# The effect of innovation on firm export activity in a developing country: evidence from Ecuador

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**Abstract:** Using data from Ecuador's 2015 Innovation Survey, this article examines whether engaging in innovation activities influences firms' export propensity and intensity, in a developing country like Ecuador. Additionally, it explores whether the introduction of innovative technologies influences firms' export behaviour. Given the observational nature of the data, this paper uses the *inverse probability weighting* (IPW) method to generate a counterfactual that can be compared to firms that engage in innovative activities and have introduced innovative technologies. The results suggest that engaging in innovation activities has no effect on firms' export behaviour. However, the introduction of innovative technologies increases a firm's propensity to export, though it does not account for firm differences in export intensity.

**Keywords:** innovation; exports; developing country; inverse probability weighting; IPW; Ecuador.

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## 1 Introduction

Participation in international markets through exports is positively associated with firm performance since it facilitates the exploitation of economies of scale, access to new knowledge and the improvement of technological capabilities (Crespi et al., 2008; Damijan et al., 2017). Furthermore, there is evidence that exporting firms are more capital intensive, have a more qualified workforce, pay higher wages, and invest more in R&D (Damijan et al., 2010; Bravo-Ortega et al., 2014).

Given that exporting firms require a set of products that is attractive to destination markets and productivity levels high enough to compete internationally, innovation is widely considered an effective strategy to achieve success in the export market (Cassiman et al., 2010; Lo Turco and Maggioni, 2015). This is so because firms increase their productivity through the accumulation of knowledge and the introduction of innovative technologies, enabling them to gain a competitive advantage in global markets (Aw et al., 2008; Cassiman et al., 2010; Rodil et al., 2016).

Various, diverse empirical studies examine whether innovation activities affect firms' export behaviour. Overall, they point out that innovation has a positive impact on export behaviour (Aw et al., 2008; Bravo-Ortega et al., 2014; Geldres-Weiss et al., 2016); something that does not necessarily translate to all industries or countries (Damijan et al., 2010; Pagés et al., 2010; Hao et al., 2016). In fact, most studies that find evidence of a positive effect concern developed countries, where firms possess enough technological capabilities to engage in formal R&D activities and introduce innovative technologies to the market (Bayraktutan and Bldlrdl, 2018). However, the effect of innovation on export activity may be different in the context of firms located in a developing country, simply because the innovation activities and technologies developed by these firms are fundamentally different from those developed by firms in more advanced nations (Chaminade et al., 2009; Schwartz and Guaipatín, 2014).

The present work seeks to examine whether being an innovative firm in a developing country like Ecuador has an effect on its export propensity and intensity. A firm is considered innovative if it fulfils one of the following criteria:

1 it has introduced new or significantly improved goods, services, or processes

2 it has engaged in innovation activities or maintains active investments in them

3 it has abandoned innovation activities.

Additionally, because the effect of innovation on export activity is expected to occur primarily after the introduction of innovative technologies, the existence (or not) of an effect of the introduction of innovative technologies on firms' export behaviour is also analysed. Given the observational nature of the data, the researchers use the inverse probability weighting (IPW) method to estimate a causal effect. This method is based on a propensity score which simulates an experimental design by generating a counterfactual control group whose performance can be compared to the treatment groups, which in this case are comprised by firms that are innovative and that have introduced innovative technologies. The results indicate that being an innovative firm has no effect on a firm's export behaviour, while the introduction of innovative technologies has a positive effect on the firm's propensity to export, albeit not its export intensity.

The rest of this paper is organised as follows: Section 2 reviews the existing literature on the effect of innovation on export activity and establishes the work's research questions. Section 3 presents the data and the method used in the estimation. Section 4 discusses the results' implications. Finally, Section 5 concludes.

## 2 Literature review

Innovation is considered an essential strategy to foster export activity. This is so because, through the introduction of new products and processes, firms increase their productivity, rendering them more competitive in the international arena (OECD and Eurostat, 2005; Bravo-Ortega et al., 2014). The phenomenon by which innovation leads firms to enter the export market or to increase their export volume is known in the literature as 'exporting by innovating'.

Many studies find that innovative firms respond with a higher propensity to export and export intensity. Aw et al. (2008) provide evidence of a positive effect of innovation on Taiwanese firms' decision to export. Becker and Egger (2009) also find evidence of a positive effect of product and process innovation on German firms' propensity to export. Bravo-Ortega et al. (2014) show that innovation increases firms' probability of exporting, in Chile. Cassiman and Martinez-Ros (2007) find that innovation has a positive influence on small and medium sized Spanish firms' decision to export. Filipescu et al. (2013) give evidence that both investment in R&D activities and the introduction of new processes has a positive impact on the export activity of Spanish firms. Lachenmaier and Wößmann (2006) show that German manufacturing firms that innovate report a higher export revenue than non-innovative firms. Lo Turco and Maggioni (2015) conclude that product and process innovation drove Turkish firms to export to developed markets. Finally, Rodil et al. (2016) find that innovation activities have a positive effect on the export activity of firms located in the Spanish region of Galicia. On the other hand, some studies find no significant effect between innovation and export intensity and propensity. Damijan et al. (2010) report that product innovation is not significant when analysing the differences between exporting and non-exporting firms in Slovenian firms. Pagés et al. (2010) reveal that studies conducted on firms in Argentina, Chile and Uruguay find no link between innovation and export intensity.

Even when overall the empirical literature reports a positive effect of innovation on the export behaviour of firms, the way in which innovation is quantified varies widely from study to study. This is the case because innovation may be measured by looking at its inputs (investment in innovation activities) or its end results (the introduction of new products and processes).

Numerous studies on innovation and export activity have focused on analysing the effect of R&D investment on export activity. Presumably, firms that invest in R&D exhibit a higher propensity to export, not only because this investment may materialise into innovative technologies that increase a firm's productivity, but because firms that invest in R&D also enhance their capability to absorb external knowledge and technologies, which might ultimately impact its export behaviour. Furthermore, there is evidence that points to the positive effect that the investment in R&D activities has on firms' export activity (Aw et al., 2008; Filipescu et al., 2013; Bravo-Ortega et al., 2014; Rodil et al., 2016).

Although most studies focus on analysing whether R&D investment has an effect on firm export behaviour, R&D investment is not the only innovation input. There exist other types of innovation activities which are more related to the absorption of new knowledge and the adoption of innovative technologies for the introduction of new products and processes (Schwartz and Guaipatín, 2014). Moreover, in the context of a developing country, very few firms invest in R&D activities and most firms that engage in innovation activities invest in other types of activities (Chaminade et al., 2009). These other innovation activities include: the acquisition of machinery, equipment, hardware and software; the acquisition of unincorporated technology: the hiring of technical assistance and consulting services; engineering and industrial design activities; employee training and market research (Anlló et al., 2014; INEC, 2015).

There is evidence of the positive effect that investing in other types of innovation activities has on firms' innovation and economic performance. This observation suggests that these investments could impact firm export behaviour as well. López-Rodríguez and Martínez-López (2017) show that investing in other types of activities has a positive effect on the technological catching-up process and firm productivity in the European Union. Santamaría et al. (2009) find evidence that investing in design has a positive effect on the introduction of new products, that the adoption of advanced equipment results in a positive impact on product and process innovation, and that employee training has a positive effect on the introduction of innovative technologies. Furthermore, there exists evidence that investing in this kind of activities also has a positive effect on firm export behaviour (Sterlacchini, 1999).

As mentioned previously, in developing countries very few firms invest in R&D as most of them invest in other innovation activities. This is the case because the innovation projects firms embark on and the obstacles that present to them are restricted, to a considerable extent, by the characteristics of the institutional context in which they operate (Ocampo-Wilches et al., 2020). In this sense, the innovation activities firms choose to invest in are sorely limited by the absence of organisations that generate scientific knowledge and by the weak cooperation relations that exist among the different agents that participate in the innovation process (Arocena and Sutz, 2002; Chaminade et al., 2009; Crespi and Zuñiga, 2012). As a result, one may expect for developing countries that the effect on export activity of investments in innovation activities be limited by a context in which most innovative firms invest in innovation activities that are more directed towards building technological capabilities than developing new knowledge necessary for the introduction of products and processes which are new to the market. However, various empirical studies show the positive effects technological innovation has on distinct aspects related to firm performance in developing countries (Kiveu et al., 2019; Khaled et al., 2020), or find important differences between innovative and non-innovative firms (Carvalho et al., 2019).

On the other hand, studies that examine the effect of innovation on firm export activity through the introduction of new products and processes emphasise that this effect occurs when innovation is realised in the form of the introduction of innovative technologies. This is the case because the introduction of a new product may be attractive to international markets, which may help increase the firm's export volume. Cassiman and Golovko (2011) indicate that the introduction of new products increases firms' propensity to export thanks to the productivity gains these generate, and because firms will seek to expand to other markets in an effort to increase their sales volume and spread the costs of their innovation activities. Similarly, the introduction of new processes also influences firms' export behaviour since these make possible product quality optimisation and cost reduction (OECD and Eurostat, 2005). Therefore, the introduction of new processes is positively associated with increases in technical efficiency, productivity, and export activity (Cassiman et al., 2010; Damijan et al., 2010). Hence, there is extensive evidence for the positive effect that the introduction of new products and processes has on firms' export behaviour (Cassiman and Martinez-Ros, 2007; Becker and Egger, 2009; Lo Turco and Maggioni, 2015).

Other works on the introduction of innovative technologies and firm export activity have explored the effect of the degree of novelty of the innovations. Dohse and Niebuhr (2018) find incremental innovations have a positive impact on firms' export behaviour, while more radical innovations require more time to take effect. Moreover, they find no significant effect of process innovations or imitation on export activity. Some studies have examined the effect of organisational innovations on export activity in addition to the effect of technological innovation and their degree of novelty. Azar and Ciabuschi (2017) consider the relationship between technological and organisational innovations, and export activity in the case of Swedish firms. Their results suggest that organisation innovations strengthen firms' innovation performance, both directly and by sustaining technological innovations. Yet other studies have taken an interest in examining the existence of persistent effects through time and the complementarities between firms' innovation and export activities. For example, Ayllón and Radicic (2019) use longitudinal data of Spanish manufacturing firms and find complementarity between innovation and export activities only through contemporaneous effects. In addition, their results find no causal relationship between product and process innovations in the past, and present export activity.

Other papers have also examined whether the effect of product and process innovations on export activity varies significantly at a regional level. For example, López-Bazo and Motellón (2017) show that the effect of innovation on firms' export activity is far from uniform across different Spanish regions. Their results suggest that, after controlling for individual firm characteristics, the difference between the export propensity of innovative and non-innovative firms is particularly large in regions with a high extensive margin of exports. However, other studies on the regional influence on innovation find that individual firm characteristics (as opposed to geographical location) prove more relevant when explaining differences in firm innovative behaviour and dismiss the external environment as a determinant of innovation (Disoska and Toshevska-Trpchevska, 2019).

As mentioned in the introduction, the present work aims to examine the effect of innovation on export activity for firms in the context of a developing country like Ecuador. To do so, we set out two research questions. The first one seeks to examine whether being an innovative firm has an impact on firm export propensity and intensity. For the purposes of this work, we define an innovative firm as one which meets one of the following three criteria:

1 the firm has introduced new or significantly improved goods, services, or processes

2 the firm has developed or maintains active investments in innovation activities

3 the firm has abandoned innovation activities.

The first research question is set out as follows:

Q1 Does being an innovative firm impact a firm's export propensity and intensity?

Moreover, given that the effect of innovation on export activity is expected to take place after the introduction of innovative technologies and as the result of the development or abandonment of innovation activities, the present work seeks, specifically, to assess whether the introduction of innovative technologies influences firm export propensity and intensity. To address this, a second research question is set out:

Q2 Does the introduction of innovative technologies influence firm export propensity and intensity?

## 3 Data, variables, and methods

The present study uses data from the Ecuadorian National Innovation Activities Survey (ENAI, by its acronym in Spanish) of 2015 (INEC, 2015). The survey comprises data for a total of 6,275 firms, for the period of 2012–2014 and was conducted by the National Institute of Statistics and Census and the Secretariat of Higher Education, Science and Technology. The initial sample comprised a total of 7,055 firms, drawn from the DIEE-2014 sample frame. 6,275 firms responded to the survey, yielding a response rate of 88.9%. The survey sample includes firms with 10 or more employees in the manufacturing, domestic trade, mining, and service industries. In accordance with the guidelines stated in the Oslo Manual (OECD and Eurostat, 2005), the survey conducted a probabilistic stratified sampling method with Neyman allocation and random selection, using the total sales in 2014 as the design variable. After discarding firms in non-exporting industries and observations with outlier values, the sample used for the present analysis contained 5.381 firms in the manufacturing and service industries. Firms that were removed from the sample include: 218 firms that reported hiring zero employees in any given year of the examined period; 75 firms that reported zero sales in any given year; five firms that reported an average R&D investment above USD1.33 million; 50 firms with reported R&D investments below USD100 for any given year; two firms with a reported a share of R&D investment with respect to total sales that exceeded 30%; ten firms that reported investments in other innovation activities above USD15 million; one firm with a fixed capital investment larger than five times its average total sales over the analysed period; 25 firms with a market share above 95% in their respective industry and 513 firms pertaining to non-exporting industries: construction, electricity, gas, steam and air conditioning supply; water supply, sewerage, waste management and remediation.

Since the aim of the study is to assess whether innovation influences firms' export behaviour, the outcome variables, firm export propensity and export intensity, were selected to capture this behaviour. Both variables' descriptions are summarised in Table 1.

**Table 1** Definition of the outcome variables

| *Name* | *Description* |
|---|---|
| Export propensity (propensity) | Dummy variable taking the value of 1 if a firm reported export sales in 2014 and 0 otherwise |
| Export intensity (intensity) | Export sales divided by total sales for 2014 |

*Source:* Survey data

Regarding the treatment variables, two variables were generated to address each of the research questions. Their definitions and some relevant descriptive statistics are shown in Table 2.

**Table 2** Treatment variables

| *Treatment* | *Description* | *Yes (1)* | *No (0)* | *Total* |
|---|---|---|---|---|
| Innovative firm | Dummy variable taking the value of 1 if the firm meets at least one of the following criteria: 1 the firm has introduced new goods, services, or processes during the period of 2012–2014 2 the firm has developed or maintains active investments in innovation activities (both R&D and others) between 2012–2014 3 the firm has abandoned innovation activities during the period of 2012–2014, and 0 if the firm meets none of these criteria. | 2,342 | 3,039 | 5,381 |
| Introducing firm | Dummy variable taking the value of 1 if the innovative firm has introduced new goods, services, or processes during the period of 2012–2014 and 0 if it developed or maintains active investments in innovation activities or has abandoned said investments but has not introduced innovative technologies. | 1,128 | 1,214 | 2,342 |

*Source:* Survey data

Notice that since treatment variables are defined for the period 2012–2014, the outcome variables were defined for the year 2014. Additionally, notice that the *introducing firm* treatment variable takes the value of 0 for innovative firms that did not introduce any new product or process technologies during the period of analysis. This control group was selected over the control group derived from the *innovative firm* treatment variable to construct the counterfactual because this group of firms is expected to be more similar in terms of non-observable characteristics than the latter. The resulting control group yields a better comparison to the treatment group, considering the method employed, which is described below.

### *3.1 Methods*

Let $T \in [0, 1]$ be one of the treatment variables (*innovative firm* or *introducing firm*) and Y one of the outcome variables (*export propensity* or *export intensity*). Then, the *average treatment effect on the treated* (ATT) may be obtained by using the following expression:

$$\text{ATT} = \text{E}\left(\text{Y}_{1\text{i}} \middle| \text{T} = 1\right) - \text{E}\left(\text{Y}_{0\text{i}} \middle| \text{T} = 1\right) \tag{1}$$

where $Y_{1i}$ is the export propensity or intensity of firm i when it has received treatment T, that is, if firm i is innovative or has introduced innovative technologies; and $Y_{0i}$ is the export propensity or intensity of firm i if it has not received the treatment. However, a methodological problem emerges when looking to compute the effect of innovation on export activity since it is impossible to observe $E(Y_{0i}|T = 1)$ directly, with the available data, as it is a potential outcome. Therefore, the treatment effect may only be estimated by computing the difference between the means of the treatment and control groups,

$E(Y_{1i}|T = 1) - E(Y_{0i}|T = 0)$, with the condition that the treatment be assigned randomly among the firms. Random assignment is a prerequisite because it guarantees that firm characteristics that influence export propensity and intensity are not significantly different between the treatment and control groups in the absence of a treatment, which is to say that $E(Y_{0i}|T = 0) = E(Y_{0i}|T = 1)$. In other words, random assignment ensures that the treatment is independent of the potential outcomes ($T \perp (Y_{0i}, Y_{1i})$).

However, given that we are working with observational data, treatment assignment is not random but dependent on each firm's decision and related to individual firm characteristics, characteristics which might also play a role in determining firm export behaviour. Therefore, there is a need to generate a pseudo control group that is comparable to the existing treatment groups, to simulate an experimental design that may establish the causal effect between being an innovative firm and introducing innovative technologies for export activity. One method that may be used for generating a counterfactual is the IPW method which estimates the ATT through the following expression:

$$\mathrm{ATT} = E\left(Y_{1i} \middle| T = 1\right) - E\left(Y_{0i}\, p(x)/(1 - p(x)) \middle| T = 0\right) \tag{2}$$

As shown in expression (2), a control group is generated by assigning different weights to non-treated firms using p(x), which is the propensity score that captures the probability of receiving a treatment conditioned on a set of covariates measured prior to the treatment assignment (Rosenbaum and Rubin, 1983). Now, this method relies on two assumptions which must be met for the ATT obtained through expression (2) to be trustworthy; they are stated below:

*Assumption 1 [conditional independence assumption (unconfoundedness assumption)]:* conditional on a set of covariates measured prior to the treatment assignment, the potential outcomes are independent of the probability of receiving the treatment. Stated formally, this assumption is shown below:

$$T \perp \left(Y_{0i}, Y_{1i}\right) \middle| p(X) \tag{3}$$

*Assumption 2 (overlap condition):* it requires that the propensity score contains values between zero and one (Imbens and Wooldridge, 2007). It states that each observation has a probability of being treated (or not), given a vector of covariates. Expressed formally, this assumption is characterised as follows:

$$0 < p(T = 1 | X = x) < 1 \tag{4}$$

The first step in using this method consists in using a probit model to estimate the *propensity score p(X)* for treated and non-treated firms, for both treatments. Then, non-treated firms are weighted by the inverse probability of receiving the treatment, as shown in expression (2). This procedure balances the number of observations in each of the control and treatment groups, as imbalances might arise in the process (Imbens and Wooldridge, 2007).

**Table 3** Definition of the variables used in the propensity score model estimation

| *Name* | *Definition* |
|---|---|
| Export propensity | Dummy variable taking the value of 1 if the firm reported an export revenue in 2012 and 0 otherwise. |
| Export intensity | The firm's export sales in 2012 divided by its total sales in 2012. |
| Labour productivity | Natural logarithm of the ratio between the firm's total sales and its number of employees in 2012. |
| Fixed capital investment | Dummy variable taking the value of 1 if the firm invested in fixed capital in 2012 and 0 otherwise. |
| Size | Natural logarithm of the firm's number of employees in 2012. |
| Foreign investment | Dummy variable taking the value of 1 if the firm owns foreign capital and 0 otherwise. |
| R&D* | Dummy variable taking the value of 1 if the firm invested in R&D in 2012 and 0 otherwise. |
| Others* | Dummy variable taking the value of 1 if the firm invested in other innovation activities in 2012 and 0 otherwise. |
| Regional cooperation | Percentage of firms located in the same region as the firm which cooperated in innovation activities with external agents (clients, competitors, suppliers, consultants, science and technology agents, other related firms, the intellectual property office, or other firms belonging to the same business group or parent company). |
| Industry | The model includes seven individual industry dummy variables, aggregated according to R&D intensity. These variables take the value of 1 if the firm falls under a specific industry and 0 otherwise. The industry dummies include:<br>1 low-technology manufacturing industries<br>2 medium-low-technology manufacturing industries<br>3 medium-high-technology manufacturing industries<br>4 high-technology manufacturing industries<br>5 extractive industries<br>6 knowledge-intensive services<br>7 less knowledge-intensive services**. |

Notes: *the variables *R&D* and *others* are only included in the propensity score computation for the treatment *introducing firm*, since in the case of the *innovating firm* treatment, all the observations in the control group take a value of 0.
**the aggregation of industries is based on the ISIC classification at the two-digit level, as follows:
1 C10, C11, C12, C13, C14, C15, C16, C17, C18, C31, and C32
2 C19, C23, C24, C25, C33, and S95
3 C20, C22, C27, C28, C29, and C30
4 C21 and C26
5 B05, B06, B07, and B08
6 J58, J59, J60, J61, J62, J63, K64, K65, K66, M69, M70, M71, M72, M74, M75, N80, P85, Q86, Q87, Q88, R90, R91, R92, and R93
7 B09, G45, G46, G47, H49, H50, H51, H52, H53, I55, I56, L68, M73, N77, N78, N79, N81, N82, O84, S94, S96, T97, T98, and U99.
Notice that category 4: high-technology manufacturing industries, is the reference category in the propensity score computations.

*Source:* Survey data

The construction of a propensity score requires a set of pre-treatment variables correlated with both the treatment and the outcome variables, the lagged outcome variable and the inclusion of variables associated with the geographical location of the firms (Fernández-Sastre and Montalvo-Quizhpi, 2019). Table 3 describes the set of variables used in the model.

Table 4, on the other hand, shows the propensity score estimations for the *innovative firm* and the *introducing firm* treatment variables. These scores are used as weights for determining the effect of each treatment on export propensity. The estimated scores for the effect on export intensity are listed in Appendix 1. Notice that the only difference between both estimated models lies in the outcome variable (*export propensity* or *export intensity*) and its corresponding lagged variable, measured in 2012.

**Table 4** Propensity score derived from the probit model – export propensity

| | ($T_1$) *innovative firm* | ($T_2$) *introducing firm* |
|---|---|---|
| Export propensity | 0.112 (0.11) | 0.107 (0.14) |
| Labour productivity | –0.04 (0.02) | –0.027 (0.03) |
| Fixed capital investment | 0.971 (0.06)*** | 0.13 (0.11) |
| Size | 0.183 (0.02)*** | 0.056 (0.03) |
| Foreign investment | 0.04 (0.10) | 0.013 (0.14) |
| I + D | NA | 0.202 (0.12)* |
| Others | NA | –0.009 (0.10) |
| Regional cooperation | 0.562 (0.20)*** | –0.136 (0.29) |
| 1 Low-technology manufacturing industries | –0.01 (0.34) | –0.803 (0.29)*** |
| 2 Medium-low-technology manufacturing industries | –0.036 (0.35) | –0.487 (0.32)*** |
| 3 Medium-high-technology manufacturing industries | –0.004 (0.35) | –0.371 (0.31)* |
| 5 Extractive industries | –0.15 (0.36) | –0.217 (0.37)*** |
| 6 Knowledge-intensive services | –0.044 (0.34) | –0.706 (0.30)** |
| 7 Less knowledge-intensive services | –0.602 (0.33) | –1.084 (0.29)*** |
| N | 5.381 | 2.342 |
| Pseudo R-squared | 0.199 | 0.027 |

Notes: NA: not applicable to the model; standard errors in parentheses; *p < 0.05, **p < 0.01 and ***p < 0.001.

*Source:* Survey data

The results in Table 4 show that, compared to non-innovative firms, innovative firms have a larger number of employees, a higher propensity to invest in fixed capital and to be located in regions with a higher level of technological cooperation. On the other hand, when comparing firms that introduced innovative technologies and those that engaged in innovation activities but did not introduce innovative technologies, the only variable that is observably different is investment in R&D activities. In other words, firms that introduced innovative technologies to the market between 2012 and 2014 exhibit a higher propensity to invest in R&D. Moreover, the results for the *introducing firm* treatment reveal significant differences among industries.

Once the propensity scores for each treatment have been estimated, the method's key assumptions must be verified. First, the conditional independence assumption cannot be assessed directly since that would require that observable and non-observable characteristics be balanced prior to the treatment. However, this assumption may be checked by assessing the balance between the observable covariates prior to the treatment (Imbens and Wooldridge, 2007). To evaluate the balance between covariates before and after applying the weights, Table 5 shows the differences in means and variance ratios between treated and non-treated groups for the *innovative firm* treatment variable and the *export propensity* outcome variable. Appendix 2 contains the results for the rest of treatment and outcome variable pairings. Notice that following the probit model (treatment – outcome variable) some interaction terms are included. The balance between these interactions is also presented in the tables.

**Table 5** Covariate balance for the treatment – outcome variable pairing: *innovative firm – export propensity*

| *Covariate* | *Standardised differences* | | *Variance ratio* | |
|---|---|---|---|---|
| | *Raw* | *Weighted* | *Raw* | *Weighted* |
| Export propensity | 0.15 | –0.07 | 1.37 | 0.88 |
| Labour productivity | –0.07 | –0.01 | 0.66 | 0.94 |
| Fixed capital investment | 0.83 | –0.07 | 1.04 | 1.06 |
| Size | 0.37 | –0.02 | 1.37 | 1.01 |
| Foreign investment | 0.12 | –0.05 | 1.34 | 0.90 |
| Regional cooperation | 0.58 | 0.00 | 0.99 | 1.02 |
| Labour productivity # foreign investment | 0.11 | –0.04 | 1.22 | 0.95 |
| 1 Low-technology manufacturing industries | 0.29 | –0.07 | 1.62 | 0.93 |
| 2 Medium-low-technology manufacturing industries | 0.09 | 0.02 | 1.42 | 1.09 |
| 3 Medium-high-technology manufacturing industries | 0.18 | 0.06 | 2.05 | 1.23 |
| 5 Extractive industries | –0.14 | 0.00 | 0.41 | 0.97 |
| 6 Knowledge-intensive services | 0.23 | 0.02 | 1.54 | 1.03 |
| 7 Less knowledge-intensive services | –0.49 | 0.01 | 1.03 | 1.00 |

*Source:* Survey data

The results in Table 5 (and the rest of tables in Appendix 2) show the differences in the means of the covariates and the variance ratios prior to treatment, after applying the IPW method. As can be observed, the differences approach zero and the variance ratios are close to one, indicating the covariates have been successfully balanced after the matching process.

An alternative way of checking the balance of the covariates is to perform a chi-square overidentification test, for which the null hypothesis assumes the covariates are balanced (Fernández-Sastre and Montalvo-Quizhpi, 2019). Table 6 shows the results of applying this test to each treatment and the export intensity and propensity outcome variables. As can be observed from the table, for all the treatment-outcome variable pairings the null hypothesis is not rejected, indicating that the observable covariates are balanced.

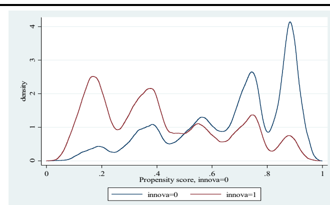
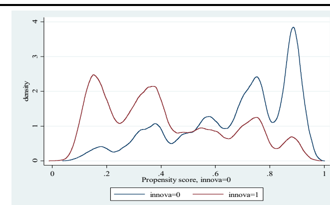
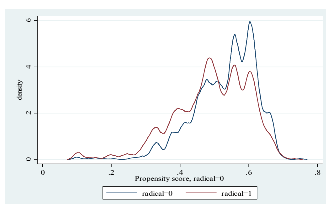
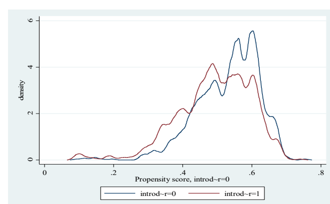
**Table 6** Chi-square test on covariate balancing, by treatment

| $T_i$ | *Export propensity* | | *Export intensity* | |
|---|---|---|---|---|
| | *Chi*$^2$ | *Prob. > chi*$^2$ | *Chi*$^2$ | *Prob. > chi*$^2$ |
| Innovative firm | 14.74 | 0.396 | 14.41 | 0.568 |
| Introducing firm | 15.17 | 0.513 | 15.72 | 0.612 |

*Source:* Survey data

Finally, to assess the overlap condition, Table 7 shows the densities of the probability of being treated, for the treatment and control groups, for each treatment-outcome variable combination. As can be seen, most of the density areas overlap with one another and are not concentrated near 0 or 1, indicating the overlap condition is met.

**Table 7** Overlap condition plots for each treatment (*innovative firm* and *introducing firm*) and outcome variable (*export propensity* and *export intensity*) (see online version for colours)

| $T_i$ | *Export propensity* | *Export intensity* |
|---|---|---|
| Innovative firm |  |  |
| Introducing firm |  |  |

*Source:* Survey data

## 4 Results

Table 8 summarises the results for the ATT for the *innovative firm* and *introducing firm* treatments on the export propensity and intensity outcome variables. The remaining columns present the standard error and p-value of each estimation.

**Table 8** ATT of the *innovative firm* and *introducing firm* treatments on export propensity and intensity

| *Ti* | *Treatment* | *Export propensity* | | | *Export intensity* | | |
|---|---|---|---|---|---|---|---|
| | | *ATT* | *SE* | *P* > \|*z*\| | *ATT* | *SE* | *P* > \|*z*\| |
| $T_1$ | Innovative firm | –0.020 | 0.016 | 0.207 | –0.000 | 0.006 | 0.980 |
| $T_2$ | Introducing firm | 0.029 | 0.014 | 0.036 | 0.005 | 0.006 | 0.394 |

*Source:* Survey data

The results in Table 8 show that the treatment *innovative firm* has no significant impact on neither the firm's export propensity nor its export intensity. On the other hand, the treatment *introducing firm* displays a positive and significant impact on the firm's propensity to export, yet non-significant when the firm's export intensity is concerned.

Notice that the *innovative firm* treatment variable takes a value of 1 if the firm is engaged in innovation activities, regardless of whether it introduced a new technology to the market or not, while the introducing *firm* treatment variable takes a value of 1 only if the firm introduced innovative technologies. Consequently, that the former leaves export propensity and intensity unaffected while the latter has an effect on export propensity suggests that for innovation to impact the firm that engages in it and increase its propensity to participate in international markets, it must materialise into the introduction of new product or process technologies. In other words, the results suggest that investing in innovation activities by itself does not affect firm export behaviour. This result is in direct contrast with most of the evidence reported for developed countries, which maintains that R&D investments increase productivity and the capability to absorb external knowledge and improve firms' export behaviour (Aw et al., 2008; Yu and Dai, 2011; Schwartz and Guaipatín, 2014). One possible explanation for this finding is that, in developing countries, most firms that invest in innovation activities do not invest in R&D but in other innovation activities directed towards building technological capabilities necessary for future innovations (Anlló et al., 2014; Schwartz and Guaipatín, 2014). In contrast to R&D investment, investments in these other innovation activities do not stimulate firms' absorption capability to the extent necessary to increase their propensity to export.

However, the finding that the introduction of new product or process technologies increases firms' propensity to export is in line with the evidence reported for other developed and developing countries (Cassiman and Martinez-Ros, 2007; Nguyen et al., 2008; Becker and Egger, 2009; Chadha, 2009). Along the same line, this result suggests that in the case of Ecuador, firms that introduce innovative technologies are more likely to export compared to those that do not. Finally, the observation that the introduction of innovative technologies has an impact on export propensity but not export intensity suggests that given the imitative and incremental nature of firm innovations in developing countries (Crespi and Zuñiga, 2012; Lo Turco and Maggioni, 2015), the introduction of these types of technologies has no impact on their export volume but might increase their propensity to compete in the international arena. Nevertheless, it is important to note that the treatment introducing firm makes no distinction between the type of technology that firms introduce and that the effect on export intensity might depend on the specific type of technology introduced by the firm (new products or processes).

## 5 Conclusions

The present work uses the IPW method to estimate the impact of innovation on firms' export behaviour, in the case of a developing country like Ecuador. To this aim, we create two treatment variables which reflect a firm's innovative behaviour. The first treatment variable, *innovative firm*, identifies firms that engage in innovation activities (both R&D and other activities), regardless of whether they introduce innovative technologies to the market or not. The second treatment, *introducing firm*, identifies only the firms that did introduce innovative technologies. In this way, we examine whether being an innovative firm or introducing innovative technologies has an effect on the firm's export propensity and intensity.

Our results show that the treatment *innovative firm* has no significant effect on either export propensity or intensity, while there is a positive and significant effect of the treatment *introducing firm* on firms' export propensity. Based on these findings, we argue that in the context of a developing country like Ecuador, investment in innovation activities by itself has no impact on firms' export behaviour and that for innovation to influence firms' propensity to participate in global markets, it must crystallise into the introduction of new products and processes to the market. Investment in innovation activities has no effect on firms' export behaviour because most firms that invest in innovation activities in developing countries do not invest in R&D but in other activities; these activities are not enough to foster firms' absorption capability to the extent necessary to impact their propensity to export. Finally, the fact that the introduction of innovative technologies has an effect on export propensity yet not on export intensity suggests that the specific technologies introduced by the firms have no effect on their export intensity, presumably because of the imitative and incremental nature of innovation in developing countries.

Nevertheless, our results face a set of serious limitations that warrant they be taken with caution. First, the data presents considerable restrictions: the survey is only representative for firms with 10 or more employees, it excludes firms pertaining to the informal sector and it does not collect data on various other aspects that might influence firms' export activity and innovative behaviour. Furthermore, the cross-sectional nature of the data complicates the interpretation of causality in the results. A crucial assumption in this regard is that causality may only be inferred under the assumption that firms in the control and treatment groups are equal with respect to all other factors that influence export activity but for which there is no data, something that seems unlikely.

Despite these limitations, the study's findings have important implications for the implementation of policies aimed at promoting export activity through innovation, in the context of a developing country. Our results suggest that to ease their participation in global markets, it is not enough for firms to engage in innovation activities, but they must also introduce innovative technologies to the market.

## References

Anlló, G., Crespi, G., Lugones, G., Suárez, D., Tacsir, E. and Vargas, F. (2014) *Manual para la Implementación de Encuestas de Innovación*, Inter-American Development Bank, Washington, DC.

Arocena, R. and Sutz, J. (2002) *Innovations Systems and Developing Countries* [online] https://www.researchgate.net/profile/Judith-Sutz/publication/4719334_Innovation_Systems_and_Developing_Countries/links/5537db770cf247b8587ca3a7/Innovation-Systems-and-Developing-Countries.pdf (accessed 19 July 2018).

Aw, B.Y., Roberts, M.J. and Xu, D.Y. (2008) 'R&D investments, exporting, and the evolution of firm productivity', *The American Economic Association*, Vol. 98, No. 2, pp.451–456.

Ayllón, S. and Radicic, D. (2019) 'Product innovation, process innovation and export propensity: persistence, complementarities and feedback effects in Spanish firms', *Applied Economics*, Vol. 51, No. 33, pp.3650–3664.

Azar, G. and Ciabuschi, F. (2017) 'Organizational innovation, technological innovation, and export performance: the effects of innovation radicalness and extensiveness', *International Business Review*, Vol. 26, No. 2, pp.324–336.

Bayraktutan, Y. and Bldlrdl, H. (2018) 'Innovation and high-tech exports in developed and developing countries', *Journal of International Commerce, Economics and Policy*, Vol. 9, No. 3, pp.1–21.

Becker, S.O. and Egger, P.H. (2009) 'Endogenous product versus process innovation and a firm's propensity to export', *Empirical Economics*, Vol. 44, pp.329–354 [online] https://link.springer.com/article/10.1007/s00181-009-0322-6#citeas.

Bravo-Ortega, C., Benavente, J.M. and González, Á. (2014) 'Innovation, exports, and productivity: learning and self-selection in Chile', *Emerging Markets Finance and Trade*, Vol. 50, No. 1, pp.68–95.

Carvalho, N., Raposo, V., Torres, M. and Carvalho, M. (2019) 'Innovative vs. non-innovative manufacturing SMEs: do strategies and goals differ?', *International Journal of Business Innovation and Research*, Vol. 19, No. 2, pp.251–284.

Cassiman, B. and Golovko, E. (2011) 'Innovation and internationalization through exports', *Journal of International Business Studies*, Vol. 42, No. 1, pp.56–75.

Cassiman, B. and Martinez-Ros, E. (2007) *Product Innovation and Exports: Evidence Spanish Manufacturing* [online] https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.616.3672&rep=rep1&type=pdf (accessed 22 January 2021).

Cassiman, B., Golovko, E. and Martínez-Ros, E. (2010) 'Innovation, exports and productivity', *International Journal of Industrial Organization*, Vol. 28, No. 4, pp.372–376.

Chadha, A. (2009) 'Product cycles, innovation, and exports: a study of Indian pharmaceuticals', *World Development*, Vol. 37, No. 9, pp.1478–1483.

Chaminade, C., Lundvall, E., Vang-Lauridsen, J. and Joseph, K.J. (2009) 'Innovation policies for development: towards a systemic experimentation-based approach', in Lundvall, B-A. et al. (Eds.): *Handbook of Innovation Systems and Developing Countries: Building Domestic Capabilities in a Global Setting*, pp.360–379, Edward Elgar Publishing Limited, Cheltenham, UK.

Crespi, G. and Zuñiga, P. (2012) 'Innovation and productivity: evidence from six Latin American countries', *World Development*, Vol. 40, No. 2, pp.273–290.

Crespi, G., Criscuolo, C. and Haskel, J. (2008) 'Productivity, exporting, and the learning-by-exporting hypothesis: direct evidence from UK firms', *Canadian Journal of Economics*, Vol. 41, No. 2, pp.619–638 [online] https://www.jstor.org/stable/25478294.

Damijan, J.P., Kostevc, Č. and Polanec, S. (2010) 'From innovation to exporting or vice versa?', *World Economy*, Vol. 33, No. 3, pp.374–398.

Damijan, J.P., Kostevc, Č. and Rojec, M. (2017) 'Exporting status and success in innovation: evidence from CIS micro data for EU countries', *The Journal of International Trade & Economic Development*, Vol. 26, No. 5, pp.1–27 [online] https://www.tandfonline.com/doi/abs/10.1080/09638199.2016.1271819?journalCode=rjte20.

Disoska, E.M. and Toshevska-Trpchevska, K. (2019) 'Innovation performance of European SMEs: determined by regional or firm specific factors?', *International Journal of Business Innovation and Research*, Vol. 20, No. 2, pp.253–265.

Dohse, D. and Niebuhr, A. (2018) 'How different kinds of innovation affect exporting', *Economics Letters*, Vol. 163, pp.182–185 [online] https://www.sciencedirect.com/science/article/abs/pii/S0165176517305128.

Fernández-Sastre, J. and Montalvo-Quizhpi, F. (2019) 'The effect of developing countries' innovation policies on firms' decisions to invest in R&D', *Technological Forecasting and Social Change*, Vol. 143, No. C, pp.214–223 [online] https://econpapers.repec.org/article/eeetefoso/v_3a143_3ay_3a2019_3ai_3ac_3ap_3a214-223.htm.

Filipescu, D.A., Prashantham, S., Rialp, A. and Rialp, J. (2013) 'Technological innovation and exports: unpacking their reciprocal causality', *Journal of International Marketing*, Vol. 21, No. 1, pp.23–38.

Geldres-Weiss, V.V., Uribe-Bórquez, C., Coudounarisc, D. and Monreal-Pérez, J. (2016) 'Innovation and experiential knowledge in firm exports: applying the initial U-model', *Journal of Business Research*, Vol. 69, No. 11, pp.5076–5081.

Hao, L., Qiu, B. and Cervantes, L. (2016) 'Does firms' innovation promote export growth sustainably? – evidence from Chinese manufacturing firms', *Sustainability*, Vol. 8, No. 11, pp.1–20.

Imbens, G.W. and Wooldridge, J. (2007) 'Lecture 1: estimation of average treatment effects under unconfoundedness', *in Summer Institute 2007 Methods Lectures*, No. 1, Cambridge, MA.

Instituto Nacional de Estadísticas y Censos (INEC) (2015) *Encuesta Nacional de Actividades de Innovación*, Quito [online] http://www.ecuadorencifras.gob.ec/encuesta-nacional-de-actividades-de-ciencia-tecnologia-e-innovacion-acti/ (accessed 25th July 2018).

Khaled, A.S., Ahmed, S., Yahya, A. and Farhan, N. (2020) 'The role of innovation on Indian retail industry', *International Journal of Business Innovation and Research*, Vol. 23, No. 4, pp.453–479.

Kiveu, M.N., Namusonge, M. and Muathe, S. (2019) 'Effect of innovation on firm competitiveness: the case of manufacturing SMEs in Nairobi County, Kenya', *International Journal of Business Innovation and Research*, Vol. 18, No. 3, pp.307–327.

Lachenmaier, S. and Wößmann, L. (2006) 'Does innovation cause exports? Evidence from exogenous innovation impulses and obstacles using German micro data', *Oxford Economic Papers*, Vol. 58, No. 2, pp.317–350.

Lo Turco, A. and Maggioni, D. (2015) 'Dissecting the impact of innovation on exporting in Turkey', *Economics of Innovation and New Technology*, Vol. 24, No. 4, pp.309–338.

López-Bazo, E. and Motellón, E. (2017) 'Firm exports, innovation and the regional dimension in Spain', *Regional Studies*, Vol. 52, No. 4, pp.490–502.

López-Rodríguez, J. and Martínez-López, D. (2017) 'Looking beyond the R&D effects on innovation: the contribution of non-R&D activities to total factor productivity growth in the EU', *Structural Change and Economic Dynamics*, Vol. 40, No. C, pp.37–45 [online] https://econpapers.repec.org/article/eeestreco/v_3a40_3ay_3a2017_3ai_3ac_3ap_3a37-45.htm.

Nguyen, A.N., Pham, N., Nguyen, C. and Nguyen, N. (2008) 'Innovation and exports in Vietnam's SME sector', *The European Journal of Development Research*, Vol. 20, No. 2, pp.262–280 [online] https://www.tandfonline.com/doi/abs/10.1080/09578810802060801?journalCode=fedr20.

Ocampo-Wilches, A.C., Naranjo-Valencia, J.C. and Calderon-Hernandez, G. (2020) 'How the perception of obstacles to innovation affects innovation results: evidence in a developing country', *International Journal of Business Innovation and Research*, Vol. 22, No. 2, pp.281–307.

OECD and Eurostat (2005) *Manual Guidelines for Collecting and Interpreting Innovation Data*, Organization for Economic Co-operation and Development, Oslo.

Pagés, C. et al. (2010) *La era de la Productividad: Cómo Transformar las Economías Desde sus Cimientos*, Inter-American Development Bank, Washington, DC.

Rodil, Ó., Vence, X. and Sánchez, M.d.C. (2016) 'The relationship between innovation and export behaviour: the case of Galician firms', *Technological Forecasting and Social Change*, Vol. 113, Part B, pp.248–265 [online] https://www.sciencedirect.com/science/article/abs/pii/S0040162515002644.

Rosenbaum, P.R. and Rubin, D.B. (1983) 'The central role of the propensity score in observational studies for causal effects', *Biometrika*, Vol. 70, No. 1, p.41.

Santamaría, L., Nieto, M.J. and Barge-Gil, A. (2009) 'Beyond formal R&D: taking advantage of other sources of innovation in low- and medium-technology industries', *Research Policy*, Vol. 38, No. 3, pp.507–517.

Schwartz, L. and Guaipatín, C. (2014) *Ecuador: Análisis del Sistema Nacional de Innovación: Hacia la Consolidación de una Cultura Innovadora*, Inter-American Development Bank, Washington, DC.

Sterlacchini, A. (1999) 'Do innovative activities matter to small firms in non-R&D-intensive industries? An application to export performance', *Research Policy*, Vol. 28, No. 8, pp.819–832.

Yu, M. and Dai, M. (2011) *Pre-Export R&D, Exporting and Productivity Gains: Evidence from Chinese Firms* [online] https://ssrn.com/abstract=1734721 or http://dx.doi.org/10.2139/ssrn.1734721 (accessed 25 July 2021).

## Appendix 1

**Table A1** Propensity score derived from the probit model – *export intensity*

| | ($T_1$) *innovative firm* | ($T_2$) *introducing firm* |
|---|---|---|
| Export intensity | 0.055 (0.20) | 0.032 (0.26) |
| Labour productivity | –0.033 (0.02) | –0.018 (0.03) |
| Fixed capital investment | 0.974 (0.06) *** | 0.132 (0.11) |
| Size | 0.198 (0.02)*** | 0.074 (0.03) |
| Foreign investment | 0.054 (0.10) | 0.029 (0.14) |
| I + D | NA | 0.206 (0.12)* |
| Others | NA | –0.009 (0.10) |
| Regional cooperation | 0.562 (0.20)*** | –0.135 (0.29) |
| 1 Low-technology manufacturing industries | –0.022 (0.33) | –0.81 (0.29)*** |
| 2 Medium-low-technology manufacturing industries | –0.045 (0.34) | –0.492 (0.32)*** |
| 3 Medium-high-technology manufacturing industries | –0.011 (0.34) | –0.376 (0.31)* |
| 5 Extractive industries | –0.154 (0.35) | –0.217 (0.37)*** |
| 6 Knowledge-intensive services | –0.063 (0.33) | –0.72 (0.30)** |
| 7 Less knowledge-intensive services | –0.628 (0.33) | –1.101 (0.29)*** |
| N | 5.381 | 2.342 |
| Pseudo R-squared | 0.198 | 0.026 |

Notes: Standard errors in parentheses; *p < 0.05, **p < 0.01, and ***p < 0.001.

*Source:* Survey data

## Appendix 2

**Table A2** Balance of the covariates for the treatment – outcome variable pairing: *innovative firm – export intensity*

| *Covariate* | *Standardised differences* | | *Variance ratio* | |
|---|---|---|---|---|
| | *Raw* | *Weighted* | *Raw* | *Weighted* |
| Export intensity | –0.04 | –0.01 | 0.76 | 0.86 |
| Labour productivity | –0.07 | –0.01 | 0.66 | 0.91 |
| Fixed capital investment | 0.83 | –0.06 | 1.04 | 1.05 |
| Size | 0.37 | 0.01 | 1.37 | 1.06 |
| Foreign investment | 0.12 | –0.02 | 1.34 | 0.96 |
| Regional cooperation | 0.58 | –0.01 | 0.99 | 1.02 |
| Labour productivity # foreign investment | 0.11 | –0.01 | 1.22 | 0.99 |
| Export intensity # size | 0.03 | 0.02 | 1.10 | 0.99 |
| Export intensity # fixed capital investment | 0.14 | 0.03 | 1.71 | 0.98 |
| 1 Low-technology manufacturing industries | 0.29 | –0.04 | 1.62 | 0.96 |
| 2 Medium-low-technology manufacturing industries | 0.09 | 0.02 | 1.42 | 1.07 |
| 3 Medium-high-technology manufacturing industries | 0.18 | 0.07 | 2.05 | 1.27 |
| 5 Extractive industries | –0.14 | –0.01 | 0.41 | 0.96 |
| 6 Knowledge-intensive services | 0.23 | 0.00 | 1.54 | 0.99 |
| 7 Less knowledge-intensive services | –0.49 | –0.01 | 1.03 | 1.00 |

*Source:* Survey data

**Table A3** Balance of the covariates for the treatment – outcome variable pairing: *introducing firm – export propensity*

| *Covariate* | *Standardised differences* | | *Variance ratio* | |
|---|---|---|---|---|
| | *Raw* | *Weighted* | *Raw* | *Weighted* |
| Export propensity | 0.13 | –0.03 | 1.27 | 0.95 |
| Labour productivity | 0.06 | 0.06 | 0.87 | 0.92 |
| Fixed capital investment | 0.09 | –0.05 | 0.93 | 1.05 |
| Size | 0.19 | 0.04 | 1.19 | 1.08 |
| Foreign investment | 0.15 | 0.09 | 1.35 | 1.18 |
| I + D | 0.26 | 0.02 | 1.52 | 1.03 |
| Others | 0.04 | –0.06 | 0.99 | 1.02 |
| Regional cooperation | –0.10 | 0.00 | 1.00 | 0.98 |

*Source:* Survey data

**Table A3** Balance of the covariates for the treatment – outcome variable pairing: *introducing firm – export propensity*

| *Covariate* | *Standardised differences* | | *Variance ratio* | |
|---|---|---|---|---|
| | *Raw* | *Weighted* | *Raw* | *Weighted* |
| Export propensity | 0.13 | –0.03 | 1.27 | 0.95 |
| Labour productivity # foreign investment | 0.15 | 0.08 | 1.36 | 1.16 |
| 1 Low-technology manufacturing industries | –0.04 | –0.01 | 0.96 | 0.98 |
| 2 Medium-low-technology manufacturing industries | 0.02 | 0.05 | 1.08 | 1.18 |
| 3 Medium-high-technology manufacturing industries | 0.12 | 0.00 | 1.50 | 0.99 |
| 5 Extractive industries | –0.05 | –0.02 | 0.67 | 0.88 |
| 6 Knowledge-intensive services | 0.19 | 0.06 | 1.32 | 1.08 |
| 7 Less knowledge-intensive services | –0.21 | 0.00 | 0.91 | 1.00 |

*Source:* Survey data

**Table A4** Balance of the covariates for the treatment – outcome variable pairing: *introducing firm – export intensity*

| *Covariate* | *Standardised differences* | | *Variance ratio* | |
|---|---|---|---|---|
| | *Raw* | *Weighted* | *Raw* | *Weighted* |
| Export intensity | 0.01 | –0.02 | 0.84 | 0.82 |
| Labour productivity | 0.06 | 0.06 | 0.87 | 0.91 |
| Fixed capital investment | 0.09 | –0.05 | 0.93 | 1.05 |
| Size | 0.19 | 0.04 | 1.19 | 1.09 |
| Foreign investment | 0.15 | 0.09 | 1.35 | 1.19 |
| I + D | 0.26 | 0.03 | 1.52 | 1.04 |
| Others | 0.04 | –0.06 | 0.99 | 1.02 |
| Regional cooperation | –0.10 | 0.00 | 1.00 | 0.98 |
| Labour productivity # foreign investment | 0.15 | 0.08 | 1.36 | 1.16 |
| Export intensity # size | 0.04 | 0.00 | 1.05 | 0.96 |
| Export intensity # fixed capital investment | 0.02 | 0.01 | 0.87 | 0.91 |
| 1 Low-technology manufacturing industries | –0.04 | –0.01 | 0.96 | 0.99 |
| 2 Medium-low-technology manufacturing industries | 0.02 | 0.05 | 1.08 | 1.18 |
| 3 Medium-high-technology manufacturing industries | 0.12 | 0.00 | 1.50 | 1.00 |
| 5 Extractive industries | –0.05 | –0.02 | 0.67 | 0.87 |
| 6 Knowledge-intensive services | 0.19 | 0.05 | 1.32 | 1.07 |
| 7 Less knowledge-intensive services | –0.21 | 0.00 | 0.91 | 1.00 |

*Source:* Survey data