1). The first stage of the IV estimation procedure takes the following form:

$$I_i = Z'_i \cdot \gamma + D_s + D_r + \varepsilon_i \qquad (2)$$

where Z'_i is a vector of innovation impulse variables and D_s and D_r are sector (at 4 digit ISIC revision 3 level) and region fixed effects, respectively. In section 4 we show formal tests that aim to assess the validity of the innovation impulse variables as instruments.

3. Data description

The information on exports is taken from the Chilean National Customs Authority, *Servicio Nacional de Aduanas*. The data include the universe of the Chilean exports at the transaction level. Specifically, each record includes a firm identifier, the good exported (at 8-digit HS level), the destination country, the export value in US dollars, the quantity (weight) in kilograms and the unit price. We select the year 2009 from this dataset so there is at least a one-year gap between the year of the innovation (described in the next paragraph) and the year of the export. There are 7430 exporters during this year.

The information about innovation activities is taken from the Chilean Innovation Survey, *Encuesta de Innovación*, conducted by the Chilean National Statistics Institute, the *Instituto Nacional de Estadisticas (INE)*. The information is collected biyearly covering the two years prior to the year in which the survey is conducted. The survey uses a stratified random sample for firms in the agriculture, mining, manufactures and the service sectors. Since we are interested in analyzing the impact of innovation on exports, we drop from the analysis the firms in the service sectors. One important limitation from this survey is that the structure of the questions has changed somewhat over the years. Accordingly, working with several rounds of this survey is challenging since we employ a number of variables that has not remained stable in the questionnaires over time. Therefore, we use the year 2009, which reports information on innovation activities for 2007 and 2008. The data then cover the

innovation outcomes of the firms one or two years prior to the information that we use for exports, the year 2009. For the most part of the survey, and particularly for all the variables that we employ, firms are not required to provide separate answers for the year 2007 and the year 2008 but one answer that applies for the entire period of two years.

The survey includes input measures of innovation, like R&D expenditures, and also output measures, like whether the firm successfully developed an innovation in products or in processes. We use the innovation outcome variables. In particular, we construct a dummy variable equal to one if the firm develops an innovation in products or processes or both (in any of the two years). The dummy is equal to zero if no innovation is performed. After excluding the firms in the service sectors, there are 1498 firms in this dataset.

Similar to other innovation surveys used in the literature, the Chilean survey includes information on the so called exogenous impulses and obstacles to innovation (for the case of Germany, see Lachenmaier and Wößmann, 2006; and Becker and Egger, 2013). These are questions about the relevance that a number of factors have exerted on the innovations carried by the firm. In the Chilean survey there are 6 impulses (or incentives) and 16 obstacles (impediments). The firms are asked to answer these questions with a scale from 1 (not important) to 5 (highly important). From all these factors, only 3 impulses were found to have a statistically significant impact on the probability to innovate: cost reduction, quality improvement, and environmental impact reduction. Following the strategy by Lachenmaier and Wößmann (2006) of using this type of factors as instrumental variables, we employ these three impulses in our IV estimation. In the next section we provide tests that support the suitability of these variables as instruments. While these variables enter the regressions in their original categorical form, we also present results when they are transformed into binary variables.

The innovation survey also includes additional information that is relevant for our exercise, namely, the firm size in terms of employment, the sector (at the 4 digit ISIC rev3 level) and the region where the firm is located.

After merging the two datasets on innovation and exports, we have 469 firms. This is the group of firms that we employ in the analysis. Table 1 shows some descriptive statistics for these firms. The typical firm has an average export per product and destination equal to 2.1 million US dollars, and it employs 314 workers. About 44% of the firms in the sample introduced an innovation during the period examined. The percentages of firms indicating that cost reduction, quality increase and environmental impact reduction were highly important determinants to their innovations were 41%, 42% and 40%, respectively. Finally, the last two rows of the table indicate that the average exports per product and country were 2.2 million US dollars for the innovative firms and 1.9 million US dollars for the non-innovative firms. Table 2 shows the average innovation variable by sectors. For instance, 61% of the firms in the sector "fabricated metal products" engaged in some form of innovation while only 10% of the firms in the sector "wearing apparel" did the same.

4. Empirical results

As mentioned before, we aim to control for potential endogeneity between exports and innovation employing an IV-estimation. In particular, we run a 2-stage least squares regression and employ the impulse variables, cost reduction, quality improvement, and environmental impact reduction, as instruments. Column (1) in table 3 shows the results of the first-stage of the estimation. The coefficients are all positive and significant at conventional levels and the F-statistic suggests that there is not a weak-instrument problem. In column (2) we show a regression in which the impulse variables are used directly as covariates in a regression on exports. In this case, the coefficients are not statistically significant. The results from both columns give support to our choice of instruments: while they significantly affect the innovation outcome, results on Column (2) suggest they do not exert a direct impact on exports.

Columns (1) - (3) of table 4 show regressions for the second stage estimation with alternative sets of fixed effects. These estimations provide further evidence supporting the exogeneity of the instrumental variables and, thus, supporting our identification strategy. Particularly, the Hansen tests of overidentifying restrictions show that, in all the cases, we cannot reject the null hypothesis that the instruments are valid, meaning that our instruments are statistically exogenous to the error term of the exports equation.

As expected, there is a positive relationship between the level of employment and exports. The impact of innovation on exports is also positive and significant in the three regressions. The size of the effect is economically meaningful. In column (3), for example, the coefficient implies that firms that engage in innovation tend to export 132% [exp (0.84) – 1] more than the firms that do not engage in innovation. A series of robustness checks are presented in columns (4) to (6). In particular, column (4) shows the results when the instruments enter the estimation (on the first stage) as binary variables instead of categorical variables; column (5) drops potential outlier observations, in particular, the exports above the 99th percentile and below the 1st percentile; while column (6) drops potential outlier observations in terms of labor size, in particular, the firms with employment above the 99th percentile and below the 1st percentile. As shown, the estimated impact of innovation on exports holds across all the cases, sustaining the potential positive effect of innovation on exports.

4.1. Heterogeneous effects

In this section, we intent to examine whether the effects of innovation on the exports of the firm vary across a series of dimensions. First, we explore the existence of potential heterogeneous effects across destination markets. There might be reasons to expect that firms would have to engage in different innovation intensities when targeting different markets. In a different context, for example, Brambilla et al. (2012) finds that

Argentinian firms exporting to high income countries use more skills than firms exporting to low income countries. The authors provide evidence indicating that high-income countries tend to exhibit higher valuation for quality which leads to higher-quality products and higher use of skilled labor. In the context of this paper, it is possible that firms innovate to sell in markets that reward innovation, for instance because they have a higher valuation for quality. What we would like to do is to explore whether the positive impact of innovation on exports that we found in table 4 is related to this hypothesis that innovative firms penetrate more successfully high income countries for which innovative efforts are more properly rewarded.

Using the same specification as in column (3) of table 4, table 5 shows the results when we separate the exports in two groups according to the income level of the destination countries. In particular, we separate the high income countries from the medium-low income countries. This is done using the World Bank's country income classification. The first group consists on the World Bank's high-income OECD category and the second group includes the rest of the countries. The rationale here is that the insertion into high income countries might be especially difficult, for example, because of their high-valuation for quality, and thus an exporter would need to engage in particularly intensive innovation efforts to successfully penetrate into these markets.[5] The results from table 5 show some support to this hypothesis. In particular, the effect of innovation on exports is positive and significant in both markets but much more pronounced in high income countries. Specifically, firms that innovate tend to export 1.7 times more [exp(0.976)-1] than firms that do not innovate when they target high income countries, and 1.1 times more [exp(0.751)-1] when they target medium-low income countries. In other words, the edge of innovative firms over non-innovative firms is seemingly larger when they penetrate high income countries than when they penetrate the rest of the countries. This result suggests that penetrating high income markets can be particularly difficult and thus the difference in performance between innovative and non-innovative firms is much more evident in these markets than when they target less-challenging destinations. In the next section we explore whether this larger edge of innovative firms when they serve high income countries has to do with the notion that these markets have high valuations for quality and thus large innovation efforts are required to penetrate them successfully.

The second dimension that we aim to explore regarding heterogeneous impacts of innovation on exports is related to the type of goods. For example, the innovation required to develop and export successfully a computer is likely to be different than the innovation efforts required to export a cathode of copper. Accordingly, we would like to explore whether the finding that innovative firms export more is related to the hypothesis that these firms tend to export more successfully some kind of goods that reward innovation, for instance, because innovation can lead to substantial differences in the quality of the good.

[5] We employ alternative classifications for separating the countries according to their level of development. The results, available from the authors upon request, are qualitatively similar.

It is reasonable to expect that the possibility to make a substantial difference in the quality of the good is likely to be low for raw materials and basic goods. At the extreme, for example, commodities tend to vary only slightly across markets and thus a successful penetration of foreign markets with those goods might not require a great deal of differentiation in terms of quality. Following this notion, we separate all the exports in two groups, differentiated and non-differentiated products, following the classification developed by Rauch (1999). This classification distinguishes among homogeneous goods that are traded in organized exchanges, reference-priced goods that have prices quoted in specialized publications, and differentiated goods that are neither traded in organized exchanges nor have reference prices (i.e., prices do not convey all the relevant information for international trade on these goods). In this analysis, we pool together homogeneous and reference-priced goods and specifically follow the liberal classification.[6] The results, shown in table 6, suggest the existence of heterogeneity in terms of types of goods. In particular, results sustain that innovative firms tend to export 1.8 times more differentiated goods than non-innovative firms, but they do not export more of non-differentiated goods. The result suggests that innovative firms are able to sell abroad more than other firms the type of products for which innovation allows them to differentiate their varieties. In the next section we explore whether this differentiation is related to the quality of the good.

While tables 5 and 6 examined the effects of innovation on exports across goods and destination markets separately, table 7 combine both dimensions. The results suggest that innovative firms do not export more non-differentiated goods than non-innovative firms when they target either high income countries or the rest of countries (columns 1 and 3). However, innovative firms export more differentiated goods in both markets, with an edge that is larger when targeting high income countries (columns 2 and 4).

Universidad de SanAndrés

4.2. Channels

In this section we use additional information from the export database to explore the channels by which the larger exports induced by innovation are achieved. In particular, we examine whether the positive effects of innovation on exports are accrued via higher prices or higher quantities. The results are shown in table 8. For completeness, column (1) shows again the regression on exports. In columns (2) and (3) we use, respectively, the quantities and the prices of those exports as the dependent variables. As shown in the table, the coefficient for the regression on quantity is statistically significant but not the one for the regression on prices. This result suggests that more innovative firms are able to export more than non-innovative firms essentially because they sell more quantities. Particularly, firms that innovate tend to export 1.3 times larger quantities [exp(0.8410)-1]

[6]Results do not change when using the conservative version of the Rauch classification

than firms that do not innovate, while we find that the effect of innovation on the exports prices is not statistically different between the non-innovative firms and the firms that do innovate.

If we consider the price of a good as a proxy for its quality, not finding a relationship between innovation and prices could initially be viewed as an indication that the outcome of the innovation is not a higher quality product. But the unit value of a good is not necessarily a good proxy for quality because export prices might vary for reasons other than quality, including differences in cost structures (Hallak and Schott, 2011). In the context of a cross-country analysis, for example, Hallak and Schott (2011) identify product quality by combining information on the countries' trade balances with the observed export prices. The identification strategy that the authors employed is based on the notion that among countries with identical export prices, the country with the higher trade balance is revealed to possess higher product quality. We apply the same intuition here at the firm level. That is, among two firms with identical export prices, the firm exporting more quantities is revealed to possess a higher product quality. In terms of our estimation, this is akin to re-running the regression on quantities after controlling for differences in prices. This is done in column (4) of table 8. The result would imply that innovative firms sell more quantities abroad than non-innovative firms, even after holding prices constant. This insinuates that innovative firms are able to penetrate foreign markets with larger quantities of exports because their exports are associated with higher quality goods.

Now we are ready to combine the channels dimension with the analysis of the heterogeneous effects by destination markets and types of goods presented before. This is done in table 9. The table shows, for example, that the penetration of foreign markets by innovative firms with larger quantities of high quality exports is relevant only for the case of differentiated goods (columns 8 and 16) but not when firms export non-differentiated products (columns 4 and 12). This evidence is important because it indicates that investing in innovation provides an edge in penetrating foreign markets only in goods in which innovation leads to substantial differentiation in terms of quality. The table also shows that the difference between innovative and non-innovative firms when exporting differentiated goods is even larger when targeting high income countries than when serving medium-low income countries (column 8 versus 16). This last result gives support to the idea that there is a higher valuation for quality in high income countries than in the rest of the countries.

4.3. Difficulty effect check

In this section, we would like to propose an extra exercise with the aim of checking if we are really capturing the extra value that high-income OECD countries give to high quality goods, as the latter is what makes innovation worth it. It could be the case that innovation is more valuable when exporting to high income countries simply because it is more difficult to export to these destinations and not because they have an extra

appreciation for high quality or differenced goods. In other words, we want to check if we are not confounding the *"sophistication effect"* with a *"difficulty effect"*.

With this objective in mind, we use the bilateral distance database provided by CEPII (French research center in international economics), to extract the distance between Chile and every commercial partner as a measure of difficulty to export. In this sense, we are assuming that exporting to distant countries implies a higher grade of difficulty. If we are properly identifying in table 5 that high income countries give an extra value to high quality goods, we should find that in these countries innovation is significant on exports regardless the distance to the partner country. On the other side, in the case of low-middle income countries when exporting to distant countries innovation doesn't worth it enough and, thus, is not significant.

To test this, we sub-divide high income and medium-low income countries considering quartiles of distance. We restrict the category of distant partnerships to those that are placed in the fourth quartile of distance, constructing the remaining category with the other three quartiles of distance. Table 10, confirms the mentioned hypothesis. In the case of medium-low income countries, innovation is not significant when considering distant countries, supporting the idea that there is not a "difficulty effect". Further, in the case of high income countries, the distance to the partner country does not modify the relevance of innovation on exports.

4.4. Types of innovation

In the last part of this study we explore whether there are heterogeneous effects regarding the type of innovations that the firm performs. So far, we have lumped in the same variable the innovations in either products, processes or both; but further insights could be potentially gained by estimating separate effects for these two classes of innovations.

Regarding literature on these two types of innovations, we find that most studies exploit the process innovation channel. More specifically, based on Melitz (2003), authors such us Constantini and Melitz (2008), Atkeson and Burstein (2010), Caldera, (2010), Bustos (2011), and Aw, Roberts and Xu (2011), assume that firms set prices as a fixed markup over marginal cost. In these studies, innovation is typically introduced as improvements in the production process that conduct to a reduction of the marginal cost of production. In this scenery of enhanced efficiency of the production process, innovation may positively affect exports to all destination countries and of all types of products, and it accordingly imply that the price of exports to that market should fall. This outcome, however, does not seem to fit stylized facts very well, since innovation is not usually found to be associated with lower prices. This has been shown in recent studies using Italian exports data (Basile et al., 2006; Borin and Quintieri, 2006; Giovannetti et al., 2012).

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Given this gap between theoretical prediction and empirical findings, different authors have introduced product quality differentiation across firms to better fit the stylized facts (Baldwin and Harrigan, 2007; Johnson, 2012; Verhoogen, 2008; Kugler and Verhoogen, 2008; Hallak and Sivadasan, 2008; Kneller and Yu, 2008). In these analysis, more productive firms may enjoy superior export performance due to the exports of higher-quality goods at higher prices. In broad terms, product innovation affects products' attributes and is, thus, usually product-specific. It could also imply the customization of the product to the requirements of the destination country, providing destination-specific innovations.

In table 11 we show the estimated impacts of product and process innovations not only for export values but also for quantities, prices and quantities after controlling for price differences (our proxy for quality). The structures of the regressions are as follows: columns (1) to (4) analyze the firms that only performed product innovation; columns (5) to (8) analyze the firms that only performed process innovation, and columns (9) to (12) analyze the firms that performed both types of innovations at the same time. In all the cases, the control group is the same, that is, the firms that did not perform any innovation. Our findings suggest that the edge of innovative firms over non-innovative firms is more pronounced when the innovative firms are engaged in both product and process innovation than when they are engaged in only one type of innovation. Specifically, firms that innovate tend to export 1.9 times more [exp(1.0931)-1] than firms that do not innovate when they are engaged in both process and product innovation, and 1.15 times more [exp(0.766)-1] when they only introduce process innovations. Indeed, we find that the effect of innovation on exports is not statistically different between the non-innovative firms and the firms that only perform product innovations.

A possible explanation for the abovementioned findings, is that firms that introduce both product and process innovations simply innovate more, and thus the effect on exports may be larger for that reason. However, considering simultaneously the results described in previous sections, these findings could be interpreted as indicating the existence of important synergy effects for engaging in both types of innovation. On the one side, product innovation, for being product specific, is consistent with the finding of a larger edge of innovative firms when they serve goods and markets where innovation can lead to substantial differences in terms of quality. On the other side, process innovation, for being associated with gains in efficiency, would allow us to explain why the change in the quality composition of exports is reflected in differences in the exported volume but not in augmented prices. Therefore, this two types of innovations, when combined, would traduce in better outcomes in terms of volumes with no gains in prices.

5. Concluding remarks

Innovation is not a costless activity. Therefore, firms investing in R&D expect to generate a return. Such return could be accrued, at least partially, by selling products abroad. But firms targeting foreign markets must face

the competition from other exporters; therefore, the outcome of their innovation must give them an edge in those markets.

In this paper we show that the firms that engage in innovation tend to export more than other firms because they are able to sell goods and target markets that reward innovation. Innovative firms do not have an edge in exporting goods and in targeting markets that do not reward innovation. We show that the goods in which innovative exporters outperform non-innovative exporters are those where innovation can lead to substantial differences in terms of quality. Innovative firms do not export more the types of goods in which differentiation in terms of quality is not possible or not relevant. Similarly, we show that innovative firms have a larger edge over non-innovative firms in highly-developed countries where the high-valuation for quality means that the outcome of the innovation is more properly rewarded.

This study provides a contribution to the literature on innovation and exports by showing that the positive relationship between these two variables arises in situations where the outcome of the innovation leads to quality improvements that can generate returns to innovation but it vanishes when the innovation does not give an edge over non-innovative competitors either because quality differences are not possible or are not rewarded by the market.

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Table 1: Descriptive statistics

Variable \ Statistics	Mean	St. Dev
Exports per product and country ('000 US$)	2,090.02	36,119.71
Employment	313.76	616.75
Innovation dummy	0.44	0.49
Impulse 1: cost reduction; high importance	0.41	0.49
Impulse 2: increase in quality; high importance	0.42	0.49
Impulse 3: reduce environmental impact, high importance	0.40	0.49
Exports per product and country, innovative firms ('000 US$)	2,212.72	44,521.79
Exports per product and country, non-innovative firms ('000 US$)	1,906.65	17,093.63

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Table 2: Innovation dummy by sector

ISIC rev 3, 2 digits	Description	Mean
28	Fabricated metal products	0.61
26	Other non-metallic mineral products	0.57
25	Rubber and plastic products	0.55
24	Chemicals and chemical products	0.52
21	Paper and paper products	0.50
36	Furniture	0.50
20	Wood and wood products	0.48
29	Machinery and equipment	0.47
15	Food products and beverages	0.46
22	Publishing and printing	0.45
27	Basic metals	0.43
34	Motor vehicles	0.43
19	Leather products	0.41
35	Other transport equipment	0.40
31	Electrical machinery	0.36
13	Mining of metal ores	0.28
17	Textiles	0.28
33	Medical, precision and optical instruments	0.25
18	Wearing apparel	0.10

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Table 3: First Stage Results

	Innovation	Exports
	(1)	(2)
Impulse 1: cost reduction; high importance	0.0916***	0.166
	(0.0192)	(0.164)
Impulse 2: increase in quality; high importance	0.113***	-0.0578
	(0.0185)	(0.149)
Impulse 3: reduce environmental impact, high importance	0.0778***	0.0742
	(0.0155)	(0.137)
Labor	0.0160**	0.834***
	(0.00787)	(0.121)
F - Statistic	0.0000	0.1991
Sector fixed effect	Yes	yes
Region fixed effect	Yes	yes
Observations	469	469
R^2	0.8553	0.2659

Note: Robust standard errors clustered by firms reported in parentheses

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

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Table 4: Second Stage Results

	Alternative fixed effects			Instruments are binary	Drop outliers in terms of export size	Drop outliers in terms of labor size
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Labor	0.09521*	0.1231*	0.2177*	0.2339*	0.2146	0.2706*
	(0.05520)	(0.06339)	(0.1306)	(0.1302)	(0.1374)	(0.1530)
Innovation	0.7010***	0.5057***	0.8410***	0.8305***	0.7916**	0.8175**
	(0.2658)	(0.1815)	(0.3206)	(0.3083)	(0.3231)	(0.3244)
Hansen Test	0.219	0.150	0.268	0.222	0.276	0.311
Product fixed effect	yes	yes	no	no	no	no
Country fixed effect	yes	yes	no	no	no	no
Product-Country fixed effect	no	no	yes	yes	yes	yes
Region fixed effect	no	yes	yes	yes	yes	yes
Observations	13,393	13,393	13,393	13,393	12,778	13,179
R^2	0.0960	0.1074	0.1420	0.1434	0.1450	0.1435

Note: Robust standard errors clustered by firms reported in parentheses

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

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Table 5: Heterogeneous Effects on Destination Markets

	High income	Medium-low income
	(1)	(2)
Labor	0.2108*	0.2127
	(0.1267)	(0.1716)
Innovation	0.9759***	0.7541**
	(0.3507)	(0.3806)
Product-Country fixed effect	Yes	Yes
Region fixed effect	Yes	Yes
Observations	4,062	9,175
R^2	0.2093	0.1040

Note: Robust standard errors clustered by firms reported in parentheses

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

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Table 6: Heterogeneous Effects on Types of Goods

	Non-differentiated	Differentiated
	(1)	(2)
Labor	0.2068	0.2167
	(0.1464)	(0.1842)
Innovation	0.2032	1.0345***
	(0.4197)	(0.3695)
Product-Country fixed effect	Yes	Yes
Region fixed effect	Yes	Yes
Observations	3,988	8,935
R^2	0.0817	0.1727

Note: Robust standard errors clustered by firms reported in parentheses

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

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Table 7: Heterogeneous Effects on Destination Markets and Types of Goods

	High income		Medium-low income	
	Non-differentiated	Differentiated	Non-differentiated	Differentiated
	(1)	(2)	(3)	(4)
Labor	0.2403**	0.1557	0.1640	0.2267
	(0.1213)	(0.1956)	(0.2493)	(0.2078)
Innovation	0.4342	1.3257***	-0.1528	0.8919**
	(0.4001)	(0.4144)	(0.5945)	(0.4247)
Product-Country fixed effect	yes	yes	Yes	yes
Region fixed effect	yes	yes	Yes	yes
Observations	1,565	2,384	2,394	6,427
R^2	0.147	0.254	0.077	0.131

Note: Robust standard errors clustered by firms reported in parentheses

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

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Table 8: Channels

	Export	Quantity	Price	Quantity
	(1)	(2)	(3)	(4)
Labor	0.2177*	0.1963	0.01639	0.2114
	(0.1306)	(0.1311)	(0.03672)	(0.1294)
Innovation	0.8410***	0.8611***	-0.02321	0.8397***
	(0.3206)	(0.3112)	(0.1063)	(0.3174)
Price				-0.9229***
				(0.1445)
Product-Country fixed effect	Yes	yes	yes	yes
Region fixed effect	Yes	yes	yes	yes
Observations	13,393	13,393	13,393	13,393
R^2	0.1420	0.1355	0.0101	0.2225

Note: Robust standard errors clustered by firms reported in parentheses

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

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Table 9: Heterogeneous Effects on Destination Markets and Types of Goods, Decomposed by Channels

	Highly Developed Countries								Rest of Countries							
	Non-differentiated				Differentiated				Non-differentiated				Differentiated			
	E	Q	P	Q	E	Q	P	Q	E	Q	P	Q	E	Q	P	Q
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Labor	0.2883**	0.3213***	-0.01930	0.3182***	0.1635	0.1091	0.05467	0.1438	0.1383	0.1100	0.01182	0.1245	0.2161	0.2213	0.01673	0.2390
	(0.01467)	(0.005659)	(0.1404)	(0.007304)	(0.4235)	(0.5840)	(0.2545)	(0.4761)	(0.5541)	(0.6475)	(0.7016)	(0.5911)	(0.2863)	(0.2871)	(0.7972)	(0.2278)
Innovation	0.3457	0.4518	-0.0509	0.4437	1.4730***	1.5278***	-0.0205	1.5147***	-0.0909	0.0004	-0.0851	-0.1037	0.8793**	0.8689**	-0.01345	0.8547**
	(0.3785)	(0.2459)	(0.3591)	(0.2490)	(0.0018)	(0.0006)	(0.8772)	(0.0010)	(0.8772)	(0.9995)	(0.5764)	(0.8627)	(0.0267)	(0.0334)	(0.9275)	(0.0261)
Price				-0.1595				-0.6359***				-1.2233**				-1.0615***
				(0.8688)				(0.0018)				(0.0336)				(0.0000)
Product-Country fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Region fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1,377	1,377	1,377	1,377	1,899	1,899	1,899	1,899	2,582	2,582	2,582	2,582	6,912	6,912	6,912	6,912
R^2	0.1527	0.1791	0.0873	0.1796	0.2542	0.2513	0.0554	0.2815	0.0700	0.0667	0.0241	0.1313	0.1442	0.1300	0.0127	0.2685

Note: E (exports), P (price) and Q (quantity). Robust standard errors clustered by firms reported in parentheses

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

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Table 10: Heterogeneous Effects on Destination Markets and Distance to the Partner

	High income		Medium-low income	
	Close	**Distant**	**Close**	**Distant**
	(1)	**(2)**	**(3)**	**(4)**
Labor	0.1392	0.2866*	0.2550*	0.1308
	(0.5230)	(0.09308)	(0.08396)	(0.3789)
Innovation	0.8837*	0.5460	0.8533**	1.2050***
	(0.08281)	(0.1417)	(0.01731)	(0.006021)
Product-Country fixed effect	yes	yes	yes	Yes
Region fixed effect	yes	yes	yes	Yes
Observations	2,358	1,704	7,623	1,615
R^2	0.2173	0.2334	0.0894	0.2103

Note: Robust standard errors clustered by firms reported in parentheses

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

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Table 11: Heterogeneous Effects by Type of Innovation

	Exports	Quantity	Price	Quantity	Exports	Quantity	Price	Quantity	Exports	Quantity	Price	Quantity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Labor	0.0211	0.0572	-0.0325	0.0248	0.1146	0.0941	0.0227	0.1110	0.1210	0.1101	0.0116	0.1213
	(0.1189)	(0.1158)	(0.04342)	(0.1099)	(0.1182)	(0.1113)	(0.03809)	(0.1114)	(0.1386)	(0.1452)	(0.04603)	(0.1305)
Product Innovation	0.1651	0.0842	0.0652	0.1494								
	(0.5500)	(0.7342)	(0.3206)	(0.5388)								
Process Innovation					0.7666**	0.8616**	-0.0815	0.8009**				
					(0.3493)	(0.3465)	(0.1140)	(0.3454)				
Product and Process Innovation									1.0931**	1.0703**	-0.0185	1.0524**
									(0.5215)	(0.5000)	(0.1726)	(0.5292)
Price				-0.9999***				-0.7452***				-0.9696***
				(0.1944)				(0.1790)				(0.1875)
Product-Country fixed effect	yes	yes	Yes	yes	yes	yes	yes	yes	yes	yes	yes	Yes
Region fixed effect	yes	yes	Yes	yes	yes	yes	yes	yes	yes	yes	yes	Yes
Observations	6,309	6,309	6,309	6,309	7,167	7,167	7,167	7,167	10,595	10,595	10,595	10,595
R^2	0.0097	0.0150	0.0166	0.1371	0.0636	0.0665	0.0190	0.1242	0.1907	0.1832	0.0093	0.2780

Note: Robust standard errors clustered by firms reported in parentheses

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

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