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Abstract

Purpose

This study investigates how both technological and non-technological innovations influence export intensity in small and medium-sized enterprises (SMEs). In addition, we report results for each firm size category of micro, small and medium firms, and thus reflect SME heterogeneity.

Design/methodology/approach

The research methodology is based on the analysis of the Eurobarometer 2014 dataset from 28 EU Member States, Switzerland and the United States covering the period 2011-2014. To statistically test the three defined research hypotheses on individual and joint effects of both types of innovation, a multiple treatment model was estimated. The advantage of this empirical strategy is that it takes into account endogeneity of both technological and non-technological innovations. Moreover, we employ the production approach or the direct test of complementarity between technological and non-technological innovations.

Findings

Empirical findings indicate that technological innovations positively affect export intensity in small and medium firms, while non-technological innovations exert no influence on export intensity, regardless of the firm size. Moreover, the results from the direct test suggest no evidence of the complementary effects of technological and non-technological innovation on export intensity.

Implications

We infer that SMEs would benefit more from public support targeting both exports and innovations than micro firms, as the sunk costs of exports are too high for the latter. However, public support aimed at reducing fixed costs of exports could be particularly beneficial for micro firms.

Originality/value

The research fills a literature gap on the joint impact of technological and non-technological innovations on export intensity while taking into account endogeneity of innovation activities and SME heterogeneity.

Key words: Technological and non-technological innovations; Innovation and exports; SMEs; Multiple treatment model

1. Introduction

This study provides empirical evidence on the individual and joint impacts of technological and non-technological innovations on export behaviour of SMEs. Nowadays, policymakers at national and EU levels consider both innovation and exports as the key determinants of economic growth (Añón Higón and Driffield, 2010). Theoretical and empirical work on the innovation-export link is dominated by the focus on technological (product and process) innovations (Filipescu *et al*., 2013; Hervas-Oliver *et al*., 2016; Lewandowska *et al*., 2016). In the Schumpeterian growth models based on creative destruction, new or significantly improved products create a comparative advantage for firms to successfully enter foreign markets (Tavassoli, 2018). Process innovation, on the other hand, is often adopted because of a fierce competitive pressure in foreign markets. Namely, process innovation is focused on the reduction of production costs, which, in turn, increases firms' efficiency and thus competitiveness (Becker and Egger, 2013).

In contrast to the dominance of technological innovation in innovation studies, research on non-technological (organizational and marketing) innovations is still in its nascent phase, in particular with respect to the innovation-export link. Organizational and marketing innovations are identified in the *Oslo Manual* (OECD, 2005) as integral components of firms' innovation activities. Furthermore, non-technological innovations are often introduced simultaneously with technological innovations, Namely, new products and processes might require organizational changes and/or new marketing strategies (Azar and Drogendijk, 2016). The lack of underlying theoretical framework and of empirical evidence on the impact of non-technological innovations is even more prominent in the context of small and medium-sized enterprises (SMEs). Our objective is to fill in this gap in the literature and to further extend our investigation by taking into account SME heterogeneity. Namely, SMEs are usually considered as a homogenous group of firms, although the literature recognizes their differences in resources, capabilities and strategies (Flynn *et al*., 2015). In accordance with this supposition, our objective is to explore SME heterogeneity in relation to the effectiveness of technological and non-technological innovations in facilitating export intensity by extending the studies by Becker and Egger (2013), Imbriani *et al*. (2014) and Lewandowska *et al*. (2016).

We offer a number of extensions on the existing literature. First, most studies on the effectiveness of innovation in promoting exploring focus on large manufacturing firms (Añón Higón and Driffield, 2010), while our study provides evidence for SMEs. In addition, not only that we explore the innovation-export link in SMEs, but we also take into account that SMEs are not a homogenous firm size category because of different resources, capabilities and obstacles they encounter (Hervas-Oliver *et al*., 2016; Ortega-Argilés *et al*., 2009). Thus, we separately analyse micro, small and medium-sized firms, but also large firms for the comparative purposes. Second, very few studies adopt a broad perspective of innovation by including technological and non-technological innovations, in particular, in exploring innovative behaviour in SMEs (Battisti and Stoneman, 2010; Hervas-Oliver *et al*., 2016). In this respect, this study contributes to a scant empirical evidence on the effectiveness of non-technological innovations, with the focus on different SME firm size categories. Third, besides investigating individual effects of technological and non-technological innovations on exports, we also model their simultaneous adoption and a potential complementary effect on exports. Fourth, we report both absolute effects (when the comparison groups are non-innovating firms) and relative effects between different treatment levels (i.e. between technological and non-technological innovations; between the joint effect and technological innovations; and between the joint effect and non-technological innovations). Finally, most previous empirical studies are country-specific, while our study encompasses information on firms from 28 EU Member States, Switzerland and the United States.

The study is organized as follows. In the next section, we review theoretical frameworks at the macro and micro level that explain the innovation-export link. The next section discusses exporting activities in SMEs, followed by the section in which hypotheses are formulated. The Methodology section reviews the dataset and empirical strategy employed in this study, followed by the explanation of the model specification and the presentation of empirical findings. The next section presents the production approach or the direct test of complementarity while the final section concludes and offers some policy implications.

2. Literature review and research hypotheses

European Commission (2015) discusses the trends in SMEs' performance in 2014, noting that 99.8 per cent of the EU firms operating in the non-financial business sectors are SMEs, and majority of them (93 per cent) are micro firms (with less than 10 employees). Moreover, in 2014, SMEs employed almost 90 million people (67% of total employment) and generated 58% of the sector's value added.

Besides firms' competencies and international experience, firm size is regarded as a fundamental determinant of exporting, given that large firms exhibit scale economies and specialization, have more technological resources and better access to financial resources than smaller firms to enter and successfully compete in foreign markets (Álvarez, 2004; Dhanaraj and Beamish, 2003; Gashi *et al*., 2014; Harris and Li, 2009; Kirbach and Schmiedeberg, 2008; Lefebvre and Lefebvre, 2001; Love *et al*., 2016; Wheeler *et al*., 2008).

Melitz (2003) developed a theoretical model of exporting by explicitly modelling firm heterogeneity. The prediction of the model is that only highly productive firms will export (i.e. self-selection of firms into exporting), because their high productivity leads to higher profits, which, in turn, enable these productive firms to cover large sunk costs of exports (Ganotakis and Love, 2010; Gashi *et al*., 2014; Imbriani *et al*., 2014; Love and Ganotakis, 2013). The model has important implication for SMEs. Given the constraints associated with the lack of human and financial resources, SMEs are expected to have a lower export participation than larger firms due to economies of scale and large sunk costs. In addition, the latter leads to hysteresis in exports, i.e. large firms are more likely to persistently export than their smaller counterparts (Gashi et *al*., 2014). Consistent with Melitz's (2003) argument, Harris and Li (2009) report that the probability of exports is directly related to firm size, i.e. smaller firms are between 17 and 28 per cent more likely to export than micro firms, while medium-sized firms have 36 per cent higher probability of exports than micro firms.

Although there is a large number of empirical studies exploring the innovation-exports link, most of them focus on large firms (Añón Higón and Driffield, 2010; Ganotakis and Love, 2010). Thus, our study aims to contribute to this stream of research by focusing on SMEs. In addition, we take into account SME heterogeneity such that SMEs are not a homogenous group of firms but vary in their capabilities, objectives and obstacles across industry sectors and size groups (Flynn *et al*., 2015; McKevitt and Davis, 2015; Morrissey and Pittaway, 2006). Therefore, we separately analyse micro, small and medium firms, but also large firms for the comparative purposes.

Two different economic disciplines identified the role of technological innovations in firms' export participation and propensity. First, international economic theory posits that the two critical factors for export propensity are investment in firm-specific assets and high total factor productivity (TFP). The former can be associated with product innovation (Becker and Egger, 2013; Caldera, 2010). Second, within industrial economics, Spencer and Brander (1983) were among the first scholars to explore the effects of cost-reducing innovation (i.e. process innovation) in international oligopoly models. That is, process innovation enables firms to charge lower prices and be more profitable in foreign markets than non-innovating firms (Becker and Egger, 2013).

According to Schumpeter's model of creative destruction, product innovation is the critical factor in accessing foreign markets (Becker and Egger, 2013). Product innovation can positively influence the probability of exporting if firms expand the demand through horizontal product differentiation (introducing new products), vertical product differentiation (upgrading existing products), by entering new markets and by affecting demand for new products. Process innovation enable firms to reduce marginal costs and thus attain a cost advantage over foreign rival firms. The purposes of process innovation can be to decrease costs of production or delivery, to enhance product quality or to produce a new product (Álvarez, 2004; Beveren and Vandenbussche, 2010; Caldera, 2010; D'Angelo, 2012; Ganotakis and Love, 2010; Kirbach and Schmiedeberg, 2008; Lewandowska *et al*., 2016).

Caldera (2010) develops a theoretical model which predicts that innovating firms have a higher probability of exporting than non-innovating firms. Namely, innovating firms are more profitable than non-innovating firms, because they have lower marginal costs of production, which allows firms to charge lower prices, which, in turn, will increase total revenue more than proportionally, because it is assumed that demand is elastic. Another prediction of the model is that, if innovation entails some fixed costs, more productive firms will self-select themselves into innovating because benefits from innovation are an increasing function of firm productivity. (More productive firms will engage in innovation given the increase in total sales as a result of reduction in marginal costs, and this increase is positively associated with productivity.)

However, Wakelin (1998) found that the UK innovating firms are less likely to export than non-innovating firms of the same size. Additionally, large innovating firms are likely to export than smaller innovating firms. Wakelin (1998) and Álvarez (2004) note that a potential explanation for this finding is that the fixed costs of entering foreign markets are higher for smaller firms. These findings have motivated our study which explores SME heterogeneity with respect to innovation-exports link.

Most empirical studies exploring the innovation effects on exports utilize R&D activities as a measure of innovation (for a review, see e.g. D'Angelo, 2012; Ganotakis and Love, 2010; Nguyen *et al.*, 2008). These studies mostly report a weak association between innovation and exports (Añón Higón and Driffield, 2010; Becker and Egger, 2013). Recently, scholars begin using measures of innovation outputs, such as the introduction of product and process innovations (see e.g. Añón Higón and Driffield, 2010, Becker and Egger, 2013; Beveren and Vandenbussche, 2010; Caldera, 2010; Damijan *et al.*, 2010; Filipescu *et al.*, 2013; Ganotakis and Love, 2010; Roper and Love, 2002; Tavassoli, 2018). Product and process innovations, as innovation output indicators, allow more precise investigation than R&D investments of mechanisms through which innovation activities influence exports (Caldera, 2010; Ganotakis and Love, 2010; Tavassoli, 2018). Ganotakis and Love (2010) and Roper and Love (2002) conclude, based on a number of studies that report an insignificant influence of R&D investment on exports, that firms' competitiveness in foreign markets is primarily determined by their capacity to compete in foreign markets, rather than their investment in research activities. Moreover, using innovation output indicators rather than innovation inputs (i.e. R&D investment) is particularly relevant in the case of SMEs, whose engagement in R&D is often underreported because they are either too small to have a separate R&D department or R&D budget, but still innovate (Filipescu *et al.*, 2013; Ganotakis and Love, 2010; Love *et al.*, 2016; Wakelin, 1998).

Empirical evidence is on the effectiveness of product and process innovations in stimulating exports are inconclusive. Concerning product innovations, though, majority of empirical studies reports a positive effect (e.g. Becker and Egger, 2013; Caldera, 2010; Kirbach and Schmiedeberg, 2008; López Rodríguez and García Rodríguez, 2005; Tavassoli, 2018), while some studies find no effect (Beveren and Vandenbussche, 2010; Damijan *et al.*, 2010; Love *et al.*, 2016). Opposite holds for process innovation; most studies indicate no effect of process innovation on exports (Becker and Egger, 2013; Beveren and Vandenbussche, 2010; Damijan *et al.*, 2010; Kirbach and Schmiedeberg, 2008; Love *et al.*, 2016), while few report a positive effect (Caldera, 2010; López Rodríguez and García Rodríguez, 2005).

Product and process innovations are often introduced simultaneously, which suggests their potentially complementary effect on exports (Becker and Egger, 2013; Beveren and Vandenbussche, 2010; Evangelista and Vezzani, 2010; Kirbach and Schmiedeberg, 2008; Lewandowska *et al.*, 2016; Nguyen *et al.*, 2008). Indeed, Becker and Egger (2013) report the complementary effects of product and process innovation on exporting activities in Germany. In contrast, Beveren and Vandenbussche (2010) find no effect, individual or joint, of product and process innovations on exports in Belgium. Di Maria and Ganau (2014) find a heterogeneous effect of product and process innovation, conditional on the measure of exports. Namely, while product innovation positively influences firms' decision to enter foreign markets (export propensity), process innovation has a positive effect on export intensity (Lewandowska *et al.*, 2016). Although these studies take into account endogeneity of innovation with respect to exports, their differentiated findings could imply that the innovation-exports link is country-specific.

Becker and Egger (2013) argue that, consistent with the new trade theory, product innovation has a larger effect on firms' propensity to exports than process innovation. This proposition is confirmed by Becker and Egger (2013) in their study of the individual and joint effects of product and process innovations in German firms. In addition, they report that process innovation in isolation has no effect on the probability to export, while only when combined with product innovation, it results in a positive influence on exports. Similar findings are reported in Lo Turco and Maggioni (2015), who found that product innovation has a greater effect on export performance of Turkish firms than process innovation, while their joint effect is the largest.

Lachenmaier and Wößmann (2006) report insignificant effects of product and process innovation on exports when adopted in isolation, but a positive joint effect in German firms. They conclude that their results support the product-cycle theory of internationalization. The magnitude of this joint effect is seven percentage points. These results are directly comparable to ours, as the authors use the same measure of exports (export intensity - a percentage share of exports in sales) and the same measures of product and process innovations. However, while we explore different firm size categories separately, this division is not utilized in Lachenmaier and Wößmann (2006). Thus, we formulate the following.

H1: The impact of technological innovations in isolation (without non-technological innovations) on export intensity is positive among all firm size categories.

The *Oslo Manual* (OECD, 2005) identified non-technological, organizational and marketing, innovations as relevant components of firms' innovation activities [1]. Yet, while the theoretical and empirical work on technological innovations is abundant, little is known about non-technological innovations (Azar and Ciabuschi, 2017; Azar and Drogendijk, 2016;

Evangelista and Vezzani, 2010). This pattern is also pertinent to the studies exploring the innovation-exports link (Lewandowska *et al*., 2016), although the literature suggests that both technological and non-technological innovations constitute important sources of firms' competitive advantage (Azar and Drogendijk, 2016). Given their weak absorptive capacity, SMEs could particularly benefit from non-technological innovations, as they need to rely on the external environment to drive innovation through new marketing, design or organizational practices (Hervas-Oliver *et al*., 2016) [2]. With respect to organizational innovation, SMEs are characterized by efficient and informal internal communication networks and the lack of bureaucracy (Rothwell and Dodgson, 1991). Because of these characteristics, small firms are able to quickly respond to internal problem solving as well as reorganise rapidly to adapt to changes in the external environment. In contrast, large firms are often locked in their organizational routines (Anderson and Thushman, 1990) and bureaucratic constraints that produce inertia in adopting organizational innovations (D'Angelo, 2012).

Focusing on the impact of organizational innovation on export performance, its indirect effect is associated with the complementary nature of technological and non-technological innovations (Azar and Ciabuschi, 2017). Namely, often firms need to introduce organizational innovation in tandem with product and process innovations. New products and processes might require the reorganization of business routines (which might result in new organizational models) and/or the establishment of new divisions or departments and a consequent reorganization of workflows (Azar and Ciabuschi, 2017; Morone *et al*., 2013). On the other hand, a direct effect of organizational innovation on export performance is related to organizational changes as a response to changes and uncertainties pertinent to highly competitive foreign markets (Azar and Drogendijk, 2016).

Concerning marketing innovation, unlike large firms which have comprehensive distribution and servicing facilities (Rothwell and Dodgson, 1991), smaller firms often lack marketing expertise and financial resources for marketing activities (Hwang *et al*., 2015; O'Dwyer *et al*., 2009). But at the same time, because of their efficient internal communication and their flexibility, small firms can react quickly to customers' needs while improving the quality and variety of their products and keep abreast of fast changing market requirements (Hwang *et al*., 2015; Rothwell and Dodgson, 1991). Similar to organizational innovation, marketing innovation can have direct and indirect effects on export performance. The latter occurs when the introduction of new products or processes in foreign markets requires a new marketing strategy. Export performance is directly affected when firms adapt their distribution, pricing and promotion strategies specifically related to foreign markets.

Based on the above arguments on the impact of non-technological innovations on firms' innovation and export performance, we formulate:

H2: Non-technological innovations in isolation have a positive effect on export intensity in all firm size categories.

Little is known about the links between non-technological, marketing and organizational, innovations, as well as between technological and non-technological innovations (Battisti and Stoneman, 2010; Evangelista and Vezzani, 2010). Recent theoretical and empirical research indicate that firms simultaneously adopt different types of innovation, rather than introducing individual innovations in isolation (Battisti and Stoneman, 2010; Doran, 2012; Evangelista and Vezzani, 2010). The assumption underlying this theoretical argument is associated with the fact that the simultaneous introduction of complementary innovations can significantly improve productivity and quality, and often results in higher firm profitability than the adoption of single innovations in isolation (Aboal and Garda, 2016; Battisti and Stoneman, 2010; Evangelista and Vezzani, 2010).

The literature on marketing innovation suggest a mutual causality between product and marketing innovations. First, the causality from marketing activities to product innovation can be explained by the fact that marketing activities in foreign markets enhance firms' knowledge about international markets and enable firms to adjust their behaviour and performance in accordance to conditions in a dynamic international market environment (Lewandowska *et al*., 2016). Among others, firms' changes in behaviour include product innovations. Second, the causality from marketing to product innovation suggests that the introduction of new products is often accompanied by changes in design and packing, the creating of new distribution channels, and by changes in product promotion (Lewandowska *et al*., 2016).

With respect to the relationship between technological and non-technological innovations in the context of SMEs, the literature suggests two opposing linkages: while Rammer *et al*. (2009) posit that non-technological innovations are substitutes for technological-innovations, Hervas-Oliver *et al*. (2016) and Radicic *et al.* (forthcoming) find a complementary effect of technological and non-technological innovations on innovation performance. That is, SMEs experience a premium or additional effect if they adopt non-technological innovations together with technological innovations (Evangelista and Vezzani, 2010; Hervas-Oliver *et al*., 2016). However, these studies examined the influence of the simultaneous adoption of technological and non-technological innovation on innovation performance. Our objective is to investigate whether these types of innovations exert complementary effects on exporting activities.

Lewandowska and Golebiowski (2014) explicitly model all four types of innovation (product, process, marketing and organizational) and their impact on export participation in Bulgaria, Czech Republic, Hungary, Poland, and Romania. The results from a logistic model reveal a positive effects of product innovation in all countries, while other types of innovation have heterogeneous effects on exports. Imbriani *et al*. (2014) investigate the effects of technological and non-technological innovations on the expected export participation in Italian SMEs. Empirical findings from a probit model suggest that firms' decision to export is positively associated with product innovation and with non-technological innovations, if the latter are not introduced simultaneously with technological innovations. Álvarez (2004) uses a probit model to explore the influence of product, process and organizational innovations on export performance of Chilean SMEs. His results suggest that process innovation positively affects exports, while product and organizational innovations have no effect. Lewandowska *et al.* (2016) report complementary effects of product, process and marketing innovations on exports in Polish firms.

However, these previous studies do not take into account the endogeneity of non-technological innovation. If firms self-select themselves into technological innovations, the same argument holds for non-technological innovations as well. Thus, endogeneity between innovation and exports should be appropriately treated regardless of the type of innovation (or their combinations) under investigation. In this respect, our study complements the previous empirical work (Imbriani *et al*., 2014; Lewandowska and Golebiowski, 2014; Lewandowska *et al*., 2016), but, at the same time, goes one step further by treating non-technological innovation as endogenous and exploring the joint effect of technological and non-technological innovations on exports. Thus, we formulate:

H3: The joint impact of technological and non-technological innovations on export intensity is positive in all firm size categories.

3. Methodology

Sample and data

The data used in the study is Flash Eurobarometer 394 - "The role of public support in the commercialisation of innovations" survey, which includes firms from 28 EU Member States, Switzerland and the United States (European Commission, 2014a) and covers the period from January 2011 to February 2014. The survey was requested by the Directorate-General for Enterprise and Industry and carried out by TNS Political & Social network (for details on sampling see European Commission, 2014a). In total, 12,108 firms were interviewed. Due to missing values, the effective sample includes 11,169 firms.

The definition of innovation adopted in the survey is as follows: “Innovation occurs when a company introduces a new or significantly improved good, service, process, marketing strategy or organisational method. A company can develop the innovation itself or acquire it from other companies or organisations” This broad definition of innovation is in accordance with the *Oslo Manual* (OECD, 2005), thus encompassing both technological (product and process) innovations and non-technological (organizational and marketing) innovations.

In this study, micro-sized firms are defined as those with fewer than 10 employees, small firms with more than 10 and fewer than 50 employees and medium-sized firms with more than 50 and fewer than 250 employees. This definition is also consistent with the new European Commission (2008) guideline. Firms from individual countries were grouped into four categories following the European Innovation Scoreboard (European Commission, 2014b). The European Innovation Scoreboard publishes the average innovation performance based on a composite index, encompassing 25 individual indicators grouped into five categories: three measuring innovation input; and two representing innovation outputs. Innovation performance of each Member State is then compared to the average innovation performance of the 28 EU Member States and each country is allocated to one of four groups (for the countries in each category, see Appendix Table A1).

- *'Innovation leaders'*, six countries whose innovation performance is well above the EU28 average.
- *'Innovation followers'*, ten countries with performance close to the EU28 average;
- *'Moderate innovators'*, eleven countries whose performance is below that of the EU28 average; and
- *'Modest innovators'*, representing three countries whose performance is well below that of the EU28 average.

Table A1 in the Appendix depicts variable descriptions and summary statistics (mean and standard deviation). As expected based on theoretical and empirical work, export intensity steadily increases when looking at different firm size categories. That is, while the average exports’ share in sales in the whole sample is 12.6 per cent, micro firms report 6.2 per cent, this share is double for small firms (12.7 per cent) and even five times greater in large firms

(28.9 per cent). With respect to other firm characteristics, in the whole sample, on average, 12.9 per cent are young firms that are established after January 2008, and the largest percentage is reported for micro firms (20 per cent), while only 3.3 per cent of large firms belong to this category. The average turnover in 2013 reported by all firms is above 1.3 million euros, ranging from more than 250,000 euros in micro firms to approximately 50 million euros in large firms. As expected, the share of firms engaged in R&D activities, similar to export intensity, steadily increases from micro to large firms. Accordingly, on average, 27 per cent of all firms reported to have conducted R&D activities, which ranges from less than a fifth of micro firms (17.6 per cent) to more than a quarter of small firms (27.7 per cent), and more than a half of large firms (55.7 per cent).

Concerning market structure and competition pressure, as expected, the smallest number of firms reported to have no or one competitor (variable *Monopoly*), irrespective of the firm size (on average, only 4.2% per cent of firms operate in a monopoly). For firms with a few competitors (variable *Oligopoly*), similar shares of firms of all sizes report to operate in this market structure (on average, 35.8 per cent in the whole sample), although this share increases with the firm size (from 32.5 per cent of micro firms to 42.2 per cent of large firms). A similar pattern is observed for firms that reported tens of competitors (variable *Monopolistic competition*). Finally, the pattern is reversed for perfect competition. Here, the share of firms operating in perfect competition is largest for micro firms (30.6 per cent), and steadily decreases with the firm size, so the share of large firms is 14.2 per cent.

Econometric strategy

In assessing the impact of innovation on exports, our empirical strategy encompasses the use of a matching estimator, which is motivated by endogeneity of innovation due to self-selection of firms into innovation activities and reverse causality between innovation and exports, as discussed above (Álvarez, 2004; Añón Higón and Driffield, 2010; Becker and Egger, 2013; Beveren and Vandenbussche, 2010; Caldera, 2010; Damijan *et al*., 2010; Ganotakis and Love, 2010; Gashi *et al*., 2014; Harris and Li, 2009; Lachenmaier and Wößmann, 2006; Love and Ganotakis, 2013; Nguyen *et al*., 2008). Many previous empirical studies investigating the effectiveness of innovation in promoting firms' exports at the firm level fail to take into account the endogeneity of innovation and rather treat it as exogenous (Becker and Egger, 2013; Lachenmaier and Wößmann, 2006).

Given that we investigate the impact of technological and non-technological innovations on exports, their effect must be estimated as a treatment assignment, whereby the treatment variable is defined as follows.

- treatment =0 if a firm did not introduce technological and non-technological innovations since January 2011;
- treatment =1 if a firm introduced technological but did not introduce non-technological innovations since January 2011;
- treatment =2 if a firm did not introduce technological but did introduce non-technological innovations since January 2011;
- treatment =3 if a firm introduced both technological and non-technological innovations since January 2011 [3].

By considering the introduction of technological and non-technological innovations as the treatment variable, our empirical strategy focuses on estimating the Average Treatment on the Treated (ATT) effect. We follow the most common approach in this kind of research, which is to match by means of propensity scores participating (treated) firms to non-participating (non-treated) firms with similar characteristics, which thus constitute a comparison group, and then to estimate the difference between cooperative behaviour for firms receiving a particular treatment, as the outcome of interest (Y_1), and the outcome for the comparison group of firms (Y_0) (Cerulli, 2010) [4].

To safely attribute the estimated difference to a treatment assignment, the treated firms must be similar to the untreated firms in all respects except for innovation activities (types of innovation as the treatment variables). In turn, this depends on two identifying assumptions: the conditional independence assumption (CIA), or selection on observables, which posits that the outcome in the case of no treatment (Y_0) is independent of treatment assignment (T), conditional on covariates X (Imbens 2004; Imbens and Wooldridge 2009); and the overlap or common support condition, whereby the estimated propensity scores take positive values (Heckman and Vytilacil 2007).

Regarding the selection of covariates X, the literature suggests that all observed variables that simultaneously affect treatment assignment and the outcome should be included in the estimation of propensity scores (Caliendo and Kopeinig 2008; Steiner *et al.* 2010). Following Steiner *et al.* (2010), in situations when researchers have little or no information on the selection mechanism, the optimal modelling strategy is to include a large set of covariates, because this approach increases the probability of satisfying the assumption of selection on observables.

To take into account that technological and non-technological innovations are carried out simultaneously, we estimate treatment effects in the multiple treatment context. A matching approach with multiple treatments is first introduced by Lechner (2001). We have M+1 treatments, whereby treatment equal to zero denotes the absence of the introduction of either technological or non-technological innovations (see e.g. Becker and Egger, 2013; Lo Turco and Maggioni, 2015). The average treatment effect on the treated (ATT) effect is then calculated as:

$$ATT = E(Y^m \mid T = m) - (Y^l \mid T = m) \qquad (1)$$

Where m denotes the treatment level, l represents the comparison group (the treatment level to which m is compared), and Y^m and Y^l denote outcomes in states m and l respectively.

We employ the inverse probability of treatment weighting regression adjustment (IPWRA) estimator. The main advantage of this estimator is its double robust property. If either the propensity score model (the outcome model) or the treatment model is correctly specified, then this estimator will yield treatment effects with a lower bias than will other estimators that are not characterized by the double-robustness property (Hirano *et al*. 2003). Busso *et al.* (2014) conducted a Monte Carlo simulation of the finite sample properties of a range of matching and reweighting estimators – which include the IPWRA – in the estimation of ATTs. Their findings support our use of the IPWRA: first, we use normalised reweighting, which exhibits overt bias of the same magnitude as pair matching but much smaller variance; second, their findings suggest that normalised reweighting outperforms matching estimators when overlap is good, which is the case in our study.

The IPWRA estimator consists of three steps. First, the treatment model estimates, for each firm in the sample, the propensity score, which is the probability for each firm of participation ("treatment assignment"). Given that we evaluate multiple treatment effects, the propensity scores are estimated by a multinomial logit model, incorporating all four treatment levels: neither technological nor non-technological innovations; only technological innovations; only non-technological innovations; and both. The choice of the model is motivated by the nature of our treatment variable, which has more than two outcomes with no natural ordering. The propensity scores enable firms to be matched within each treatment level. Second, regressions are estimated by the fractional logit model, because the outcome variable

(*Export intensity*) is the export-sales ratio, in which the inverse of the estimated propensity scores are used as weights on covariates *X* and our treatment dummies. Third, from each of these regressions, the ATT effect is computed as the difference in the weighted averages of the predicted outcomes (for technical details see Wooldridge 2010). This three-step approach provides consistent estimates given the underlying assumption of the independence of the treatment from the predicted outcomes once covariates are modelled in steps 1 and 2. We report valid standard errors (of the Huber/White/sandwich type) which take into account that the estimates are computed in a three-step approach (Emsley *et al*. 2008).

Model specification

The outcome variable is *Exports intensity*, denoting the percentage of sales from exports (see Table A1 for variable description). Exporting is an important, and often the initial, mode of internationalization of SMEs (Dhanaraj and Beamish, 2003, Love *et al*., 2016). A common measure of the degree of internationalization of SMEs is export intensity (D'Angelo, 2012; Dhanaraj and Beamish, 2003; Wolff and Pett, 2000). In our study, similar to D'Angelo (2012) and Dhanaraj and Beamish (2003) and Gashi *et al*. (2014), export intensity is measured as the percentage of export sales to total sales. This is considered as a better measure of SME performance in foreign markets than other measures of innovation intensity, such as export market share, export sales growth, exports profit etc. (D'Angelo, 2012; Ramaswamy *et al*., 1996). Love *et al*. (2016) note that much of empirical evidence supports the positive link between innovation and the probability of exports, but much less support is found for a positive associate between innovation and export intensity (our measure of exports). Therefore, from this perspective, our study contributes to a scant literature examining the effectiveness of innovation in facilitating export intensity. In addition, Love *et al*. (2016) hypothesized and found support that technological innovations (and R&D activity) have no effect on export intensity in the UK SMEs.

We control for firms' business experience by including variable *Young* equal to 1 if a firm was established after January 2008 and zero otherwise, given that older firms might be more innovative than their younger counterparts (Caldera, 2010). In addition, firms' experience affects their productivity level through learning-by-doing effects (Gashi *et al*., 2014). Following Arnold and Hussinger (2005), younger firms might benefit from experience, while older firms are less likely to gain more experience (Gashi *et al*., 2014). Regarding absorptive capacity, the model includes a binary variable *R&D activity* equal to 1 if a firm carried out R&D either in-house or by subcontracting and zero otherwise in the period January 2011-February 2014 (Caldera, 2010). We also controlled for patent application, as a measure of an intermediate innovation output. The variable *Patents* is equal to 1 if a firm applied for one or more patents or trademarks and zero otherwise.

Añón Higón and Driffield (2010) note that firm-specific characteristics in relation to environmental risks, such as financial and competitive, are very important for SME export behaviour. Thus, we control for competition in the main market by including three dummy variables in the model: *Monopoly* if a firm report no competition or one competitor in the main market (zero otherwise); *Monopolistic competition* if a firm reported "Tens" as the number of competitors (zero otherwise); and *Perfect competition* if a firm reported "Hundreds" and "Too many to count" as the number of competitors (zero otherwise) (the base category is *Oligopoly* if a firm reported "A few" as the number of competitors; zero otherwise). To account for firms' financial performance, in the absence of other relevant measures (such as profitability), we modelled firms' turnover in 2013 (variable *Turnover*) (in natural logarithm). This is consistent with Becker and Egger (2013) and Aw *et al*. (2009) in controlling for firms' productivity.

Finally, the models include binary indicators for three country groups: Innovation leaders; Innovation followers; and Modest innovators (Moderate innovators is the base category). To control for industry effects, we utilized the already-created variable in the dataset dividing industries into four categories: manufacturing (NACE category C); retail (NACE categories G); services (NACE categories H, I, J, K, L, M, N, and R); and industry (NACE categories D, E, and F). The base category is manufacturing. Table A3 in the Appendix shows the number of firms by country and industry.

4. Empirical results

Table 1 shows results from the multinomial logit model of the outcome variable *Exports intensity* for micro firms, in which the base is treatment at level 0 (no introduction of technological and non-technological innovations) [5]. Table 1 also reports the treatment (selection) model. The treatment model shows the effects of covariates on the probabilities of different levels of treatment, while the outcome model estimates the impact of covariates on the export-sales ratio. The coefficients in the models are not of interest in themselves, as the purpose of specifying the multinomial logit model is to facilitate the estimation of treatment effects (Cattaneo *et al.* 2013).

[TABLE 1 NEAR HERE]

Before estimating treatment effects, we need to check the quality of matching. In doing so, we perform two tests. First, treatment effects of any matching estimator based on the propensity score are only estimated in the region of common support, as discussed above. Thus, it is necessary to check the overlap of the propensity scores at different treatment levels. The overlap plots, which are not reported but are available on request, reveal that the predicted probabilities are not concentrated near 0 or 1, which implies that the overlap assumption is not violated (Cattaneo *et al*. 2013). Second, we checked the balance of covariates before and after matching. When the distribution of a covariate is the same for all treatment levels, the covariate is said to be balanced. Table A4 in the Appendix shows the standardized differences and variance ratios for the raw data and the matched sample. The standardized differences for all treatment levels and firm size categories are very close to zero, and the variance ratios are all very close to one, which suggests that covariates are well balanced (Austin, 2009).

Table 2 shows the estimated absolute and relative Average Treatment Effects on the Treated (ATTs) for the whole sample and for each firm size category. Absolute effects represent treatment effects levels when the comparison group is treatment 0 (no technological nor non-technological innovations), while relative effects compare the effectiveness of different treatment levels, other than level 0.

Results for the whole sample show a positive and significant effect of technological innovations on export intensity (Column 1; ATT=0.027; $p<0.01$), and no effect of non-technological innovations (Column 2). The joint effect is positive and significant (Column 3; ATT=0.022; $p<0.05$). Looking at relative effects, the results show that technological innovations exert a larger effect on export intensity than non-technological innovations (Column 4; ATT=0.042; $p<0.01$). This result is reinforced in Column 6, where the joint effect of both types of innovations versus non-technological innovations suggests that firms engaged in both types have 3.9 percentage points higher export intensity than firms that engage in non-technological innovations *in isolation*. The next result is consistent with the previous relative effects; namely, the joint effect relative to technological innovations has a negative and significant effect (Column 5; ATT=-0.015; $p<0.05$). In other words, irrespective of their size, those firms that engage only in technological innovations have a higher export intensity than firms that engage in both types.

For micro firms, we find no statistically significant absolute and relative treatment effects ($p>0.10$). For small firms, we found a positive and significant effect of technological innovations on export-sales ratio (Column 1; ATT=0.033; $p<0.05$), while non-technological innovations have no impact (Column 2). There is no joint effect between technological and non-technological innovations in small firms (Column 3). With respect to relative effects, the influence of technological innovation on the export-sales ratio is higher than of non-technological innovations *in isolation* by 5.4 percentage points (Column 4; $p<0.01$), while the joint impact of technological and non-technological innovations relative to the impact of technological innovation *in isolation* is lower by 2.5 percentage points at marginally significant level (Column 5; $p<0.10$). In addition, the joint impact compared to the individual effect of non-technological innovations is higher by 4.2 percentage points (Column 6; $p<0.01$).

[TABLE 2 NEAR HERE]

Next we interpret and discuss the estimated treatment effects for medium-sized firms. Firms that introduce technological innovations have a higher export-sales ratio by 6.3 percentage points than non-innovating firms (Column 1; $p<0.05$), while the absolute effect of non-technological innovations is not significant at any conventional level (Column 2; $p>0.10$). The results also show that the joint effect of both technological and non-technological innovations is positive and marginally statistically significant (Column 3; $p<0.1$). Although this joint effect is positive, it is not larger than the absolute effect of technological innovations *in isolation*. These results imply that there is no joint effect between technological and non-technological innovations. On the contrary, based on the results reported in Column 5, we can infer that the joint effect reduces the export-sales ratio by 4.2 percentage points ($p<0.05$) relative to the effect of technological innovations *in isolation,* while the simultaneous introduction of technological and non-technological innovations increases the export-sales ratio by 8.9 percentage points (Column 6; $p<0.01$) relative to non-technological innovations *in isolation*. This is consistent with the ATT reported in Column 4, whereby the influence of technological innovations *in isolation* relative to the effect of non-technological innovation *in isolation* is higher by 12.4 percentage points ($p<0.10$).

Finally, both absolute and relative treatment effects in large firms are not statistically significant at any conventional level. However, these results might be associated with the estimated potential-outcome mean for the control group of firms (i.e. non-innovating firms). An additional advantage of the IPWRA estimator, besides its double-robust property, is that the potential-outcome mean for the control group of firms (i.e. non-innovating firms) is estimated. Thus, the estimated export-sales ratio for non-innovating micro firms is 6.17 per cent ($p<0.01$), which implies that innovating micro firms, given the insignificant treatment effects, are no more export-intensive than their non-innovating counterparts. In non-innovating small firms, the potential-outcome mean is 12.18 per cent ($p<0.01$), in non-innovating medium firms the mean is 24.51 per cent ($p<0.01$) and in non-innovating large firms, the mean is 33.43 per cent ($p<0.01$).

Therefore, non-innovating firms exhibit a rising export-sales ratio with respect to their size. In other words, in those firm-size categories in which non-innovating firms have the lowest export-sales ratio (i.e. micro firms) and in those categories of non-innovating firms with the highest export-sales ratio (i.e. large firms), the effect of both technological and non-technological innovation is not relevant. In contrast, firm size categories with the medium level of the export-sales ratio in non-innovating firms (i.e. small and medium firms) benefit from technological innovations, but not from non-technological innovations.

In summing up, based on the mean outcome for non-innovating firms, our empirical findings reveal that export intensity rises with firm size. Accordingly, innovation is a relevant factor in enhancing exports in firms at the medium level of export intensity (small and medium firms), but not so important for firms at lower and higher levels of export intensity (micro and large firms). The latter is consistent with Wakelin (1998), who found that the UK innovating firms are less likely to export than non-innovating firms of the same size.

To interpret our results with respect to the formulated hypotheses, hypothesis *H1* on the effectiveness of technological innovations in enhancing export intensity is supported in the case of small and medium-sized firms. In contrast, we find no support for *H1* for micro and large firms. Focusing on hypothesis *H2* on the impact of non-technological innovations on export intensity, the estimated treatment effects indicate no evidence to support it. Therefore, our empirical findings do not support *H2* in any firm size category. These results could be due to our empirical strategy, such that previous studies reporting a positive effect did not take into account the endogeneity between non-technological innovations and exports, while our study does. A similar pattern has been noted in previous empirical work on technological innovations. That is, most previous studies treated them as exogenous, until recent work by e.g. Becker and Egger (2013) and Damijan *et al.* (2010). Another potential explanation is that non-technological innovation may positively affect firms' innovation performance by indirectly supporting technological innovations, while their direct effect on exports might be insignificant. Naturally, given that our study is among the first to account for endogeneity of non-technological innovations, further studies should provide more evidence on this issue.

Finally, results for hypothesis *H3* on the joint impact of both technological and non-technological innovations is not supported in any firm size category, except marginally in medium-sized firms. Furthermore, relative treatment effects in small and medium firms imply that non-technological innovations in combination with technological innovations are less effective in increasing export intensity in these firm size categories, relative to the effects of technological innovations in isolations. In other words, the joint impact of technological and non-technological innovations is larger compared to the effects of non-technological innovations in isolation. Our next step is to directly test for complementarity between technological and non-technological innovations.

Existence of complementarity

To test for complementarity between technological and non-technological innovations, we follow the production function or direct approach (see e.g. Cassiman and Veugelers, 2006; Love *et al.*, 2014) by regressing export intensity on mutually exclusive combinations of technological and non-technological innovations and control variables, and then applying the formal test of complementarity.

The production function can be presented as:

$$E_i = \alpha_i I_i + \beta Z_i + \varepsilon_i \qquad (2)$$

where E_i is export intensity of firm i, I_i is a binary variable indicating whether a firm combines technological and non-technological innovations, Z_i is a vector of control variables and ε_i is the error term.

In testing complementarity between four discrete combinations of technological and non-technological innovations (see below), we adopt the framework advanced by Mohnen and Röller (2005) and Cassiman and Veugelers (2006). Two types of innovations imply that we have two variables I_1 and I_2 and four combinations:

(00)– neither technological nor non-technological innovations are introduced (variable *Neither*)

(10) – only technological innovations are introduced (variable *Technological innovation*)

(01) – only non-technological innovations are introduced (variable *Non-technological innovation*)

(11) – both technological and non-technological innovations are introduced (variable *Both*)

The theory of supermodularity (Milgrom and Roberts, 1995) suggests that two activities are complementarity (in our case, technological and non-technological innovations) if the following condition holds:

$$E(11, Z) + E(00, Z) \geq E(10, Z) + E(01, Z) \quad (3)$$

Equation (3) implies that introducing both technological and non-technological innovations has a larger positive effect (or at least the same) on export propensity than introducing technological and non-technological innovations in isolation. Equation (3) can be rearranged as below and the results of testing this inequality are reported in Table 3.

$$E(11, Z) - E(01, Z) \geq E(10, Z) - E(00, Z) \quad (4)$$

Given that our dependent variable is the share of exports in sales, we employ a fractional logit estimator. The results are shown in Table 3. Estimations do not include a constant because we want to show the contributions of all four combinations (Love *et al.*, 2014). Individual coefficients on these four combinations all have negative signs and are highly statistically significant ($p<0.01$), except for large firms, for which all coefficients are insignificant at any conventional level ($p>0.10$). Next we test the null hypothesis of no complementarity using the direct test (see Table 3, final row), which cannot be rejected in all five models. If we look at individual coefficients, we can see that the coefficients on the variable *Neither* is negative for all firm size categories except for large firms, which suggests that the lack of innovation activities reduces exports intensity. Bearing in mind that the constant is excluded and thus there is no base category, the coefficients on the variable *Technological innovation* are negative as well (except for large firms), but the magnitude of these negative effects is smaller than in the case of no innovation (variable *Neither*). In other words, by introducing technological innovations, firms increase their export intensity. However, concerning non-technological innovations, the coefficients on this variable are larger than in the case of no innovation (variable *Neither*), which indicate either no positive effects, or potentially negative effects on export intensity. In summing up, the results from the direct test indicate no complementarity between technological and non-technological innovations for all firm sizes [6]. Moreover, the results suggest that while technological innovations might increase export intensity in all but large firms, the effect of non-technological innovations is insignificant. These findings are consistent with results obtained from the matching estimator.

[TABLE 3 NEAR HERE]

As a conclusion of our empirical investigation, the direct approach suggests no evidence of complementarity between technological and non-technological innovations. However, it should be noted that, by estimating a fractional logit model, technological and non-technological innovations are treated as exogenous variables. Thus, although the results from the matching estimator reported in the previous section cannot directly confirm or refute complementarity, they are still valid for estimating the *joint* effect of technological and non-technological innovations, because the estimator takes into account the endogenous nature of both types of innovation (Bernardini Papalia *et al.,* 2018).

5. Conclusions

This study explores how technological and non-technological innovations, in isolation and jointly, affect export intensity in four firm size categories - micro, small, medium and large firms. In accordance with the recent trend in empirical work, our modelling strategy takes into account not only endogeneity between technological innovations and exports, but also endogeneity between non-technological innovations and exports. Besides estimating individual and joint effects, we also employ the production approach or the direct test of complementarity between technological and non-technological innovations.

Concerning technological innovations, empirical findings indicate their positive influence on export intensity in small and medium-sized firms, while no effect is found in micro and large firms. Consequently, positive effects of technological innovations found in small and medium firms are consistent with the prediction of the product-life cycle theory of internationalization that both types of technological innovations are the driving force of firms' internationalization. In contrast, the insignificant effects of technological innovations reported for micro and large firms could be associated with the differing impact of product and process innovations on firms' profitability, in particular, with respect to the magnitude of fixed and variable costs arising from the adoption of product and process innovations. In relation to the first argument, Lo Turco and Maggioni (2015) note that although both product and process innovation should increase firms' profit, their effects are different - product innovation should enhance revenues while process innovation should reduce costs. In other words, product innovation brings higher revenue because new or significantly improved products entail higher quality, whereas process innovation should positively affect profit through the reduction in the marginal production cost. With regards to the second argument, the authors posit that higher variable costs of process innovation, stemming from the production of higher quality products, could dampen the positive effects of product innovations. Opposite holds as well when a lower quality of product innovation counterweights the cost advantage arising from process innovation. In both of these cases, hence, the total effect of product and process innovations on firms' profitability in foreign markets is smaller than their individual effects.

Focusing on the impact of non-technological innovations on export intensity, our results uniformly suggest that organizational and marketing innovation do not exert a positive effect on export intensity regardless of firm size. When discussing non-technological innovations above, we noted that small firms had behavioural advantages relative to large firms associated with the lack of bureaucracy and flexibility in reacting to changes in the environment, including changes in customers' needs. In contrast, small firms are hampered by the lack of human and financial resources, as well as marketing expertise. Given that our results imply no effects of non-technological innovations in smaller firms, it could be that behavioural advantages of smaller firms are not large enough to counterweight resource constraints. The opposing effect might occur in the case of large firms. The availability of human and financial resources might be counterbalanced by organizational inertia and bureaucratic constraints, thus preventing large firms to quickly adopt to changes in foreign markets.

Theoretical arguments suggest that technological and non-technological innovations should have a complementary effect on firm performance, including export activities (Aboal and Garda, 2016; Azar and Ciabuschi, 2017). However, our empirical findings indicate that while their joint effect could be larger than their individual effects, they are not complementary innovation activities with respect to exports. A potential explanation could be that non-technological innovation enhance the impact of technological innovations, given the positive relative effects of both types of innovations versus non-technological innovations in isolation found in small and medium-sized firms. But this joint effect is not large enough to exert a complementary relationship between technological and non-technological innovations. Another potential explanation of the lack of complementary effect could be related to the sequence of adoption of technological and non-technological innovations. Firms might first introduce new products and/or processes, then enter foreign markets, and faced with a fierce international competition, adopt further organizational and marketing innovations to support their exporting activities. In other words, the sequence of innovation adoption in firms could be such that firms first adopt technological innovations and in later stages make organizational and marketing changes to accommodate for new products and processes (Cozzarin *et al*., 2017). However, testing this proposition would require a longitudinal data and thus remains to be investigated in future research.

Overall, our heterogeneous effects of innovation on export intensity suggest some policy implications. If policy makers are to provide an impetus for exports and innovation jointly, small and medium-sized firms are more likely to benefit from these policy interventions than micro firms. For the latter, it could be that sunk costs of exports are too high (Álvarez, 2004; Wakelin, 1998). Therefore, policy measures aimed at financing and/or reducing the fixed costs of exports could be particularly beneficial for micro firms.

Notwithstanding the contributions of the study, it suffers from limitations that can serve as suggestions for further research. First, because of the lack of longitudinal data, we are unable to take into account persistence in exports and innovation (Añón Higón and Driffield, 2010; Roper and Love, 2002). Second, future studies could explore the influence of technological and non-technological innovations on other measures of exports, such as geographical scope (the number of countries in which firms export), precocity (how close the first foreign operations are to the foundation of the firm) and speed of foreign sales (D'Angelo, 2012; Dhanaraj and Beamish, 2003; Love *et al*., 2016). Finally, firms' participation in exports is one mode of internationalizations. Future studies could investigate similarities and differences between SMEs with regards to different entry modes: exports, inter-firm equity and non-equity agreements and foreign direct investment (D'Angelo, 2012; López Rodríguez and García Rodríguez, 2005; Wheeler *et al*., 2008).

Notes

1. Non-technological innovations are defined as follows. "An organisational innovation is the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations. A marketing innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing." (OECD, 2005, p. 51 and p.49 respectively).
2. The authors use the term "management innovation" when referring to non-technological, organizational and marketing, innovations. Battisti and Stoneman (2010) use the term "wide" or "organizational innovation" to encompass marketing, organizational, management and strategic innovations.
3. Table A2 shows the number and percentage of firms in each treatment category. Further, Table A1 shows summary statistics for the introduction of each type of innovation (technologies and non-technological), regardless if the other type is introduced or not.
4. In the case of a binary treatment variable, the matching approach estimates the difference between firms in two states that cannot be observed simultaneously: the treatment state; and the counterfactual state of non-treatment.
5. Results for the other multinomial logit models (for small, medium and large firms) are not reported but are available on request.

6. To further explore this argument, we estimate a fractional logit model with the interaction term. The results are shown in Table A5 in the Appendix. The coefficients on the interaction terms are uniformly statistically insignificant at any conventional level (p>0.10).

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Appendix

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[TABLE A5 HERE]

Table 1. Estimation functions (the outcome and the treatment models) for micro firms with treatment level 0 as the base (reference) category (N=4,947)

Independent variables	**Outcome model**				**Treatment model**		
	Potential -outcome model for treatment =0	Potential -outcome model for treatment =1	Potential -outcome model for treatment =2	Potential -outcome model for treatment =3	Treatment =1	Treatment =2	Treatment =3
Turnover	0.096*	0.127***	0.204**	0.162***	0.065***	0.134***	0.117***
	(0.056)	(0.042)	(0.089)	(0.059)	(0.022)	(0.031)	(0.021)
Young	0.523*	-0.122	-0.751	0.141	0.111	0.194	0.290***
	(0.281)	(0.243)	(0.628)	(0.208)	(0.099)	(0.148)	(0.090)
R&D activity	0.702**	0.833***	1.232***	0.563***	1.547***	0.822***	2.048***
	(0.304)	(0.204)	(0.424)	(0.165)	(0.122)	(0.195)	(0.114)
Monopoly	0.634	-0.436	0.484	-0.238	-0.570***	0.089	-0.132
	(0.446)	(0.547)	(1.150)	(0.457)	(0.217)	(0.292)	(0.194)
Monopolistic competition	-0.162	-0.304	0.973**	-0.016	-0.052	0.093	0.209**
	(0.313)	(0.228)	(0.457)	(0.196)	(0.094)	(0.147)	(0.089)
Perfect competition	0.646**	-0.258	0.726	0.037	-0.336***	-0.073	-0.010
	(0.260)	(0.265)	(0.614)	(0.208)	(0.098)	(0.151)	(0.093)
Innovation leaders	0.026	-0.193	-1.804**	0.051	-0.120	-0.211	-0.535***
	(0.360)	(0.228)	(0.733)	(0.233)	(0.106)	(0.169)	(0.103)
Modest innovators	-0.885**	-0.522	0.383	-0.052	0.141	-0.121	-0.144
	(0.437)	(0.435)	(0.691)	(0.342)	(0.135)	(0.219)	(0.129)
Innovation followers	-0.100	-0.680***	-0.459	-0.185	-0.271***	-0.014	-0.276***
	(0.282)	(0.243)	(0.435)	(0.193)	(0.098)	(0.145)	(0.088)
Constant	-2.981***	-2.725***	-3.338***	-3.110***	-0.626***	-2.890***	-1.073***
	(0.440)	(0.332)	(0.673)	(0.474)	(0.173)	(0.272)	(0.169)

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Industry dummy variables are included, but not reported for the sake of brevity.

Table 2. The Average Treatment Effects on the Treated (ATTs) for technological and non-technological innovations estimated by the IPWRA estimator for each firm size category.

Firm size categories	Absolute effects			Relative effects		
	Technological innovations vs no innovation	Non-technological innovations vs no innovation	Both technological and non-technological innovations vs no innovation	Technological innovations vs non-technological innovations	Both technological and non-technological innovations vs technological innovations	Both technological and non-technological innovations vs non-technological innovations
	Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*	*Column 6*
Full sample	0.027*** (0.008)	-0.009 (0.009)	0.022** (0.009)	0.042*** (0.012)	-0.015** (0.007)	0.039*** (0.012)
Micro firms	0.004 (0.009)	-0.001 (0.011)	0.010 (0.009)	-0.004 (0.013)	0.008 (0.008)	-0.003 (0.015)
Small firms	0.033** (0.015)	-0.012 (0.018)	0.020 (0.014)	0.054*** (0.018)	-0.024* (0.013)	0.042*** (0.015)
Medium firms	0.063** (0.025)	-0.026 (0.020)	0.037* (0.019)	0.124*** (0.032)	-0.042** (0.018)	0.089*** (0.025)
Large firms	0.023 (0.051)	0.083 (0.077)	0.013 (0.043)	0.050 (0.113)	-0.020 (0.031)	-0.062 (0.109)

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 3. Results from the fractional logit model with four combinations of innovation activities

Independent variables	Full sample	Micro firms	Small firms	Medium firms	Large firms
Turnover	0.175***	0.141***	0.087***	0.095***	0.025
	(0.010)	(0.024)	(0.024)	(0.028)	(0.038)
Young	0.071	0.140	0.269*	0.211	-1.118*
	(0.087)	(0.123)	(0.146)	(0.226)	(0.679)
R&D activity	0.589***	0.708***	0.547***	0.361***	0.427**
	(0.052)	(0.109)	(0.087)	(0.093)	(0.176)
Monopoly	0.118	0.222	0.356*	0.056	-0.641*
	(0.127)	(0.257)	(0.204)	(0.239)	(0.357)
Monopolistic competition	-0.030	-0.059	-0.139	0.110	-0.053
	(0.054)	(0.116)	(0.096)	(0.096)	(0.169)
Perfect competition	0.122*	0.258**	0.198*	0.221*	-0.585**
	(0.066)	(0.120)	(0.109)	(0.132)	(0.264)
Innovation leaders	-0.553***	-0.200	-0.474***	-0.607***	-0.652***
	(0.067)	(0.131)	(0.119)	(0.123)	(0.213)
Modest innovators	0.198**	-0.293	0.102	0.238	0.353
	(0.087)	(0.205)	(0.160)	(0.153)	(0.284)
Innovation followers	-0.204***	-0.278**	0.058	-0.192*	-0.337*
	(0.058)	(0.117)	(0.098)	(0.106)	(0.198)
Technological innovation	-2.282***	-3.091***	-1.853***	-1.025***	0.271
	(0.103)	(0.212)	(0.216)	(0.286)	(0.460)
Non- technological innovation	-2.613***	-3.149***	-2.169***	-1.728***	0.380
	(0.147)	(0.274)	(0.267)	(0.358)	(0.718)
Both	-2.370***	-3.005***	-1.991***	-1.209***	0.092
	(0.107)	(0.210)	(0.209)	(0.295)	(0.463)
Neither	-2.460***	-3.112***	-2.048***	-1.283***	-0.194
	(0.103)	(0.204)	(0.213)	(0.287)	(0.476)
No of observations	11,169	4,947	3,490	2,064	668
Complementarity test (*p*-value of Chi²-test): H_0: 11-10 $\leq$ 01-00	p=0.313	p=0.305	p=0.531	p=0.146	p=0.885

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05; *p<0.10. Industry dummy variables are included, but not reported for the sake of brevity.

Appendix.

Table A1. Variable description and summary statistics.

Variables	Variable description	Full sample (N=11,169)	Micro firms (N=4,947)	Small firms (N=3,490)	Medium firms (N=2,064)	Large firms (N=668)
Outcome variable		Mean (standard deviation)	Mean (standard deviation)	Mean (standard deviation)	Mean (standard deviation)	Mean (standard deviation)
Export intensity	Percentage of firms' total revenues from selling goods and services abroad in 2013	0.126 (0.268)	0.062 (0.191)	0.127 (0.262)	0.227 (0.331)	0.289 (0.378)
Technological innovation	DV = 1 if a firm introduced either product or process innovations or both; zero otherwise	0.616 (0.486)	0.530 (0.499)	0.652 (0.477)	0.699 (0.459)	0.819 (0.385)
Non-technological innovation	DV=1 if a firm introduced either organizational or marketing innovations or both; zero otherwise	0.468 (0.499)	0.377 (0.485)	0.505 (0.500)	0.566 (0.496)	0.642 (0.480)
Independent variables						
Young	DV = 1 if a firm was founded after January 2008; zero otherwise	0.129 (0.335)	0.202 (0.402)	0.093 (0.290)	0.045 (0.206)	0.033 (0.179)
Turnover	The amount of turnover in 2013 (in '000 Euro) (in natural logarithm)	7.219 (2.559)	5.544 (1.950)	7.676 (1.884)	9.302 (1.742)	10.798 (2.304)
R&D activity	DV = 1 if a firm carried out R&D either in-house or by subcontracting since January 2011, zero otherwise	0.270 (0.444)	0.176 (0.381)	0.277 (0.448)	0.389 (0.488)	0.557 (0.479)
Monopoly	DV = 1 if a firm reported no competition or one competitor in the main market in 2014, zero otherwise	0.042 (0.200)	0.039 (0.194)	0.040 (0.196)	0.043 (0.203)	0.069 (0.253)
Oligopoly (base category)	DV = 1 if a firm reported "A few" as the number of competitors in the main market in 2014, zero otherwise	0.358 (0.479)	0.325 (0.469)	0.372 (0.483)	0.392 (0.488)	0.422 (0.494)
Monopolistic competition	DV = 1 if a firm reported "Tens" as the number of competitors in the main market in 2014, zero otherwise	0.357 (0.479)	0.330 (0.470)	0.366 (0.482)	0.400 (0.490)	0.367 (0.482)
Perfect competition	DV = 1 if a firm reported either "Hundreds" or "Too many to count" as the number of competitors in the main market in 2014, zero otherwise	0.243 (0.429)	0.306 (0.461)	0.222 (0.416)	0.165 (0.371)	0.142 (0.350)

Leaders	DV=1 if a firm is located in Denmark, Finland, Germany, Sweden, Switzerland and USA; zero otherwise	0.219 (0.414)	0.219 (0.413)	0.212 (0.409)	0.214 (0.410)	0.273 (0.446)
Followers	DV=1 if a firm is located in Austria, Belgium, Cyprus, Estonia, France, Ireland, Luxembourg, Netherlands, Slovenia and United Kingdom; zero otherwise	0.312 (0.463)	0.298 (0.457)	0.321 (0.467)	0.332 (0.471)	0.308 (0.462)
Moderate innovators (base category)	DV=1 if a firm is located in Croatia, Czech Republic, Greece, Hungary, Italy, Lithuania, Malta, Poland, Portugal, Slovakia and Spain; zero otherwise	0.370 (0.483)	0.376 (0.485)	0.379 (0.485)	0.356 (0.479)	0.314 (0.465)
Modest innovators	DV=1 if a firm is located in Bulgaria, Latvia and Romania; zero otherwise	0.099 (0.299)	0.107 (0.309)	0.088 (0.283)	0.098 (0.297)	0.105 (0.307)
Manufacturing (base category)	DV=1 if a firm operates in the NACE category C; zero otherwise	0.221 (0.415)	0.136 (0.343)	0.237 (0.425)	0.348 (0.476)	0.376 (0.485)
Retail	DV=1 if a firm operates in the NACE category G; zero otherwise	0.245 (0.430)	0.285 (0.452)	0.249 (0.432)	0.173 (0.378)	0.141 (0.348)
Services	DV=1 if a firm operates in the NACE categories H, I, J, K, L, M, N, and R; zero otherwise	0.330 (0.470)	0.358 (0.479)	0.306 (0.461)	0.310 (0.463)	0.322 (0.468)
Industry	DV=1 if a firm operates in the NACE categories D, E, and F; zero otherwise	0.204 (0.403)	0.221 (0.415)	0.208 (0.406)	0.169 (0.375)	0.161 (0.368)

Table A2: Number and percentage of firms in each treatment category

	Full sample (N=11,169)	Micro firms (N=4,947)	Small firms (N=3,490)	Medium firms (N=2,064)	Large firms (N=668)
Treatment =0 (a firm did not introduce either technological or non-technological innovations)	3,531 (31.62%)	1,987 (40.17%)	977 (27.99%)	470 (22.77%)	97 (14.52%)
Treatment =1 (a firm introduced technological innovations but did not introduce non-technological innovations)	2,416 (21.63%)	1,097 (22.17%)	752 (21.55%)	425 (20.59%)	142 (21.26%)
Treatment =2 (a firm did not introduce technological innovations but introduced non-technological innovations)	754 (6.75%)	339 (6.85%)	239 (6.85%)	152 (7.36%)	24 (3.59%)
Treatment =3 (a firm introduced both technological and non-technological innovations)	4,468 (40.00%)	1,524 (30.81%)	1,522 (43.61%)	1,017 (49.28%)	405 (60.63%)

Table A3. Number of firms by country and industry

	Number of firms in full sample	Number of micro firms	Number of small firms	Number of medium firms	Number of large firms
Innovation leaders					
Denmark	381	149	123	76	33
Finland	386	173	110	76	27
Germany	467	212	138	87	30
Sweden	369	151	120	69	29
Switzerland	392	183	104	66	39
USA	452	214	146	68	24
Innovation followers					
Austria	382	163	117	72	30
Belgium	384	115	130	94	45
Cyprus	102	45	46	11	0
Estonia	372	159	117	86	10
France	477	216	138	106	17
Ireland	365	178	107	61	19
Luxembourg	183	76	64	31	12
Netherlands	385	141	128	90	26
Slovenia	381	147	142	75	17
United Kingdom	453	234	130	59	30
Moderate innovators					
Croatia	291	102	104	65	20
Czech Republic	388	175	126	57	30
Greece	367	177	102	79	18
Hungary	377	162	126	64	25
Italy	459	212	143	78	26
Lithuania	367	149	122	81	15
Malta	169	58	75	29	7
Poland	470	257	121	75	17
Portugal	387	163	133	79	12
Slovakia	354	181	125	39	9
Spain	493	227	146	89	31
Modest innovators					
Bulgaria	375	200	81	63	31
Latvia	359	161	110	79	9
Romania	373	167	116	60	30
Manufacturing	2,469	673	827	718	251
Retail	2,732	1,413	868	357	94
Services					
NACE code H-Transportation and storage	631	247	207	127	50

NACE code I - Accommodation and food service activities	524	255	186	72	11
NACE code J- Information and communication	430	192	126	89	23
NACE code K- Financial and insurance activities	212	87	50	49	26
NACE code L- Real estate activities	257	136	63	49	9
NACE code M- Professional, scientific and technical activities	1,041	589	260	135	57
NACE code N - Administrative and support service	458	192	136	97	33
NACE code R - Arts, entertainment and recreation	139	71	40	22	6
Industry					
NACE code D- Electricity, gas, steam and air conditioning supply	109	26	34	29	20
NACE code E- Water supply, sewerage, waste management and remediation activities	199	39	59	71	30
NACE code F- Construction	1,968	1,027	634	249	58

Table A4: Checking matching quality – standardized differences and variance ratios in raw and matched data

	Standardized difference in raw data (median)	Standardized difference in matched data (median)	Variance ratio in raw data (median)	Variance ratio in matched data (median)
Full sample				
Treatment = 1	-0.023	-0.003	0.974	0.998
Treatment = 2	0.015	-0.011	1.017	0.986
Treatment = 3	-0.003	-0.004	0.997	0.997
Micro firms				
Treatment = 1	0.015	-0.008	1.011	0.989
Treatment = 2	0.029	-0.009	1.034	0.990
Treatment = 3	-0.027	-0.009	0.954	0.989
Small firms				
Treatment = 1	0.006	0.001	1.008	0.998
Treatment = 2	0.060	0.010	1.085	1.014
Treatment = 3	0.034	0.004	1.021	1.003
Medium firms				
Treatment = 1	-0.019	-0.020	0.954	0.978
Treatment = 2	0.056	0.012	1.066	0.950
Treatment = 3	0.017	-0.018	1.014	0.975
Large firms				
Treatment = 1	-0.010	0.025	0.917	0.984
Treatment = 2	0.119	-0.089	1.140	0.849
Treatment = 3	-0.022	0.029	0.976	1.025

Table A5. Results from the fractional logit models with the interaction term

Independent variables	Full sample	Micro firms	Small firms	Medium firms	Large firms
Turnover	0.175***	0.141***	0.087***	0.095***	0.025
	(0.010)	(0.024)	(0.024)	(0.028)	(0.038)
Young	0.071	0.140	0.269*	0.211	-1.118*
	(0.087)	(0.123)	(0.146)	(0.226)	(0.679)
R&D activity	0.589***	0.708***	0.547***	0.361***	0.427**
	(0.052)	(0.109)	(0.087)	(0.093)	(0.176)
Monopoly	0.118	0.222	0.356*	0.056	-0.641*
	(0.127)	(0.257)	(0.204)	(0.239)	(0.357)
Monopolistic competition	-0.030	-0.059	-0.139	0.110	-0.053
	(0.054)	(0.116)	(0.096)	(0.096)	(0.169)
Perfect competition	0.122*	0.258**	0.198*	0.221*	-0.585**
	(0.066)	(0.120)	(0.109)	(0.132)	(0.264)
Innovation leaders	-0.553***	-0.200	-0.474***	-0.607***	-0.652***
	(0.067)	(0.131)	(0.119)	(0.123)	(0.213)
Modest innovators	0.198**	-0.293	0.102	0.238	0.353
	(0.087)	(0.205)	(0.160)	(0.153)	(0.284)
Innovation followers	-0.204***	-0.278**	0.058	-0.192*	-0.337*
	(0.058)	(0.117)	(0.098)	(0.106)	(0.198)
Technological innovation=0 and non-technological innovation=1	-0.153	-0.037	-0.121	-0.445**	0.574
	(0.122)	(0.211)	(0.203)	(0.225)	(0.596)
Technological innovation=1 and non-technological innovation=0	0.177**	0.020	0.195	0.258**	0.466*
	(0.069)	(0.127)	(0.121)	(0.130)	(0.278)
Technological innovation=1 and non-technological innovation=1 (interaction term)	0.090	0.106	0.057	0.074	0.286
	(0.064)	(0.122)	(0.109)	(0.117)	(0.251)
Constant	-2.460***	-3.112***	-2.048***	-1.283***	-0.194
	(0.103)	(0.204)	(0.213)	(0.287)	(0.476)
No of observations	11,169	4,947	3,490	2,064	668

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Notes: Robust standard errors in parentheses. Industry dummy variables are included, but not reported for the sake of brevity.