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Innovation and Exporting: A Study on Eastern European Union Firms

Silvia Bertarelli * and Chiara Lodi

Department of Economics and Management, University of Ferrara, Via Voltapaletto 11, 44121 Ferrara, Italy; chiara.lodi@unife.it

* Correspondence: silvia.bertarelli@unife.it; Tel.: +39-0532-455065; Fax: +39-0532-245951

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Abstract: This paper investigates how firm-level innovation and productivity affect the export propensity in manufacturing firms in seven Eastern European Union countries. With respect to innovation activities, we analyze the complementarity between pair-wise product, process and non-technological (organizational and marketing) innovations when the objective function is represented by the exporting probability of a firm. Analyzing CIS2008 data, we find that productivity always has a positive and significant impact on the exporting propensity of firms. Furthermore, complex innovative firms, when large in size and/or from medium high–high technology sectors, can take advantage in terms of a higher attitude to export than non-innovators and simple innovators. By considering these results, governments have to introduce policies that can induce firms, especially small and medium ones, to implement complex innovations. This is fundamental in order to be more productive and more competitive.

Keywords: Eastern European Union countries; sustainability; exports; productivity; complementarity; innovation

1. Introduction

The importance of the Eastern European Union (EU) economies has been increasing for the last 20 years, and their sustainable development is a central issue within the policy debate. A sustainable development can support the integration of developing countries, and it represents a necessary step toward the solution of environmental problems. In view of this, the United Nations (UN) has defined several Sustainable Development Goals (SDGs) related to different topics, from poverty to climate issues. In order to reach these goals, a number of actions have been taken. Among them, promoting international trade and innovation is fundamental for sustainable and comprehensive economic growth, creating jobs, raising income levels, and improving welfare. Furthermore, investments in innovation and technology could facilitate the development toward the knowledge transfer, which is essential to solve economic, social, and environmental issues. Sustainability should not only be germane to governmental level but it has to also involve micro-economic agents, such as consumers and firms. Being a sustainable innovative firm means being able to rethink organizational philosophies and values, in order to reorganize processes and practices, and to provide products in order to create and realize social and environmental value, besides economic return.

Since the collapse of Soviet Union, Eastern EU countries have become geopolitically and geo-strategically relevant. They hold a strategic position in terms of international trade and democracy perspectives. These countries have captured the interest of world-powerful nations, such as USA, Russia, and advanced EU countries because, on one hand, they represent an important platform to reach Asian markets, and on the other hand, they are also regions which are key for worldwide stability and security. Eastern EU countries also provide good labor market conditions. They can supply skilled workers at low cost, especially in the Information Technology sector. Advanced EU economies take advantage of this opportunity by investing in these economies, both as producers and knowledge owners [1]. In return, foreign direct investments coming from advanced economies allow the less advanced EU countries to get benefits from employment and technology transfer. The innovation transfer is important in order to fill the existent gap. Indeed, Eastern EU firms invest a very little amount of resources in innovation, such as research and development (R&D) and patents, compared to the European Union's average.

Considering the relevance of trade and innovation in achieving sustainable development, a large number of empirical studies has investigated the role of different kinds of innovations. Product and process innovations have a positive impact on exporting propensity, which is higher than organizational (or non-technological) innovation [1–6]. Recently, there has been a significant amount of interest in assessing whether the potential complementarity between different kinds of innovation play a key role on trade decisions at a firm level. Studies on complementarity confirm that, with reference to firms located in advanced EU economies, if a firm simultaneously introduces product and process innovations, their probability of exporting increases [6–9]. However, evidence about the potential complementarity effect on export propensity is missing for less advanced economies, such as Eastern EU countries.

From a theoretical point of view, a positive correlation between productivity and export can be shown, as well as between productivity and innovative activities [10]. By assuming heterogeneous firm characteristics, the level of productivity is an important driver for exporting propensity [11]. Empirical findings for the positive impact of productivity on exports can be found in Melitz and Redding [12] and Bernard and Jensen [13]. A firm can improve its productivity by increasing its technology level; hence, its probability of being a successful exporter increases exponentially [14]. The latter result implies a positive link between export and innovation. Beside product and process innovations, no attention has been paid by previous studies on the complementarity of organizational (or non-technological) innovations, with the exception of [7,9]. Moreover, non-technological innovations are very important for firms' competitiveness, especially in terms of productivity, market share, and profits. A rethinking of the organization, such as relocating production (outsourcing or offshoring), could bring cost savings or attract high-skilled workers [15].

An important aspect, in order to promote internationalization, is represented by the evaluation of simple and complex technology adoption, which accounts for firms' differences in size, when size refers to the number of employees. By admitting firms' heterogeneity by size, we can justify for the technological knowledge peculiarities that they can generate, and we can exploit this with the introduction of technological innovations [16]. Indeed, the empirical evidence shows that large firms mainly introduce neutral technological changes while small firms—with lower levels of profitability—introduce biased technological changes.

Here, we follow the same lead of previous studies, but our work contributes to the literature three-fold. The first contribution is the investigation of how innovation and productivity affect the exporting propensity within manufacturing firms in less advanced EU countries, accounting for firms' heterogeneity. Differently from the existing studies, we extend the analysis to six Eastern EU countries (Bulgaria, Czech Republic, Hungary, Lithuania, Slovenia, and Slovakia), and we compare results. We use the econometric methodology proposed by [9], and Community Innovation Survey (CIS) 2008 data. The second contribution of this study is to test for the existence of complementarity among three different kinds of innovations: product, process, and non-technological. The literature generally studies product and process innovations only. The third contribution of the paper is to focus the final part of the analysis on medium high-high technology firms, because these sectors can bridge the gap between more advanced and less advanced EU countries [17]. On top of that, high-tech sectors require larger stocks of technological knowledge and specific skills so that complex innovations are expected to be more relevant in shaping high tech firms' performance, than lower tech ones.

This paper is organized as follows. Section 2 reports an analysis of the main macroeconomic indicators for Eastern EU countries. A theoretical model based on [11,14] to describe innovation and export decisions is presented in Section 3. The econometric strategy developed by [9] to study complementarity among innovative practices using *supermodular* function properties is described in Section 4. Section 5 shows the marginal effects and results on the complementarity test for all countries by firm size, as well as for firms operating in medium high–high technology sectors. In Section 6 a brief discussion of results is reported, and finally, Section 7 concludes.

2. Macroeconomic Indicators for Eastern EU Countries

As a preliminary analysis, some macroeconomic indicators are proposed [18–20] Eastern EU countries are less advanced than other EU members, as confirmed by data on per capitaGross Domestic Product (GDP) real terms, R&D expenditure over GDP, public funds for R&D over GDP, and number of patents of the European Patent Office (EPO).

Between 2006 and 2008, per capita real GDP values of Slovenia and Czech Republic filled the highest levels. In both countries, they recorded a positive trend during the considered period (from 10,900 euro in 2006 to 11,700 euro in 2008 for Czech Republic, and from 15,100 euro in 2006 to 16,600 euro in 2008 for Slovenia). The GDP levels of Bulgaria and Hungary were the lowest, at below 5000 euro. As for the other countries (Lithuania, Slovakia, and Hungary), GDP levels were between 6900 euro and 8000 euro for Lithuania, between 7700 euro and 9000 euro for Slovakia, while for Hungary, the GDP value was equal to 9200 euro.

As for R&D expenditure, firms invested few resources in these countries. All shares were well below the European Union's average (1.85%). Bulgaria, Slovakia, and Lithuania were the least innovative countries; their total R&D expenditure was well below 0.89% of GDP. Slovenia was the most active country in investing resources in R&D, whose R&D expenditure was between 1.53% and 1.63% of GDP during the 3-year period. This country was followed by Czech Republic and Hungary. Public funding of R&D investment was negligible (Czech and Slovenian governments, which are the most active, have spent on average 0.55% and 0.51% of GDP for R&D, respectively).

Another important indicator is the number of patents. Hungary and Czech Republic are the countries that registered the highest number of patents to EPO (164.13 and 150.46 in 2006, with an increase in the following two years. In 2008, Czech Republic registered 207.64 patents, against 180.21 in Hungary, and followed by Slovenia (98.42 in 2006, 119.11 in 2007, and 138.91 in 2008). Other countries had a few patents: Lithuania had the lowest number of registered patents (9.67 in 2006, 9.8 in 2007 and 16.87 in 2008); Bulgaria and Slovakia could be considered as middle-patent applicants with respect to other Eastern EU countries. The former registered 27.13 patents to EPO, with a decrease in 2008 (18.65), while the latter has submitted 40.36 patents in 2006, 38.55 in 2007, and 35.87 in 2008.

Finally, we looked at Foreign Direct Investments (FDI) stocks, and trade flows between Western and Eastern Europe. The six Eastern EU countries have the following major economic partners: Germany, Italy, Netherlands, Austria, and United Kingdom. As for inward FDI stocks in the manufacturing sector, Germany was the most important investor for these countries in 2008. The highest value of inward FDI stocks from Germany refers to Hungary and Czech Republic, 7603 and 6090 million euros, respectively. Italy was the second relevant investor of Eastern EU countries in 2008. Netherlands was the third most important investor, especially for Hungary and Czech Republic [21]. Concerning outward FDI stocks, the Eastern EU countries invest many resources in Germany, Netherlands, and Austria. This is interesting the Hungarian case. Hungarian investment stocks in Asian countries—such as Korea and Israel—are very high. As for exports, Slovakia, Hungary, Czech Republic, and Slovenia have the largest degree of openness for all years, with all being above 50% of GDP (in 2006, Slovenia had an export value of 58.62%, Czech Republic of 61.10%, Hungary of 65.90%, and Slovakia of 73.64%). These percentages increased in 2007 and slightly decreased in 2008, but they always remained above 50%. Bulgaria was the country with the least export activity (below 30% in each period). As for merchandise exports in 2006 and 2008, Germany and Italy were the most important exporting partners of Eastern EU countries. Germany was the major exporting partner for all countries in 2008. Exports over the GDP ratio of Germany during the considered period were equal to 30.56% for Czech Republic and to 26.64% for Hungary. In 2006 and

2007, Italy was the first exporting partner of Bulgaria (10.15% in 2006 and 10.34% in 2007). Analyzing the merchandise imports for the same period, Germany was the leading commercial exporter, especially to Czech Republic and Hungary (about 26% and 25%, respectively). Italy was also a key exporter during this three-year period. Between 2006 and 2008, trade flows toward and from Austria, Netherlands, and United Kingdom were less significant than for Germany and Italy trade flows. To conclude, Czech Republic provided the highest effort for innovation from 2006–2008, and it was a relatively good exporter, while Bulgaria seemed to have the least propensity to innovate and to export.

3. Theoretical Model: Innovation, Productivity, and Exports

We present a partial equilibrium model, which strictly follows [11,14], in the simplified version of [22]. We consider an economy characterized by monopolistic competition and product differentiation. There are no barriers for firms to enter the market. The production function of each firm has increasing returns to scale. Firm's productivity is random. Specifically, firms do not know ex ante their productivity. They discover it after entering the market and paying fixed sunk costs. To simplify the analysis, labor is the only input. Production needs both skilled and unskilled workers. All firms aim at maximizing profits, given the decreasing demand for each product. The demand of a product j, x_j, can be expressed by the following function:

$$x_j \; = \; A \; p_j^{-\varepsilon} \tag{1}$$

A represents the dimension of the market, which is an exogenous variable at the firm level, and an endogenous one at the industry level; p_j is the product's price and ε is the demand elasticity. ε is equal to $\frac{1}{1-\alpha}$, with $0 < \alpha < 1$; this means $\varepsilon > 1$. Each firm chooses the price p_j that maximizes its profit π_j, given good j demand:

$$\begin{cases} max\ \pi_j = p_j * x_j - \frac{c}{\vartheta_j} * x_j - cf \\ s.\,t.\ x_j \; = \; A\ p_j^{-\varepsilon} \end{cases} \tag{2}$$

The marginal cost c is exogenous, and it depends on the share of skilled and unskilled employees. This share depends on the adopted technology, and it determines both the fixed and marginal costs. A high-skilled technology implies higher fixed costs, but lower marginal costs than a low-level technological alternative.

Next, we consider three different groups of firms: non innovators, simple innovators, and complex innovators. The first group comprises all firms adopting a baseline or low technology [14]. As for the other two groups, we classify firms with reference to three kinds of innovation: product, process, and non-technological innovations. When firms use only one kind of innovation, they are called simple innovators. When they use two or more innovative practices, we call them complex innovators.

Being innovative or not has an impact on the required mix of labor skills, and implies different variable and fixed production costs. Innovators probably need more skilled workers than non-innovators. In turn, complex innovators ask for even higher skill-intensive technologies than simple innovators. The adoption of high-level technology implies two important effects on costs. First, high-level technology requires higher fixed costs, cf_T, in terms of payments for technology adoption and capital goods that embody new technologies. Second, high-level technology allows lower marginal costs, c_T, in terms of wage payments to skilled and unskilled labor, as in [14]. As considered in our work, technology, T, can be equal to NI (non-innovators), SI (simple innovators), or CI (complex innovators), so that we can draw the relation between fixed costs and between marginal costs as follows.

$$cf_{CI} > cf_{SI} > cf_{NI} \tag{3}$$

$$c_{NI} > c_{SI} > c_{CI} \tag{4}$$

Technology's variable costs (4) have an influence on production costs; in fact, they are part of the variable costs of production, which are defined as $\frac{c_T}{\vartheta_j}$. An upgraded technology involves lower variable costs of production than a baseline technology.

In the foreign markets, a firm must pay additional variable and fixed trade costs. They concern transport, information, commercial barriers, and sales costs. We model variable trade costs as iceberg costs for simplicity. Firms produce a quantity that is greater than one to sell one unit to a foreign customer. They are assumed to be homogeneous across destination countries. Moreover, fixed costs to export are higher than fixed costs in the domestic market.

For each firm's type (non-innovator, simple innovator, and complex innovator), we can calculate the profits obtained in domestic and foreign markets for all productivity levels. Following [22], we get:

$$\pi^D_{T_j} = B_T * \theta^D_T - cf^D_T \quad (5)$$

$$\pi^X_{T_j} = \tau_j^{(1-\varepsilon)} * B_T * \theta^X_T - cf^X_T \quad (6)$$

where $A * \frac{\alpha}{c_T}^{(\varepsilon-1)} * (1-\alpha) = B_T$ and $\theta^D_T = \vartheta_j^{(\varepsilon-1)}$, where ϑ_j is firm's productivity.

By ordering firms along their productivity, we can identify exiters, non-exporters, and exporters. The least productive firms exit the domestic market because they cannot bear entrance costs, and they face national competition (firms' profits cannot bear fixed costs; profits are less than 0). Non exporters earn profits selling in the domestic market only, and exporters serve domestic and foreign markets. Exporters' profits are obtained by summing up profits from sales in both markets.

We can graphically represent firms' profits with straight lines (Figure 1). We start by drawing two linear functions for non-innovators, each indicating profits in domestic and foreign markets, respectively. The assumption of higher fixed and variable costs in the foreign market implies that the profit function in the foreign market is steeper than the domestic market one with a smaller vertical intercept. By summing the domestic and export profits, we obtain the total profit function. For non-innovators, total profit function corresponds to the solid line. Being a simple innovator rather than a non-innovator changes both the slope (specifically the parameter B_T) and the intersection with the y-axis ($-cf^D_T$ and $-cf^X_T$) of both domestic and export profit functions. This implies that simple innovators' total profit graph is right-shifted (dashed line). For the same reasoning, complex innovators' total profit graph is further right shifted (dotted line).

It is possible to classify firms into five categories, given their technological propensities and productivity levels:

- Firms exit the market if their productivity is lower than θ^D_{NI} because of negative profits;
- Non-innovators serve the domestic market if their productivity is between θ^D_{NI} and θ^X_{NI};
- Non-innovators serve both domestic and foreign markets if their productivity is between θ^X_{NI} and μ_{SI};
- Simple innovators serve both domestic and foreign markets if their productivity is between μ_{SI} and μ_{CI};
- Complex innovators serve both domestic and foreign markets if their productivity is higher than μ_{CI}.

We can draw three important conclusions. First, the most productive firms use more than one type of innovation. Second, some exporters do not innovate, because their productivity cannot compensate the high (fixed) costs that are required to exploit high-level technology. Finally, non-exporters have no incentive to innovate, so that they are non-innovators too.

The first of these results is the most important one for our study; firms that use more than one innovation can be the most productive, so they are interested to enter foreign markets [11,13]. More innovative firms have a higher propensity to export than non-innovators: analyzing Figure 1, we can see that non innovators show smaller productivity levels than simple innovators (one innovation), but complex innovators (two or more innovations) have the highest level of productivity.

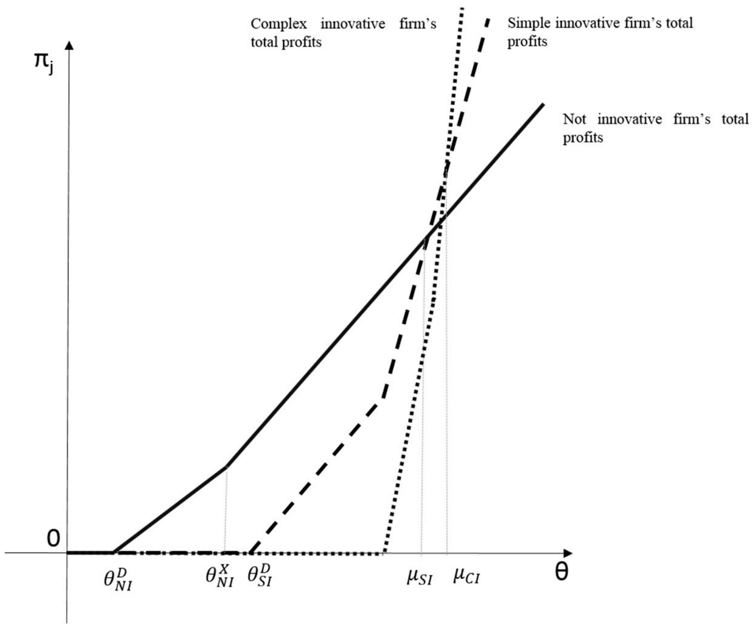

Figure 1. Firms' total profits for non-innovators, simple innovators, and complex innovators.

4. Data Description and Econometric Strategy

We used data from the Community Innovation Survey 2008 (CIS2008) for six Eastern EU countries: Bulgaria, Czech Republic, Hungary, Lithuania, Slovenia, and Slovakia. These countries have been members of the EU (EU) since 2004, with the exception of Bulgaria, which joined it in 2007. Data comes from the Sixth Community Innovation Survey (CIS2008), which is based on Oslo Manual 2005. The CIS2008 dataset covers 2006–2008 for all sectors of the economy. In this work, the focus was on the manufacturing sector. The CIS2008 survey distinguishes among four types of innovation: products, process, organizational, and marketing innovations. Product innovations involve the introduction of new goods, or an improvement of an already existing one. Process innovations include the introduction of new methods of production, or a new logistic, delivery, or distributive system, or an improvement of the existing ones. Organizational innovations concern changes in workplace organization, in external relations, or in business practices. Marketing innovations involve packaging or design changes, or the creation of new sales markets. We decided to combine organizational innovations with marketing innovations, in order to simplify the model; thus, in our work, there are three groups of innovations. Organizational and marketing innovations refer to non-technological innovations ([23]). This simplification has been made because marketing can be related with a firm's organization. For each innovation practice, the survey reports a binary variable; this means that if a firm applies a specific innovation, the variable is equal to 1, and 0 otherwise.

Considering Eurostat data on firms' composition by size, we can see from Table 1 that Eastern EU countries were characterized by a large amount of small firms, and by a few large firms. This is in line with other advanced economies.

Table 1. Number of manufacturing firms in Eastern EU countries in 2008 [24].

	N° of Manufacturing Enterprises in 2008		
Country	**Small Firms**	**Medium Firms**	**Large Firms**
Bulgaria	27,784	2158	345
Czech Republic	147,400	3475	878
Hungary	54,110	1791	445
Lithuania	14,805	824	139
Slovak Republic	6698	1051	332
Slovenia	16,611	583	150

Complex innovative firms—using more than one innovation—are the most efficient ones [11,13]; while non-innovators show the smallest productivity levels compared to simple innovators (one innovation). Descriptive statistics from CIS2008 data confirmed this prediction for all countries: the share of complex innovators with a productivity level higher than the fourth percentile value is statistically higher than the corresponding share of less productive firms (with a productivity level lower than first percentile value: descriptive statistics concerning the productivity and the adoption of complex innovations are reported in Appendix A in Table A3). The literature has also underlined that innovators have a higher propensity to export than non-innovators. This prediction is confirmed for Czech and Slovenian manufacturing firms. In Czech Republic, the share of innovative exporting firms is 44.82% higher than non-innovative exporting firms; in Slovenia, this share is equal to 29.20%. Additionally, non-exporting firms are mainly represented by non-innovators across all countries (descriptive statistics about exporting propensity and the adoption of innovations are reported in Table A4 in Appendix A). By considering size as an alternative way to measure efficiency, exporter and innovation frequencies for small, medium, and large firms are consistent with latter evidence. For Hungary and Czech Republic, large firms tend to export more frequently than small and medium ones. Moreover, Czech, Lithuanian, and Slovenian large firms usually adopt complex innovations (as we can see from Table A5 in Appendix A, in Hungary, the share of large exporters is 93.25%, with 47.43% for medium firms, and 82.38% for small ones. In Czech Republic, 91.27% of large firms, 80.39% of medium firms, and 49.55% of small firms sell their products abroad. Focusing on innovation, a share of 59.71% of large Slovenian firms adopt all types of innovation. Similarly, 38.46% of Lithuanian firms and 47.5% of Czech large firms implement complex innovation strategies).

The present work aimed at studying whether complementarities among innovations exist and whether they have a significant effect on the exporting propensity of firms. For a better understanding of the applied model, it is fundamental to describe complementarity and its meaning.

Complementarity refers to Edgeworth complements: two activities are complements if an increase of one activity increases the returns of doing more of the other activity. The complementarity relation is symmetric: an increase of one activity can imply worse economic performance, while an increase of both activities can imply a better economic performance, so that the firm prefers to implement both activities. In this work, the activities are represented by innovation practices. Since innovation practices are typically investigated in discrete settings, we study complementarity among the product, process, and non-technological innovation through the properties of *supermodular* functions [18–22], applying the methodology developed in [9].

Specifically, in the presence of three innovation practices of the firm, we introduce three binary decision variables to define the set of all possible combinations of three innovation practices. This set is the lattice I, whose elements are eight (that is 2^3):

$$I = \{\{000\}, \{001\}, \{010\}, \{100\}, \{101\}, \{110\}, \{011\}, \{111\}\} \tag{7}$$

where the element $\{000\}$ indicates that a firm adopts neither of the three practices, and $\{111\}$ indicates that a firm adopts all practices. All other elements refer to mixed innovation/no innovation combinations.

Hereafter, we refer to simple innovators if firms adopt one innovation, and to complex innovators if they use two or more kinds of innovations.

As a first step, the econometric procedure requires the estimation of the logit model:

$$Pr(E_j = 1|\theta_j) = \frac{\exp(\theta_j \beta)}{1 + exp(\theta_j \beta)} \tag{8}$$

With:

$$\theta_j \beta = a_0 + a_1 \pi_j + \sum_{i \epsilon I} b_i D_{ij} + \sum_{s \epsilon S} a_s D_{sj} + \sum_{e \epsilon E} b_e D_{ej} + \varepsilon_j \tag{9}$$

where D_{ij}, with $i \in I$, is a dummy equal to one for innovation activity i and zero otherwise, where i is an element of the lattice I, as defined in (7). D_{sj}, is a sector-specific dummy, where s is an element of S, a set of possible technology levels that a firm can adopt. Dummies for technology intensity refer to low, medium-low, and medium-high technology sectors (this classification follows the OECD (2008) by aggregating medium-high and high technology-intensive sectors. Sectors in CIS data are reported following NACE Rev.2 classification). In our study, S includes low and medium-high—high technology sectors. Productivity is measured in terms of the firm's relative profitability, as proposed by [25]. For any firm j, we calculate the natural log of the turnover share as follows:

$$Prod_j = \ln\left(\frac{turnover_j}{sector\ turnover}\right) - \frac{1}{n}\sum_j \ln\left(\frac{turnover_j}{sector\ turnover}\right) \tag{10}$$

where n is the number of firms in a sector.

D_{ej} is a dummy's size; e is an element of E, which captures the firms' dimension in terms of employees. We refer to the CIS2008 classification, grouping firms by size. The firm size depends on the number of employees: a firm is small when the number of employees is less than 50; it is a medium firm if the number of employees is between 50 and 249; finally, it is a large firm if there are more than 249 employees. Finally, ε_j is an error term. A detailed description of all variables used in the empirical analysis is listed in Table A1 in the Appendix A.

Following [26], we state that innovation variables included in the lattice I are complements, if and only if the exporting probability is significantly influenced by complementarities between innovation practices considered two by two. For each couple of innovation practices, we wanted to test for it by estimating the econometric model (8) subject to the following inequality constraints stated in [9]:

Hypotheses 1. *Complementarity between product and process innovation practices:*

$$\begin{aligned} b_{000} + b_{110} \geq b_{100} + b_{010} \geq 0\ (\mathbf{a}) \\ b_{111} + b_{001} \geq b_{101} + b_{011} \geq 0\ (\mathbf{b}) \end{aligned} \tag{11}$$

with at least one of the two inequalities holding strictly.

Hypotheses 2. *Complementarity between the product and non-technological innovation practices:*

$$\begin{aligned} b_{000} + b_{101} \geq b_{100} + b_{001} \geq 0\ (\mathbf{a}) \\ b_{111} + b_{010} \geq b_{011} + b_{110} \geq 0\ (\mathbf{b}) \end{aligned} \tag{12}$$

with at least one of the two inequalities holding strictly.

Hypotheses 3. *Complementarity between the process and non-technological innovation practices:*

$$\begin{aligned} b_{000} + b_{011} \geq b_{010} + b_{001} \geq 0\ (\mathbf{a}) \\ b_{111} + b_{100} \geq b_{101} + b_{110} \geq 0\ (\mathbf{b}) \end{aligned} \tag{13}$$

with at least one of the two inequalities holding strictly. It is also tested in the presence of substitutable innovation practices by replacing the $\geq$ sign by the $\leq$ sign in all inequalities.

Our idea was to evaluate complementarity hypotheses by using a parametric bootstrap procedure for directly testing the combined hypotheses (1), (2), or (3) as proposed by [9]. The procedure is repeated for each couple of complementarity constraints by estimating the constrained and the unconstrained models, and testing the null hypothesis by bootstrapping. We estimated the constrained and unconstrained logit models to compute the likelihood ratio test (LRT) from the original dataset of size N. We then drew a random sample of size N with replacement from the original dataset, fit constrained and unconstrained models, and compute the LRT (a detailed description of the bootstrapping methodology is reported in [9]). We repeated this step 1000 times. Standard errors, z-statistics, and normal-based 95% confidence interval were then computed to verify if the null hypothesis at hand cannot be rejected.

5. Results

In this section, we analyzed the effects of simple and complex innovative practices on the export propensity for all countries, taking also into account the firm dimension (small, medium, and large) and medium-high–high tech sectors.

As a first step, the exporting propensity was studied through a logit estimation model. The model was specified by (8), and the marginal effects of innovation variables and productivity were calculated (summary statistics for all variables used in the econometric estimation of export propensity are reported in Table A2 in the Appendix A). We then tested the complementarity by applying the methodology presented in Section 4. As we can see from Tables 2 and 3, the firm productivity (Prod) has always had a positive impact on the exporting propensity of firms, whatever the considered country; values spread from +5.5% in Lithuania to +10.15% in Slovenia, and all of them were statistically significant.

Considering innovation marginal effects, results are summarized by firm size as follows.

Small Firms: An interesting result can be noted for Bulgarian firms, which show negative and statistically significant marginal effects. This is the case for firms that introduce process innovation, while it is weaker when all types of innovation are adopted. By analyzing the results for the other countries, complex innovative small firms have a higher propensity of exporting than simple or non-innovative ones, except for Slovakian firms. For example, Czech and Slovenian firms are more inclined to export if product and non-technological innovations are jointly introduced; the corresponding marginal effects are equal to 32.7% for the former firms, and to 42.10% for the latter ones. On the contrary, we can see that for Hungarian and Lithuanian small firms, the conjoint use of product and process innovation generates the highest probability of exporting. Firms that implement these innovations are 36.3% and 31.6% more likely to export than the other ones. In general, firms less likely export if no innovation is introduced, but a contrasting situation occurs for Lithuanian firms; they show a smaller probability of being an exporter if all innovations are simultaneously adopted.

Medium Firms: Results for medium firms are similar to small ones in Bulgaria. The probability of Czech and Slovenian firms being exporters is higher when a simple process innovative activity is developed. This result was confirmed by dummy variable d010, whose marginal effect is 37.7% for Czech Republic and 38.1% for Slovenia. Hungarian firms show a highest marginal effect for adopting all kinds of innovations; indeed, the dummy d111 marginal effect is positive and highly significant (51.2%). Finally, simple and non-innovative firms have the lowest probability of exporting across all countries, except for Czech Republic where complex innovators that adopt both product and process innovations have less attitude to export; dummy d110 shows the lowest marginal effect value.

Large Firms: In general, less statistically significant results were obtained for large firms. Concerning Bulgarian large firms, a different result from small and medium firms was reported. As Table 3 shows, the impact of adopting all types of innovation becomes positive; the dummy d111 marginal effect is 20%. Paying attention to Hungarian and Lithuanian firms, it was confirmed that the simultaneous adoption of product, process and non-technological innovations generates a higher propensity to export for them. In Hungary, these firms are 48.6% more likely to export, and in Lithuania, they are 44.2% more inclined to sell their products abroad. Simple non-technological innovations seem to have a higher effect on the exporting status of Slovakian firms. Czech complex innovative firms have higher propensity for exporting (40.7%). Finally, non-innovative firms have the smallest propensity to export in every country, except for Czech Republic' firms.

We then check for complementarities between pair-wise innovative practices within Eastern EU manufacturing firms when the objective function is represented by the exporting propensity. Results by firm size are reported in Table 4.

Table 2. Exporting propensity logit estimates, coefficients (note: statistical significance: * 0.05–0.1; ** 0.01–0.05; *** <0.01 *p*-values. Dummies related to size and technological level have been considered). See Table A1 of Appendix A for variable description.

	Bulgaria		Czech Republic		Hungary		Lithuania		Slovenia		Slovakia	
	Coeff.	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**
Prod	0.428 ***	−0.025	0.479 ***	−0.054	0.545 ***	−0.056	0.319 ***	−0.072	0.655 ***	−0.185	0.460 ***	−0.101
Small Firms												
d000	−1.523 ***	−0.067	0.816 ***	−0.177	1.014 ***	−0.134	0.134	−0.206	1.079 ***	−0.185	0.800 ***	−0.254
d001	−1.516 ***	−0.137	1.247 ***	−0.224	0.799 ***	−0.24	0.557	−0.506	1.301 ***	−0.269	0.690 *	−0.392
d010	−1.650 ***	−0.141	1.177 ***	−0.358	2.207 ***	−0.538	0.061	−0.624	2.026 ***	−0.515	1.143	−0.814
d100	−1.361 ***	−0.16	2.138 ***	−0.581	1.717 ***	−0.411	1.186	−1.299	2.463 ***	−0.594	2.320 *	−1.212
d110	−1.385 ***	−0.241	1.190 **	−0.553	2.300 ***	−0.532	1.832 *	−0.991	1.879 ***	−0.56	0.892	−0.891
d101	−1.159 ***	−0.171	2.294 ***	−0.487	2.027 ***	−0.514	/	/	2.717 ***	−0.928	1.192	−0.936
d011	−1.387 ***	−0.19	1.438 ***	−0.335	2.149 ***	−0.437	1.558 ***	−0.586	1.818 ***	−0.461	1.197 **	−0.578
d111	−0.954 ***	−0.154	1.727 ***	−0.248	2.118 ***	−0.36	0.922 *	−0.511	1.936 ***	−0.363	1.186 **	−0.559
Medium Firms												
d000	−0.866 ***	−0.088	1.358 ***	−0.144	1.564 ***	−0.139	0.701 ***	−0.197	0.995 ***	−0.22	1.948 ***	−0.262
d001	−0.706 ***	−0.135	1.972 ***	−0.223	2.154 ***	−0.316	1.967 **	−0.766	1.533 ***	−0.428	1.741 ***	−0.489
d010	−0.882 ***	−0.174	2.649 ***	−0.585	2.225 ***	−0.524	1.718 ***	−0.513	2.459 **	−1.063	2.090 *	−1.069
d100	−0.781 ***	−0.218	2.273 ***	−0.622	2.144 ***	−0.491	/	/	2.183 **	−0.891	/	/
d110	−0.715 **	−0.333	1.347 ***	−0.353	2.656 ***	−0.708	0.904	−0.591	/	/	/	/
d101	−0.308	−0.225	1.894 ***	−0.364	2.404 ***	−0.418	1.769	−1.1	1.321 **	−0.568	2.328 ***	−0.759
d011	−0.468 **	−0.184	1.879 ***	−0.275	2.965 ***	−0.719	1.349 ***	−0.497	1.560 ***	−0.54	1.759 ***	−0.639
d111	−0.245	−0.177	2.202 ***	−0.203	3.246 ***	−0.502	1.707 ***	−0.467	2.435 ***	−0.465	2.246 ***	−0.454
Large Firms												
d000	−0.563 **	−0.252	1.079 ***	−0.247	1.416 ***	−0.28	0.862 *	−0.498	/	/	1.238 ***	−0.361
d001	−0.434	−0.392	2.653 ***	−0.579	2.993 ***	−0.977	/	/	/	/	2.720 **	−1.094
d010	−0.568	−0.452	2.372 **	−1.094	2.128 *	−1.123	/	/	/	/	1.513 **	−0.716
d100	−0.024	−0.65	1.885 ***	−0.704	/	/	/	/	/	/	/	/
d110	−0.484	−0.605	2.859 ***	−0.963	1.853 **	−0.853	/	/	/	/	/	/
d101	−0.148	−0.456	1.335 ***	−0.501	/	/	/	/	0.029	−1.076	2.185 **	−0.999
d011	−0.720 **	−0.363	1.036 ***	−0.348	/	/	1.463	−1.06	0.578	−1.258	1.358 **	−0.651
d111	1.223 *	−0.627	2.100 ***	−0.248	3.077 ***	−0.726	2.564 ***	−0.891	/	/	2.533 ***	−0.695
Observations	8126		2688		2577		816		1086		766	

Table 3. Exporting propensity logit estimates, marginal effects (note: statistical significance: * 0.05–0.1; ** 0.01–0.05; *** <0.01 p-values. Dummies related to size and technological level have been considered).

	Bulgaria		Czech Republic		Hungary		Lithuania		Slovenia		Slovakia	
	Marginal Effect	Std. Error	Marginal Effect	Std. Error	Marginal Effect	Std. Error	Marginal Effect	Std. Error	Marginal Effect	Std. Error	Marginal Effect	Std. Error
Prod	0.071 ***	0.004	0.068 ***	0.007	0.0869 ***	0.008	0.055 ***	0.012	0.101 ***	0.014	0.068 **	0.014
Small Firms												
d000	−0.253 ***	0.010	0.116 ***	0.025	0.160 ***	0.020	0.023	0.035	0.167 ***	0.025	0.118 ***	0.037
d001	−0.252 ***	0.022	0.178 ***	0.031	0.126 ***	0.037	0.096	0.087	0.202 ***	0.039	0.102 *	0.058
d010	−0.274 ***	0.023	0.168 ***	0.051	0.348 ***	0.084	0.010	0.108	0.314 ***	0.078	0.169	0.120
d100	−0.226 ***	0.026	0.305 ***	0.082	0.271 ***	0.064	0.205	0.223	0.381 ***	0.090	0.344 *	0.178
d110	−0.230 ***	0.040	0.169 **	0.078	0.363 ***	0.083	0.316 *	0.170	0.291 ***	0.084	0.132	0.132
d101	−0.193 ***	0.028	0.327 ***	0.068	0.320 ***	0.080	/	/	0.421 ***	0.141	0.177	0.138
d011	−0.231 ***	0.031	0.205 ***	0.047	0.339 ***	0.068	0.269 ***	0.100	0.282 ***	0.070	0.177 **	0.085
d111	−0.159 ***	0.025	0.246 ***	0.034	0.334 ***	0.055	0.159 *	0.088	0.300 ***	0.044	0.176 **	0.082
Medium Firms												
d000	−0.144 ***	0.014	0.193 ***	0.019	0.247 ***	0.020	0.121 ***	0.033	0.154 ***	0.033	0.28 8 ***	0.035
d001	−0.117 ***	0.022	0.281 ***	0.030	0.340 ***	0.048	0.339 ***	0.131	0.237 ***	0.066	0.258 ***	0.071
d010	−0.147 ***	0.029	0.377 ***	0.083	0.351 ***	0.082	0.296 ***	0.087	0.381 **	0.164	0.310 **	0.158
d100	−0.130 ***	0.036	0.324 ***	0.088	0.338 ***	0.076	/	/	0.338 **	0.139	/	/
d110	−0.119 **	0.055	0.192 ***	0.050	0.419 ***	0.111	0.156	0.101	/	/	/	/
d101	−0.051	0.037	0.270 ***	0.051	0.379 ***	0.065	0.305	0.189	0.205 **	0.089	0.345 ***	0.111
d011	−0.078 **	0.031	0.268 ***	0.038	0.468 ***	0.113	0.233 ***	0.084	0.242 ***	0.084	0.261 ***	0.094
d111	−0.041	0.029	0.314 ***	0.027	0.512 ***	0.078	0.295 ***	0.079	0.377 ***	0.073	0.333 ***	0.064
Large Firms												
d000	−0.094 **	0.042	0.154 ***	0.035	0.223 ***	0.044	0.149 *	0.085	/	/	0.183 ***	0.052
d001	−0.072	0.065	0.378 ***	0.082	0.472 ***	0.154	/	/	/	/	0.403 **	0.160
d010	−0.094	0.075	0.338 **	0.155	0.336 *	0.177	/	/	/	/	0.224 **	0.106
d100	−0.004	0.108	0.268 ***	0.100	/	/	/	/	/	/	/	/
d110	−0.081	0.101	0.407 ***	0.137	0.292 **	0.135	/	/	/	/	/	/
d101	−0.025	0.076	0.190 ***	0.071	/	/	/	/	0.005	0.167	0.324 **	0.148
d011	−0.120 **	0.060	0.148 ***	0.049	/	/	0.252	0.182	0.090	0.195	0.201 **	0.096
d111	0.203 *	0.104	0.299 ***	0.034	0.486 ***	0.115	0.442 ***	0.153	/	/	0.375 ***	0.101
Observations	8126		2688		2577		816		1086		766	

Table 4. Complementarity and substitutability in Eastern Europe countries, bootstrapping test results (Note: '1 vs. 2' indicates the combination between product and process innovations, '1 vs. 3' refers to the combination between product and organizational/marketing innovations, and '2 vs. 3' concerns the combination between process and organizational/marketing innovations. 'C' indicates complementarity between two innovation practices, 'S' indicates substitutability. Statistical Significance: * 0.05–0.1; ** 0.01–0.05; *** <0.01 *p*-values).

	Small Firms			Medium Firms			Large Firms		
Country/Innovations	**1 vs. 2**	**1 vs. 3**	**2 vs. 3**	**1 vs. 2**	**1 vs. 3**	**2 vs. 3**	**1 vs. 2**	**1 vs. 3**	**2 vs. 3**
Bulgaria	C **	C **	C **		C **				
Czech Republic	S **								S **
Hungary				C **		C **	C ***		
Lithuania	C **				C **		C ***	C ***	C ***
Slovenia	S **		S **				C **	S **	C **
Slovakia	S **				C **			C ***	

Small Firms: By analyzing Columns 1–3 of Table 4, complementarity existed for all pair-wise combinations of innovations in Bulgarian firms. Complementarity was also confirmed between product and process innovations for Lithuanian small firms. Substitutability occurred in Czech, Slovenian, and Slovakian firms, especially between product and process innovations, and in Slovenian firms, when process and non-technological innovations were combined. No complementarity or substitutability relation was obtained for Hungarian small firms. These results can be interpreted as a propensity of adopting simple innovation strategies for small firms.

Medium Firms: With regards to medium firms, only complementarities were reported, especially between product and non-technological innovations. This was verified for Bulgarian, Lithuanian, and Slovakian medium firms. The Hungarian result was interesting. In this country, medium firms exhibit complementarity between product and process innovative practices and between process and non-technological innovations. As we can see from Table 4, any types of relationship between pair-wise innovations exist for Czech and Slovenian firms.

Large Firms: In line with [9], complementarity between product and process innovation could be seen in Hungarian, Lithuanian, and Slovenian large firms. Furthermore, empirical findings showed that other complementarities always involve non-technological innovations; this result confirmed previous evidence reported in [7]. Specifically, product and non-technological innovations were complements in Lithuanian and Slovakian large firms, while complementarity between process and non-technological innovations was found for Lithuanian and Slovenian firms. Only two cases of substitutability were found. In Slovenia, it was confirmed for product and non-technological innovation combinations, and in Czech Republic, for process and non-technological innovation combinations.

The Case of Medium-High–High Technology Manufacturing Firms

In this section, results regarding the medium-high–high tech sectors are presented. These specific sectors are important for global sustainable development, because they may contribute to reduce the gap between advanced and less advanced EU countries, and to improve firms' competitiveness. Medium-high and high tech manufacturing firms come from C26, C27, C28, C29, and C30 sectors of the NACE Rev 2.2 classification.

As we can see from Tables 5 and 6, it was confirmed that positive and significant effects of productivity (Prod). Considering innovation, results suggest different conclusions by country. In some countries, such as the Czech Republic and Slovakia, the adoption of a single product innovation had the highest effect on the export propensity (35.5% for Czech Republic and 38.4% for Slovakia). This is not verified for the other countries; for Bulgaria, Lithuania, and Slovenia firms have a higher propensity to export, if they invest on the mix of all types of innovation. The marginal effect of such a complex strategy is equal to +24.8% in Bulgaria, +47.9% in Lithuania, and +42.6% in Slovenia. Furthermore, the combination of process and non-technological innovations generates a large increase of the exporting propensity for Hungarian firms; the dummy d011 marginal effect is 41.9%. In all countries, medium-high–high technology firms have a weaker propensity of being exporters if they do not innovate.

Table 5. Exporting propensity in medium-high–high technology firms, coefficients (note: statistical significance: * 0.05–0.1; ** 0.01–0.05; *** <0.01 *p*-values. Dummies related to size are included in the model but are not reported). See Table A1 of Appendix A for variable description.

	Bulgaria		**Czech Republic**		**Hungary**		**Lithuania**		**Slovenia**		**Slovakia**	
	Coeff.	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**
Prod	0.363 ***	−0.08	0.433 ***	−0.125	0.535 ***	−0.123	0.451	−0.313	0.592 ***	−0.205	0.597 **	−0.258
d000	0.199	−0.175	2.240 ***	−0.293	1.941 ***	−0.228	1.353 ***	−0.421	2.023 ***	−0.502	2.599 ***	−0.478
d100	0.756 **	−0.335	3.968 ***	−1.018	1.678 ***	−0.514	/	/	3.617 ***	−1.08	3.612 **	−1.601
d010	−0.278	−0.345	2.838 ***	−0.611	2.987 ***	−0.823	/	/	/	/	2.290 **	−1.05
d001	0.312	−0.254	2.785 ***	−0.401	1.815 ***	−0.422	/	/	2.013 ***	−0.636	2.775 ***	−0.555
d110	0.545	−0.394	3.469 ***	−0.795	2.897 ***	−0.735	1.389	−1.498	/	/	/	/
d101	0.906 ***	−0.283	3.963 ***	−0.682	/	/	/	/	/	/	3.128 ***	−0.912
d011	0.384	−0.347	2.254 ***	−0.397	3.270 ***	−0.991	/	/	3.394 ***	−0.989	2.926 **	−1.164
d111	1.250 ***	−0.302	3.643 ***	−0.398	3.137 ***	−0.557	3.088 ***	−0.848	4.566 ***	−1.106	3.599 ***	−0.878
Observations	854		799		662		107		293		226	

Table 6. Exporting propensity in medium-high–high technology firms, marginal effects (note: statistical significance: * 0.05–0.1; ** 0.01–0.05; *** <0.01 *p*-values. Dummies related to size are included in the model but not reported).

	Bulgaria		**Czech Republic**		**Hungary**		**Lithuania**		**Slovenia**		**Slovakia**	
	Marginal Effect	**Std. Error**	**Marginal Effect**	**Std. Error**	**Marginal Effect**	**Std. Error**	**Marginal Effect**	**Std. Error**	**Marginal Effect**	**Std. Error**	**Marginal Effect**	**Std. Error**
Prod	0.072 ***	0.015	0.039 ***	0.010	0.069 ***	0.014	0.07	0.047	0.055 ***	0.018	0.063 **	0.027
d000	0.039	0.034	0.200 ***	0.021	0.249 ***	0.020	0.210 ***	0.043	0.189 ***	0.044	0.276 ***	0.035
d100	0.150 **	0.065	0.355 ***	0.089	0.215 ***	0.063	/	/	0.338 ***	0.097	0.384 **	0.159
d010	−0.055	0.068	0.254 ***	0.051	0.383 ***	0.101	/	/	/	/	0.243 **	0.106
d001	0.062	0.05	0.249 ***	0.030	0.233 ***	0.051	/	/	0.188 ***	0.058	0.295 ***	0.054
d110	0.108	0.078	0.310 ***	0.069	0.371 ***	0.091	0.215	0.225	/	/	/	/
d101	0.179 ***	0.055	0.354 ***	0.059	/	/	/	/	/	/	0.332 ***	0.097
d011	0.076	0.069	0.201 ***	0.032	0.419 ***	0.125	/	/	0.317 ***	0.086	0.311 ***	0.119
d111	0.248 ***	0.057	0.326 ***	0.028	0.402 ***	0.070	0.479 ***	0.124	0.426 ***	0.092	0.382 ***	0.075
Observations	854		799		662		107		293		226	

While testing for the existence of complex and simple innovations for exporting propensity, we have found heterogeneous results across countries. As reported in Table 7, the complementarity is the only relationship that occurs between any two innovations; no substitutability is detected. Bulgarian, Hungarian, and Lithuanian firms are the only ones showing a relation of complementarity between product and process innovations. These results underline the presence of complementarity between product and process innovations for exporting propensity, which are consistent with [8,12]. Complementarity between process and non-technological innovations exists in high tech firms across all countries, except for Czech and Slovenian firms. Conversely [7] found neither complementarity nor substitutability between process and non-technological innovations for Dutch firms. Bulgaria and Lithuania have high tech firms within which complementarity between processes and non-technological innovative practices exists.

Table 7. Complementarity and substitutability in medium-high–high technology sectors, bootstrapping test results (note: '1 vs. 2' indicates the combination between product and process innovations, '1 vs. 3' refers to the combination between product and organizational/marketing innovations, and '2 vs. 3' concerns the combination between process and organizational/marketing innovations. 'C' indicates the complementarity between two innovation practices, 'S' indicates the substitutability. Statistical significance: * 0.05–0.1; ** 0.01–0.05; *** <0.01 *p*-values).

	Medium-High–High Tech Firms		
Country/Innovations	**1 vs. 2**	**1 vs. 3**	**2 vs. 3**
Bulgaria		C **	C **
Czech Republic			
Hungary	C **		C **
Lithuania	C ***		
Slovenia			
Slovakia	S ***		C **

6. Discussion

In general, we can specify two important conclusions. First, productivity always has a positive and statistically significant effect on the export status of firms, whichever is their size. Second, all kinds of innovations, alone or combined with each other, have significant and positive marginal effects across all Eastern EU countries, except for Bulgaria. However, some differences arise when firms are grouped by size.

Small Firms: As Table 6 shows, the export propensity of small firms is positively affected by innovation decisions, concentrating their efforts into one or, at maximum, two types of innovation practices. This evidence is verified for each country, but for Lithuania and Slovakia, marginal effects are less statistically significant than other countries. However, we have to specify that the resulted complementarity for Lithuanian small firms is confirmed by the marginal effect (significance level 10%).

Medium Firms: Concerning medium firms, a positive correlation between pair-wise innovations and the probability of exporting is confirmed for Hungary and Slovakia, while other countries' firms opt for the integration of a single innovation. Bulgarian firms have a negative propensity of being exporters if innovations are implemented. Additionally, complementarity results are verified through marginal effects for Czech and Slovakian firms.

Large Firms: The positive and significant link between innovations and the exporting probability is confirmed for all large firms, except for Bulgarian and Slovenian ones. The assumption of complementarity for all possible couples of innovative practices cannot be rejected, and results are highly significant for Lithuanian large firms. This is the only case where complementarity between all pairs of innovations is detected. This result is consistent with results on marginal effects. Hungarian and Lithuanian large firms show a significant complementarity between product and process innovations. Simple and complex innovators have a higher exporting propensity than non-innovative firms. There are only two substitutability cases, which involve process and non-technological innovations for Czech firms, and product and non-technological innovations for Slovenian firms.

Medium-high–high technology firms: Focusing on medium high and high technology firms across all countries, two relevant results emerge. First, in technologically advanced sectors, firms have an advantage in terms of a higher exporting propensity when they use more than one innovation. This suggests a crucial role of innovation practices rather than other firms' characteristics in influencing their competitive advantage in international markets. However, it is also true that firms prefer to introduce only one kind of innovation in Czech Republic and Slovakia. Second, concerning the complementarity test, process innovations are always involved in complementarity cases, and no substitutability relationship has been detected for all innovative practices.

7. Conclusions

Given the increasing importance of Eastern EU countries in the geopolitical and economic scenario, and the attention of policy-makers to international trade and innovation as key drivers of a sustainable development, this paper has investigated the relationship between innovation and the propensity to export in manufacturing sectors, admitting productivity differences across firms. In our analysis, positive effects of productivity on firms' exporting probability have been found for Eastern EU countries, as in advanced EU countries. In turn, all combinations of innovation practices improve the exporting propensity of firms. By testing for the presence of complementarity between all possible couples of innovation practices—considering the product, process, and non-technological innovations—we have found that both complementarity and substitutability emerge, depending on the dimension of firms in terms of employees and the analyzed country. While large firms take advantage of complex innovation strategies across less advanced Eastern EU economies, small firms concentrate their efforts into simpler innovation alternatives to increase their competitive advantage and to afford global markets. This result can be interpreted by the limited depth of small firms' competence and the ability to develop more formal R&D activities.

From a policy point of view, small, and medium firms have an important role in Eastern EU economies. As such, governments should implement sustainable policies focused on innovation, in order to improve firms' productivity level, expand their size, and be more competitive. These policies should consider funding schemes or reliefs for the introduction of new innovative practices. Specifically, we argue that knowledge exchange partnerships and the creation of networks could represent good sustainable policies, with positive effects at the macro- and micro-levels. At the macro-level, they can help less advanced countries to introduce or to improve innovations by learning from more advanced countries. At the micro-level, knowledge networks can be useful, especially for small firms, because they can help in developing capabilities to better manage innovations. Finally, subsidies and incentives for financing innovation expenditure could be fundamental in a longer term perspective.

The implementation of new innovative strategies by firms can have important managerial implications. They could allow to enlarge the export propensity, especially in small and medium firms. Moreover, small-sized and medium-high–high technology firms should take advantage from complementarity and further increase the possibility of adopting complex innovative practices. In view of the positive role of complex innovation strategies on improving firms' efficiency and export propensity, all firms should pay more attention to the implementation of all types of innovative practices, and policy interventions should find the right incentives to integrate these types of innovative practices.

Further investigation should be devoted to explore potential dynamic feedbacks in terms of positive learning effects by exporting, which can affect firms' competitive advantage, as well as their innovative propensity. Learning-by-interacting with global customers and learning-by-competing with international competitors are themselves the source of new competences. Specifically, past exporting status could be an important determinant of all kinds of innovative practices, as well as of productivity levels. Such a dynamic framework requires information over several time periods, which is not included in the CIS dataset. Furthermore, some measurement errors due to the potential existence of uncodified information on learning processes, especially for small firms, can underestimate complex innovation effects on export propensity. Datasets with more detailed information about such informal learning processes are advocated in this view.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix

Table A1. Description of model variables.

Variable	Description
dEXP	Exports: dummy equal to 1 if a firm is an exporter, equal to 0 if a firm is a non-exporter
d000	Non-innovator: dummy equal to 1 if a firm does not apply any types of innovation, 0 otherwise
d100	Product innovator: dummy equal to 1 if a firm only applies product innovations, 0 otherwise
d010	Process innovator: dummy equal to 1 if a firm only applies process innovations, 0 otherwise
d001	Non-technological innovator: dummy equal to 1 if a firm only applies non-technological innovations, 0 otherwise
d110	Product and process innovator: dummy equal to 1 if a firm applies both product and process innovations, 0 otherwise
d101	Product and non-technological innovator: dummy equal to 1 if a firm applies both product and non-technological innovations, 0 otherwise
d011	Process and non-technological innovator: dummy equal to 1 if a firm applies both process and non-technological innovations, 0 otherwise
d111	Complex innovator: dummy equal to 1 if a firm applies all types of innovations, 0 otherwise
Prod	productivity: turnover share calculated as (10)
dsize_small	Small firm: dummy equal to 1 if a firm is classified as small (<50 employees), 0 otherwise
dsize_medium	Medium firm: dummy equal to 1 if a firm is classified as medium (>50 and $\leq$250), 0 otherwise
dsize_large	Large firm: dummy equal to 1 if a firm is classified as large (>250), 0 otherwise
dTech_L	Low technology firm: dummy equal to 1 if a firm is classified as low tech, 0 otherwise
dTech_ML	Medium-low technology firm: dummy equal to 1 if a firm is classified as medium low tech, 0 otherwise
dTech_H	Medium-high–high technology firm: dummy equal to 1 if a firm is classified as medium-high–high tech, 0 otherwise

Table A2. Summary statistics.

	Bulgaria					Czech Republic					Hungary				
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
dEXP	8942	0.285	0.452	0	1	2792	0.736	0.441	0	1	2698	0.676	0.468	0	1
d000	8942	0.647	0.478	0	1	2792	0.348	0.476	0	1	2698	0.646	0.478	0	1
d100	8942	0.045	0.207	0	1	2792	0.027	0.163	0	1	2698	0.032	0.176	0	1
d010	8942	0.070	0.256	0	1	2792	0.039	0.193	0	1	2698	0.032	0.177	0	1
d001	8942	0.085	0.279	0	1	2792	0.144	0.351	0	1	2698	0.087	0.283	0	1
d110	8942	0.019	0.138	0	1	2792	0.038	0.192	0	1	2698	0.027	0.161	0	1
d101	8942	0.038	0.192	0	1	2792	0.051	0.220	0	1	2698	0.039	0.194	0	1
d011	8942	0.042	0.200	0	1	2792	0.088	0.284	0	1	2698	0.036	0.185	0	1
d111	8942	0.053	0.224	0	1	2792	0.265	0.441	0	1	2698	0.101	0.302	0	1
Prod	8126	0.00	1.639	−7.10	8.48	2688	0.000	1.794	−6.63	6.06	2636	0.000	1.812	−6.98	7.04
dsize_large	8942	0.038	0.192	0	1	2792	0.279	0.449	0	1	2698	0.148	0.355	0	1
dsize_medium	8942	0.240	0.427	0	1	2792	0.404	0.491	0	1	2698	0.383	0.486	0	1
dsize_small	8942	0.722	0.448	0	1	2792	0.317	0.466	0	1	2698	0.469	0.499	0	1
dTech_L	8942	0.655	0.475	0	1	2792	0.381	0.486	0	1	2698	0.462	0.499	0	1
dTech_ML	8942	0.118	0.322	0	1	2792	0.137	0.344	0	1	2698	0.138	0.345	0	1
dTech_H	8942	0.096	0.294	0	1	2792	0.286	0.452	0	1	2698	0.245	0.430	0	1
	Lithuania					**Slovenia**					**Slovakia**				
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
dEXP	880	0.711	0.453	0	1	1327	0.766	0.423	0	1	824	0.738	0.440	0	1
d000	880	0.589	0.492	0	1	1327	0.427	0.495	0	1	824	0.513	0.500	0	1
d100	880	0.020	0.142	0	1	1327	0.035	0.185	0	1	824	0.025	0.158	0	1
d010	880	0.051	0.220	0	1	1327	0.038	0.192	0	1	824	0.028	0.165	0	1
d001	880	0.059	0.236	0	1	1327	0.124	0.330	0	1	824	0.108	0.311	0	1
d110	880	0.039	0.193	0	1	1327	0.051	0.221	0	1	824	0.033	0.178	0	1
d101	880	0.016	0.125	0	1	1327	0.041	0.199	0	1	824	0.046	0.210	0	1
d011	880	0.077	0.267	0	1	1327	0.064	0.245	0	1	824	0.072	0.258	0	1
d111	880	0.149	0.356	0	1	1327	0.218	0.413	0	1	824	0.175	0.380	0	1
Prod	857	0.000	1.770	−9.42	6.36	1238	0.000	1.712	−10.15	5.73	801	0.000	1.894	−8.18	7.01
dsize_large	880	0.148	0.355	0	1	1327	0.105	0.306	0	1	824	0.329	0.470	0	1
dsize_medium	880	0.491	0.500	0	1	1327	0.357	0.479	0	1	824	0.348	0.477	0	1
dsize_small	880	0.361	0.481	0	1	1327	0.538	0.499	0	1	824	0.323	0.468	0	1
dTech_L	880	0.553	0.497	0	1	1327	0.368	0.482	0	1	824	0.399	0.490	0	1
dTech_ML	880	0.115	0.319	0	1	1327	0.251	0.434	0	1	824	0.155	0.362	0	1
dTech_H	880	0.122	0.327	0	1	1327	0.221	0.415	0	1	824	0.274	0.446	0	1

Table A3. Descriptive statistics: productivity and complex innovators (note: t-test on frequencies cannot reject the hypothesis of different values in all cases).

Productivity			Complex Innovators			
			The Least Productive Firms (<First perc.)		The Most Productive Firms (>Fourth perc.)	
Country	**1st perc.**	**4th perc.**	**Frequency**	**Share**	**Frequency**	**Share**
Bulgaria	−1.069	0.984	152	7.48%	638	22.40%
Czech Republic	−1.259	1.257	164	24.37%	474	61.08%
Hungary	−1.324	1.199	44	6.68%	266	36.89%
Lithuania	−1.104	1.175	32	14.95%	100	42.02%
Slovenia	−1.093	1.09	55	17.86%	228	57.14%
Slovakia	−1.302	1.31	34	16.92%	114	50.89%

Table A4. Descriptive statistics: exporting status and innovation status (note: t-test on frequencies cannot reject the hypothesis of different values in all cases).

	Exporting Firms				Non-Exporting Firms			
	Innovators		Non-Innovators		Innovators		Non-Innovators	
Country	Frequency	Share	Frequency	Share	Frequency	Share	Frequency	Share
Bulgaria	1224	48.00%	1326	52.00%	1931	30.21%	4,461	69.79%
Czech Republic	1489	72.42%	567	27.58%	332	45.11%	404	54.89%
Hungary	804	44.08%	1020	55.2%	152	17.39%	722	82.61%
Lithuania	806	32.27%	1692	67.73%	55	2.14%	199	78.35%
Slovenia	657	64.60%	360	35.40%	103	33.23%	207	66.77%
Slovakia	331	54.44%	277	55.56%	70	32.41%	146	67.59%

Table A5. Descriptive statistics: size and innovation combinations.

	Bulgaria									**Czech Republic**								
Size	**Innovation Dummies**									**Innovation Dummies**								
	Total	000	001	010	100	110	101	011	111	Total	000	001	010	100	110	101	011	111
Small	6456	4599	422	428	276	116	205	180	230	886	446	157	40	17	20	32	59	115
Medium	2142	1092	301	170	106	40	100	150	183	1127	387	177	44	30	47	70	118	254
Large	344	96	40	31	19	17	38	44	59	779	138	67	24	29	40	41	70	370
Share																		
Small	100.00%	71.24%	6.54%	6.63%	4.28%	1.80%	3.18%	2.79%	3.56%	100.00%	50.34%	17.72%	4.51%	1.92%	2.26%	3.61%	6.66%	12.98%
Medium	100.00%	50.98%	14.05%	7.94%	4.95%	1.87%	4.67%	7.00%	8.54%	100.00%	34.34%	15.71%	3.90%	2.66%	4.17%	6.21%	10.47%	22.54%
Large	100.00%	27.91%	11.63%	9.01%	5.52%	4.94%	11.05%	12.79%	17.15%	100.00%	17.72%	8.60%	3.08%	3.72%	5.13%	5.26%	8.99%	47.50%
	Hungary									**Lithuania**								
	Innovation Dummies									**Innovation Dummies**								
	Total	000	001	010	100	110	101	011	111	Total	000	001	010	100	110	101	011	111
Small	1265	988	98	22	28	23	19	31	56	318	235	21	11	4	6	2	20	19
Medium	1033	609	99	46	45	31	64	40	99	432	243	21	32	10	18	9	37	62
Large	400	145	39	19	13	18	23	25	118	130	40	10	2	4	10	3	11	50
Share																		
Small	100.00%	78.10%	7.75%	1.74%	2.21%	1.82%	1.50%	2.45%	4.43%	100.00%	73.90%	6.60%	3.46%	1.26%	1.89%	0.63%	6.29%	5.97%
Medium	100.00%	58.95%	9.58%	4.45%	4.36%	3.00%	6.20%	3.87%	9.58%	100.00%	56.25%	4.86%	7.41%	2.31%	4.17%	2.08%	8.56%	14.35%
Large	100.00%	36.25%	9.75%	4.75%	3.25%	4.50%	5.75%	6.25%	29.50%	100.00%	30.77%	7.69%	1.54%	3.08%	7.69%	2.31%	8.46%	38.46%
	Slovenia									**Slovakia**								
Size	**Innovation Dummies**									**Innovation Dummies**								
	Total	000	001	010	100	110	101	011	111	Total	000	001	010	100	110	101	011	111
Small	714	396	105	25	30	26	17	34	81	266	181	32	6	7	5	5	18	12
Medium	474	159	52	18	13	36	30	41	125	287	150	**33**	8	8	7	16	14	51
Large	139	12	8	8	4	6	8	10	83	271	92	24	9	6	15	17	27	81
Share																		
Small	100.00%	55.46%	14.71%	3.50%	4.20%	3.64%	2.38%	4.76%	11.34%	100.00%	68.05%	12.03%	2.26%	2.63%	1.88%	1.88%	6.77%	4.51%
Medium	100.00%	33.54%	10.97%	3.80%	2.74%	7.59%	6.33%	8.65%	26.37%	100.00%	52.26%	11.50%	2.79%	2.79%	2.44%	5.57%	4.88%	17.77%
Large	100.00%	8.63%	5.76%	5.76%	2.88%	4.32%	5.76%	7.19%	59.71%	100.00%	33.95%	8.86%	3.32%	2.21%	5.54%	6.27%	9.96%	29.89%

References

1. Halpern, L.; Muraközy, B. Innovation, Productivity and Exports: The Case of Hungary. *Econ. Innov. New Technol.* **2012**, *21*, 151–173. [CrossRef]
2. Wagner, J. Exports and Productivity: A Survey of the Evidence from Firm-level Data. *World Econ.* **2007**, *30*, 60–82. [CrossRef]
3. Damijan, J.P.; Kostevc, C.; Polanec, S. From Innovation to Exporting or Vice Versa? *World Econ.* **2010**, *33*, 374–398. [CrossRef]
4. Caldera, A. Innovation and Exporting: Evidence from Spanish Manufacturing Firms. *Rev. World Econ.* **2010**, *146*, 657–689. [CrossRef]
5. Cassiman, B.; Golovko, E.; Martínez, E. Innovation, Exports and Productivity. *Int. J. Ind. Organ.* **2010**, *28*, 372–376. [CrossRef]
6. Becker, S.O.; Egger, P.H. Endogenous product versus process innovation and a firm's propensity to export. *Empir. Econ.* **2013**, *44*, 329–354. [CrossRef]
7. Polder, M.; Van Leeuwen, G.; Mohnen, P.; Raymond, W. Product, Process and Organisational Innovation: Drivers, Complementarity and Productivity Effects. In *United Nations University—Maastricht Economic and Social Research and Training Centre on Innovation and Technology (MERIT), Working Paper Series*; Elsevier: Amsterdam, The Netherlands, 2010.
8. Van Beveren, I.; Vandenbussche, H. Product and Process Innovation and Firms' Decision to Export. *J. Econ. Policy Reform* **2010**, *13*, 3–24. [CrossRef]
9. Bernardini Papalia, R.; Bertarelli, S.; Mancinelli, S. Innovation, complementarity, and exporting. Evidence from German manufacturing firms. *Int. Rev. Appl. Econ.* **2017**, *32*, 3–38. [CrossRef]
10. Constantini, J.A.; Melitz, M. The Dynamics of Firm-Level Adjustment to Trade Liberalization. In *The Organization of Firms in a Global Economy*; Helpman, E., Marin, D., Verdier, T., Eds.; Harvard University Press: Cambridge, UK, 2008.
11. Melitz, M. The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity. *Econometrica* **2003**, *71*, 1695–1725. [CrossRef]
12. Melitz, M.J.; Redding, S.J. Heterogeneous Firms and Trade. In *Handbook of International Economics*, 4th ed.; Elsevier: Amsterdam, The Netherlands, 2014; pp. 1–54.
13. Bernard, A.B.; Jensen, J.B. Exporting and Productivity. In *The National Bureau of Economic Research*; Working Paper No. 7135; Oxford University Press: Oxford, UK, 1999.
14. Bustos, P. Multilateral Trade Liberalization, Exports and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinean Firms. *Am. Econ. Rev.* **2011**, *101*, 304–340. [CrossRef]
15. Marin, D. *The New Corporation in Europe*; Munich Reprints in Economics 19242; University of Munich, Department of Economics: Munich, Germany, 2008.
16. Antonelli, C.; Scellato, G. Firms size and directed technological change. *Small Bus. Econ.* **2015**, *44*, 207–218. [CrossRef]
17. Smit, J.; Kreutzer, S.; Moeller, C.; Carlberg, M. *Industry 4.0, Policy Department A: Economic and Scientific Policy*; European Parliament's Committee on Industry, Research and Energy (ITRE): Brussels, Belgium, 2016.
18. Eurostat: GDP and Main Components (nama_10_gdp). Available online: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_gdp&lang=en (accessed on 9 October 2018).
19. Eurostat: Intramural R&D Expenditure by Sectors of Performance and Source of Funds (rd_e_gerdfund). Available online: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_e_gerdfund&lang=en (accessed on 9 October 2018).
20. Eurostat: Patent Applications to the EPO by Priority Year (pat_ep_ntot). Available online: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=pat_ep_ntot&lang=en (accessed on 9 October 2018).
21. Eurostat: EU Direct Investment, Breakdown by Country and Economic Activity (bop_fdi_pos_r2). Available online: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_fdi_pos_r2&lang=en (accessed on 9 October 2018).
22. Helpman, E. Trade, FDI and the Organisation of Firms. *J. Econ. Lit.* **2006**, *44*, 589–630. [CrossRef]
23. OECD. *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd ed.; OECD: Paris, France, 2005.
24. Eurostat: General Information about Enterprises (inn_cis6_gen). Available online: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=inn_cis6_gen&lang=en (accessed on 9 October 2018).

25. Aw, B.Y.; Roberts, M.J.; Xu, D.Y. R&D Investments, Exporting and the Evolution of Firm Productivity. *Am. Econ. Rev.* **2008**, *98*, 451–456.
26. Topkis, D.M. *Super Modularity and Complementarity*; Princeton University Press: Princeton, NJ, USA, 1998.