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ORIGINAL PAPER

Self-selection and learning-by-exporting hypotheses: micro-level evidence

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Abstract The purpose of this paper is to investigate the self-selection (SS) and learning-by-exporting (LBE) hypothesis. That is, this paper examines the reverse causality between innovation, productivity and exporting. Previous studies have neglected the empirical analysis of the SS and LBE hypotheses using firm level data on 29 countries from Eurasia and Central and Eastern European (CEE) firms. Regression results have supported the SS and LBE hypotheses using the Crepon–Duguet–Mairesse (CDM) model. In addition, the innovation by exporting hypothesis asserts that innovation proxies (product/process, R&D and organizational innovation) positively influence the export performance. These results are robust across Eurasian and CEE firms. Moreover, foreign owned firms are more productive, and innovative and have a greater tendency to export than domestic firms because they are superior in terms of technology and management capabilities. Regarding policy implications, economic policies must target the economic integration between Eurasian and CEE firms through improvements in innovation, productivity and export performance.

Keywords Innovation · Productivity · Exporting

1 Introduction

International trade theories emphasized the role of innovation and productivity growth for accelerating export performance. International trading unions such as European Union (EU), Organization for Economic Cooperation and Development (OECD) and Eurasian economies are striving to compete in terms of technological

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innovation for gaining high trade volume. Concerning the global trade linkages, European Neighbourhood Policy (ENP) is an example of establishing the trade networks of European economies with neighbouring countries such as Azerbaijan, Belarus, Georgia, Israel, Turkey and Russia. ENP covers diverse and multilateral economic ties with each neighbouring country in terms investment, competition, labour and technological standards (Liargovas 2013). Regarding international trade, it is worth mentioning that whether a country is developed or developing, it must maintain a minimum threshold of GDP per capita to sustain their economic development. For economic sustainability, economies continuously need to make investment in innovation activities because the more they innovate, the larger their export share which results in foreign income. Concerning innovation, numerous endogenous growth models (e.g., see Lachenmaier and Wobmann 2006; Bravo-Ortega et al. 2014; Monreal-Perez et al. 2012) endogenize the innovation factor and predict the productivity-export relationship. The innovation factor stems from the intense competition in foreign markets which forces exporting firms, first, to improve their productivity i.e., to cover the sunk costs of entry into the international markets. Second, to remain competitive, firms' need to develop high-quality products and services. Thus, producing high-quality products and services increase the likelihood of innovation investment.

Unsurprisingly, exporters are better performers than non-exporters because exporting is associated with high productivity and competitiveness (Imbriani et al. 2014). Consequently, exporters tend to pay higher wages, recruit more skilled employees and are more capital and technology intensive than non-exporters (Trofimenko 2008). In particular, the empirical literature on international trade has extensively discussed the self-selection (SS) and learning-by-exporting (LBE) hypotheses. Several quantitative studies (e.g., Harris and Li 2008; Manez-Castillejo and Rochina-Barrachina 2009; Haidar 2012) identified the endogenous link between productivity and exporting, while another group of researchers (e.g., Sharma and Mishra 2012) investigated the relation between innovation and exporting. These past studies asserted that innovation and productivity significantly boost export performance and vice versa.

Earlier studies (Bravo-Ortega et al. 2014; Cassiman and Golovoko 2007) provided little evidence in terms of empirical analysis of the SS (pre-entry performance) and LBE (post-entry performance) hypotheses using micro level data. This present study estimates the reverse causality between innovation, productivity and exporting with introducing possible two research questions. Do innovation, productivity and exporting have a causal link or bi-directional relationship? How do multiple proxies of innovation affect exporting using micro level data? In addition, previous studies focused on a single country analysis and were limited in terms of generalizing their results. This present paper estimates the SS and LBE hypotheses using firm level data on 29 countries mainly from Eurasian and Central and Eastern European (CEE) countries. Further, to estimate the effect of innovation on exporting, this empirical paper has divided data into two economic blocs (Eurasia and CEE) and used multiple proxies of innovation such as product and process innovation, R&D and organizational innovation. This strategy has been used to examine the separate effect of each innovation proxy on exporting which has been neglected by past studies.

To estimate the SS and LBE hypotheses, this study has used the Crepon–Duguet–Mairesse (CDM) model. This estimation method addresses selectivity, simultaneity and endogeneity biases. Using micro level data on 29 countries, estimation of SS and LBE hypotheses findings revealed that innovation, productivity and exporting has bi-directional (i.e., reverse causality) relationship. Similarly, innovation by exporting hypothesis is estimated by using 2SLS method of instrumental variable approach. The results show that firms that are engaged in product/process innovation, R&D and/or organizational innovation are more likely to involve in exporting. This finding is robust across all Eurasian and CEE firms. Lastly, foreign owned firms are more likely to engage in innovation activities as well as in exporting due to their technological superiority over domestic firms.

The remainder of the paper is organized as follows: Sect. 2 reviews the empirical literature and Sect. 3 provides information on the data source and empirical analysis of hypotheses. Section 4 concludes the study and presents policy implications.

2 Related literature

Innovation is an important factor in explaining the productivity-export relationship. A firm's innovation capabilities provide sustain competitive advantage because innovation is an important and valuable asset which is difficult to imitate or substitute (Guan and Ma 2003). In particular, international markets select the most productive and innovative firms. Previous studies (e.g., Alvarez and Lopez 2005; Masso and Vahter 2011; Lopez 2009; Bravo-Ortega et al. 2014; Harris and Li 2008; Manez-Castillejo and Rochina-Barrachina 2009) have examined the link between innovation, productivity and exporting. They categorized the relationship into two major hypotheses. First, there is the SS hypothesis i.e., highly productive or most innovative firms self select export markets, and second, the LBE hypothesis, which suggests that exporting positively influences innovation and productivity performance. Briefly, several studies have addressed these two hypotheses in the empirical literature. However, this present study not only supports the findings in the previous but also extends the empirical analysis to a rich dataset on Eurasian and CEE firms with effective global economic policies in terms of innovation, productivity and export performance. To shed light on reviewed literature regarding the SS and LBE hypotheses, this study has also highlighted the possible research gaps in the empirical literature and then performed quantitative analysis.

2.1 Self-selection (SS) hypothesis

Firms' selling goods abroad carry extra costs (sunk costs), for example, collection of information related to the demands of international customers, transportation costs, distribution or marketing costs and the costs of managing foreign networks (Haidar 2012; Harris and Li 2008). To cover the sunk costs of entry into the international markets, exporters require prior high productivity. Harris and Li (2008) investigated the productivity-export relationship.[1] They argued that exporters are more productive than non-exporters and before exporting, firms should improve production efficiency as well as increasing the quality of their products and services, which is likely to result in higher productivity (Guan and Ma 2003). Masso and Vahter (2011) study on Estonian firms and Baumann and Kritikos (2016) study on German SMEs concluded that innovation and productivity are important factors in a firm's performance. However, neither study estimated the reverse causality between innovation, productivity and exporting. Concerning the estimation of the SS hypothesis, several researchers e.g., Antonielly and Cainelli (2010) in their panel study of Italian manufacturing firms, Banri and Ayumu (2013) in their panel study of Japanese firms and Movahedi and Gaussens (2011) analysis of French SMEs, showed that innovation and productivity significantly improve export performance, thus supporting the SS hypothesis. Consequently, these studies indicate that firms require a high level of productivity and investment in innovation activities prior to exporting. Bravo-Ortega et al. (2014) analyzed the Chilean manufacturing firms. They found that innovative firms (R&D firms) are more likely to export than non-innovative firms. Similarly, Cassiman and Golovoko (2007) examined the relationship between innovation, productivity and export for Spanish manufacturing firms. They stated that innovation and productivity drives firms' export performance because innovative and productive firms can more easily afford the sunk costs of international markets which is not possible for less innovative and productive firms (Lopez 2009; Cassiman et al. 2010).

In other empirical studies on the SS hypothesis, numerous researchers (Caldera 2010; Monreal-Perez et al. 2012; Halpern and Murakozy 2012; Faustino and Matos 2015; Haidar 2012) have examined the link between innovation, productivity and exporting. Caldera (2010) and Monreal-Perez et al. (2012) used the two-stage least squares (2SLS) method to resolve the endogeneity between innovation (product/process) and exporting. However, their study failed to address the reverse causality between innovation and exporting. In addition, Halpern and Murakozy (2012) analyzed the innovation, productivity-export relationship for Hungarian firms. In order to correct the selectivity and simultaneity bias between innovation and productivity, they used the CDM model.[2] They asserted that innovation positively influences the firm's productivity and exporting. However, their findings omitted to identify the reverse causality between innovation and exporting. On the other hand, the causal link between innovation (product/process) and exporting was identified by Lachenmair and Wobmann (2006) using micro level data on German manufacturing firms. Further, Manez-Castillejo and Rochina-Barrachina (2009) investigated the simultaneous relationship between innovation, productivity and exporting using panel data (1990–2000) on Spanish firms. The results of their empirical analysis, i.e., the dynamic trivariate probit model, showed that highly

[1] All factors (inputs) of production process except labour. To measure total factor productivity (TFP), this study has used output as sales turnover, intermediate inputs (cost of sales less remuneration) and capital stock (tangible assets). This study has followed the empirical approach of Harris and Li (2008) regarding measuring the total factor productivity (TFP).

[2] The CDM model is based on a set of four procedures i.e., firms decision to invest in R&D, decision regarding R&D level, R&D transformation into product and process innovation and then innovation output transformation into productivity..

productive firms self-select international markets for exporting. Therefore, the higher the labour productivity, the greater the probability of introducing process innovation and the greater the firm's probability of exporting. However, no statistical evidence is found while using the product innovation in explaining the innovation, productivity-export relationship.

To conclude, previous studies have provided inconsistent results in the estimation of the SS hypothesis and mainly focused on analysis of a single country. In other words, their empirical findings are not robust in terms of reverse causality between innovation, productivity and exporting. This study will estimate the SS hypothesis on 29 Eurasian and CEE countries using micro-level data. The next subsection provides a review of the literature on the LBE hypothesis.

2.2 Learning-by-exporting (LBE) hypothesis

LBE is simply learning-by-doing; it refers to firms' post entry performance or firms becoming more innovative and productive when they enter international markets. When firms enter international markets, they acquire superior knowledge through the demands of innovation of overseas customers, adopt new production techniques with higher capacity utilization in the foreign markets and thus increase their productivity and innovation performance (Lu and Beamish 2006; Castellani 2002; De Loecker 2013). In contrast, the "born global" theory of firms' internationalization suggests that firms should start exporting in their early stages without going through the different stages of internationalization (e.g., firms' initially start exporting via agents) (see Bell et al. 2003; Johanson and Vahlne 1977). Consequently, born global firms experience high productivity and innovation performance in international markets. Evidence for the LBE hypothesis is provided by Martins and Yang (2009). They conducted a meta-analysis of the LBE hypothesis on more than 30 papers and identified that exporting significantly improves the productivity of firms' in developing countries due to their greater distance to the technological frontier.

In addition, Trofimenko (2008) investigated the LBE hypothesis for 1057 Colombian manufacturing firms using quantile regression analysis. Trofimenko's study revealed that exporting to advance countries provides efficiency gains which are generated through the information on production methods, product quality and design which in turn result in decreasing product costs and consequently improve the firms' productivity. Sharma and Mishra (2012) conducted a panel (unbalance) study on Indian automobile manufacturing firms. They analyzed the causal link between exporting and productivity by estimating the SS and LBE hypotheses. However, their empirical findings supported only the LBE hypothesis. A similar study was carried out by Damijan et al. (2010). They studied the causal link between innovation (product and process) and exporting using panel data on Slovenian firms. However, their empirical results were only that exporting increases the probability of a firm's undertaking process innovation rather than introducing product innovations. Their results demonstrated that the LBE effect takes place through the mechanism of process innovation which improves the firm's technical efficiency and thus results in high productivity.

In addition, De Loecker (2013) conducted a study on Estonian firms. De Loecker (2013) found that Slovenian firms substantially gain productivity from entering into export markets. Harris and Moffat (2011) examined the link between R&D, innovation (product/process) and exporting using probit regression analysis for UK firms. Their empirical study found that R&D, innovation and exporting have a causal link and that these three endogenous variables are economically interdependent. Similarly, Greenaway and Yu (2004) investigated the reverse causality between productivity and exporting for the UK chemical industry. Their study empirical outcome supported the SS and LBE hypotheses but neglected the innovation variable in the analysis.

To summarize, the aforementioned studies provided mixed outcomes concerning the estimation of reverse causality between innovation, productivity and exporting. Similarly, the direction of causality is not very clear or robust across several countries using micro-level data. This study would revisit the SS and LBE hypotheses by using a rich micro level data on 29 countries. This present research study has developed the basic research question; Does reverse causality exist between innovation, productivity and exporting? This paper also adds to the empirical literature by introducing an additional hypothesis, i.e., innovation by exporting uses the multiple proxies of innovation.

3 Data source

This empirical study obtained cross-sectional micro-level data though the World Bank's enterprise survey. The survey was jointly conducted in CEE and Eurasian economies by the World Bank in cooperation with the European Bank for Reconstruction and Development (EBRD). Countries were surveyed in 2012 as part of the Business Environment and Enterprise Performance Surveys (BEEPS), and the survey questions refer to the fiscal year 2011. The survey includes 15,883 observations from 29 countries in the Eurasian and CEE regions (see Appendix A1). Over 90% of the questions were specifically designed to ask objectively about the characteristics of a country's business environment (e.g., infrastructure). The remaining questions were designed to measure the firms' growth and obstacles to their business. Regarding the sampling procedure, a stratified random sample of firms' representative of a country's manufacturing and service sectors was selected. Enterprise surveys usually are conducted in cooperation with business organizations and government institutions. The data were collected from business owners and top managers from formal (registered) firms with 5 or more employees were targeted for interview.

The method of data collection was face-to-face interviews. The strength of the dataset is that, it provides micro-level data on 29 countries using innovation, productivity and exporting variables. The survey collected comprehensive information related to key variables such as firms' size, age, sales, exports, and obstacles to the business as well as on innovation variables, i.e., product and process innovation, R&D, and marketing and organizational innovation. The innovation variables were coded dummy 1 if firms' were engaged in either product/process, R&D, marketing and organizational innovation, otherwise they were coded 0. Moreover, information on costs of intermediate input variable such as electricity and labor costs allowed this study to measure TFP (see Appendix A2). The average number of employees was approximately 65 and the average age of the firms was 16 years.

3.1 Innovation, productivity and export distribution—a graphical assessment

Prior to estimation, Fig. 1 shows the graphical assessment of productivity difference between exporters and non-exporters. Productivity distributions for exporters and non-exporters are coincided. In addition, Figs. 2, 3, 4, 5 and 6 compare the productivity of innovators and non-innovators. The visual comparison indicates that productivity is higher for firms' that are engaged in product/process, R&D, organizational and marketing innovation. This indicates that productivity for innovators has stochastic dominance over that of non-innovators. Moreover, Figs. 7, 8, 9, 10 and 11 present a visual comparison of exports distribution of innovators and non-innovators. Overall, Figs. 7, 8, 9, 10 and 11 imply that innovators are more likely to export than non-innovators. In other words, innovation (i.e., product/process, R&D, organizational and marketing innovation) plays a vital role in productivity and export performance. Figure 12 shows the difference in productivity between foreign and domestic-owned firms. The productivity distribution is higher for foreign-owned firms because they are superior to domestic firms' in skills and technology. To sum up, innovators firms' have stochastic dominance in terms of productivity and export performance over those of non-innovators.

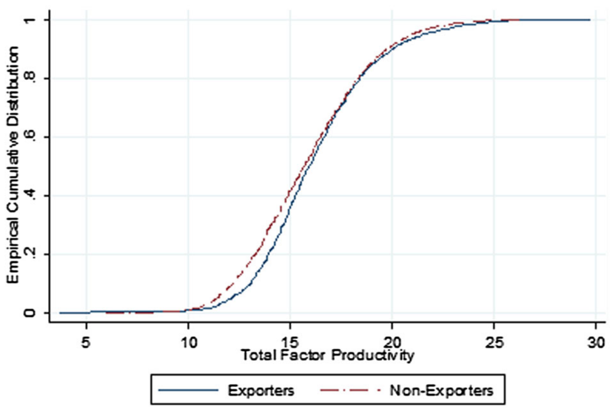

Fig. 1 Productivity difference by exports

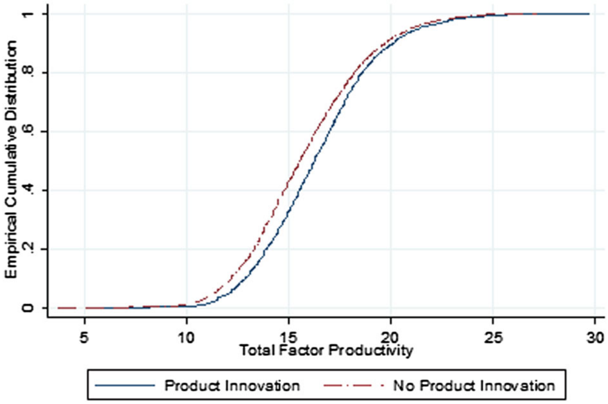

Fig. 2 Productivity difference by product innovation

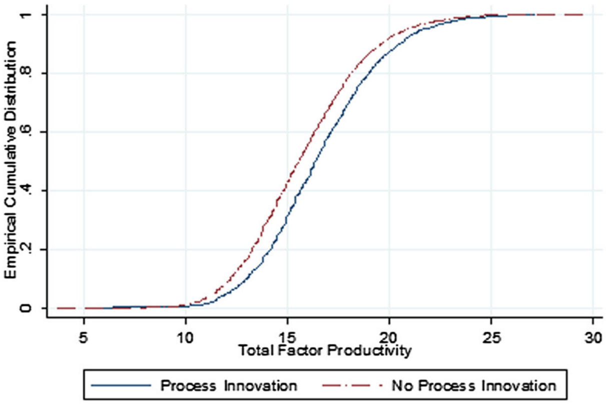

Fig. 3 Productivity difference by process innovation

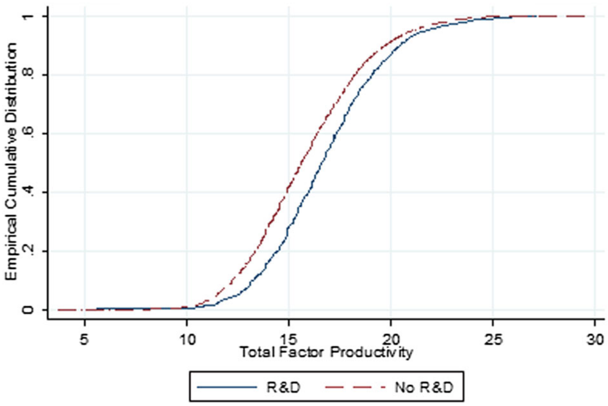

Fig. 4 Productivity difference by R&D

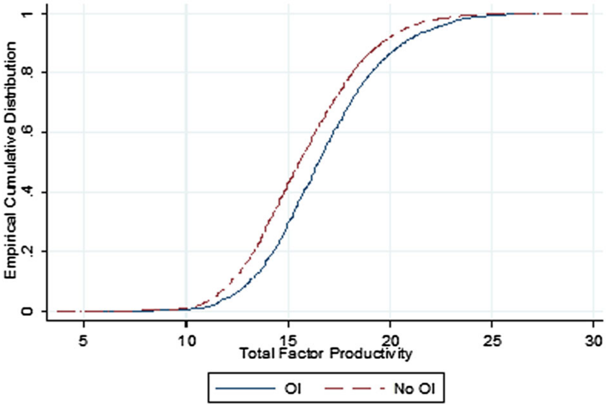

Fig. 5 Productivity difference by organizational innovation

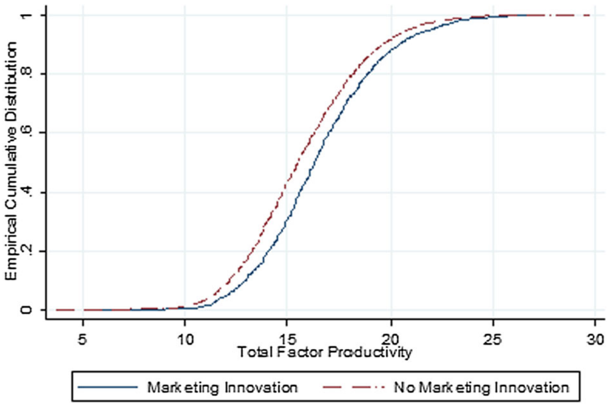

Fig. 6 Productivity difference by marketing innovation

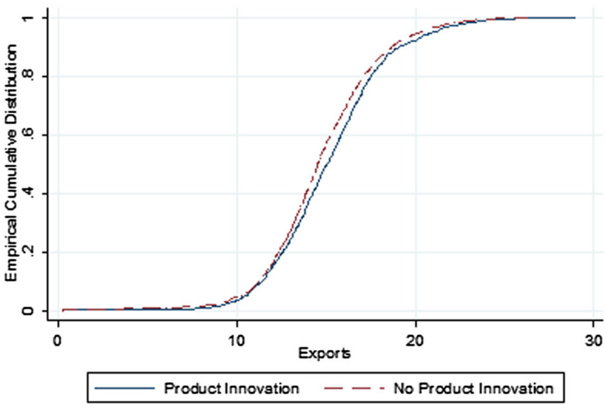

Fig. 7 Exports difference by product innovation

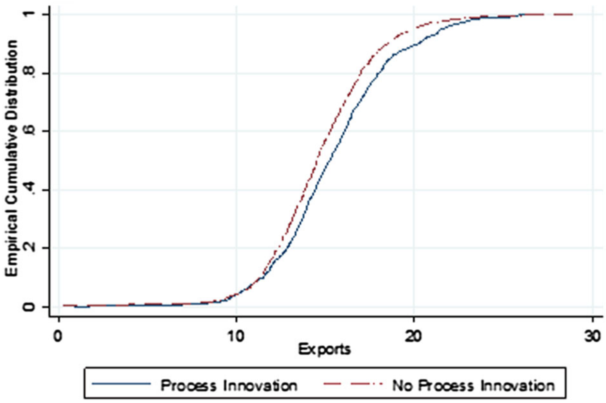

Fig. 8 Exports difference by process innovation

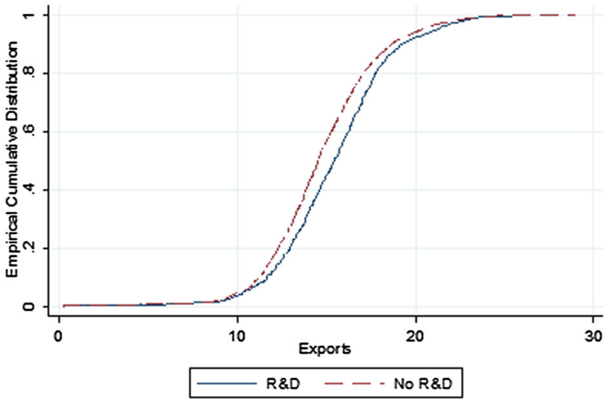

Fig. 9 Exports difference by R&D undertaking

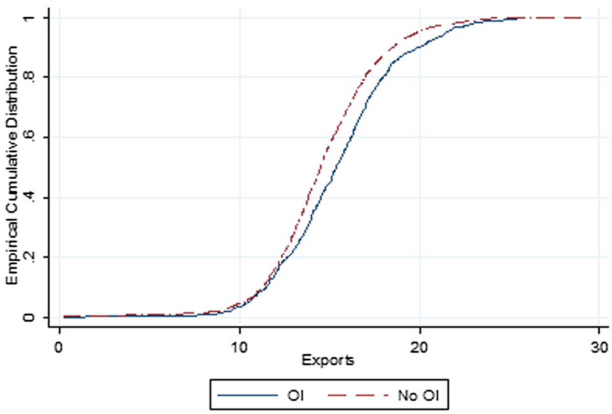

Fig. 10 Exports difference by organizational innovation

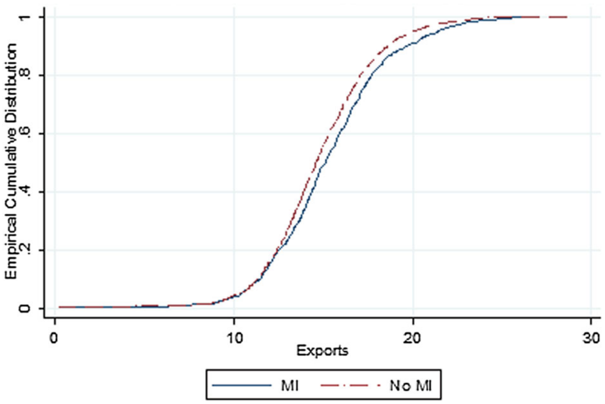

Fig. 11 Exports difference by marketing innovation

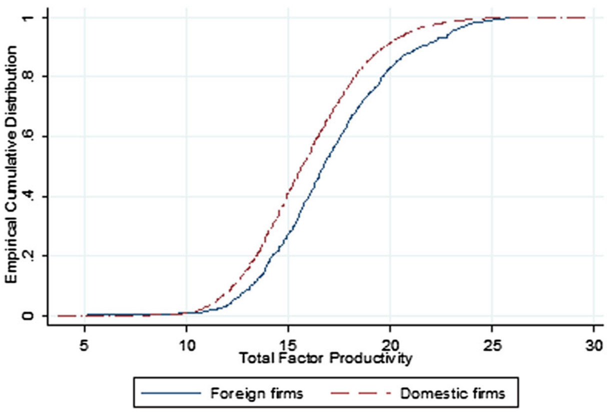

Fig. 12 Productivity difference by foreign and domestic firms

3.2 Empirical strategy

In order to analyze the SS and LBE hypotheses, this study followed the empirical strategies of Crepon et al. (1998); Viroj and Tavassoli (2014) and Baumann and Kritikos (2016). Crepon et al. (1998) initially developed a model which is referred as to the CDM model in the empirical literature. This model corrects the selectivity and simultaneity bias between R&D, innovation and productivity (see Crepon et al. 1998). They used four equations to estimate the R&D, innovation and productivity relationship and the model was applied on French manufacturing firms using cross-sectional data. Later, Viroj and Tavassoli (2014) modified the CDM model by including an additional variable, i.e., exporting, and investigated the SS and LBE hypotheses on Swedish firms. Similarly, this present study has followed the empirical strategy of Viroj and Tavassoli (2014) by using micro-level data (cross section) on 29 countries. This empirical strategy corrects selectivity, simultaneity

Table 1 Heckman selection model, regression with sample selection (two step estimation)

(1) Variables	(2) Selection equation innovation input	(3) Innovative product sales per employee (logged)
$lagged.InnovationInput_{predicted}$	–	0.0478***
		(0.0079)
Foreign owned	0.3385***	0.0006
	(0.0125)	(0.0107)
Log size	0.1292***	−0.0033
	(0.0099)	(0.0044)
Log age	0.0766***	0.0081**
	(0.0212)	(0.0032)
Obstacle	−0.3385***	−0.0057
	(0.0125)	(0.0114)
Inverse mills ratio (λ)	–	−0.0233
		(0.0499)
Constant	−1.0886***	0.1448**
	(0.0573)	(0.0775)
Observations (I_{input})	11,590	–
Observations (I_{output})	–	3746

Robust standard errors are in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

and endogeneity issues and estimates the SS and LBE hypotheses. Four equations have been formulated as follows:

$$I_{input} = \alpha_1 + \alpha_1 X_1 + e_1, \tag{1}$$

$$I_{output} = \beta_2 + \beta_2 I_{input} + \beta_{IMR} IMR + \beta_2 X_2 + e_2, \tag{2}$$

$$TFP = \gamma_3 + \gamma_3 I_{output} + \gamma_3 exp_3 + \gamma_3 X_3 + e_3, \tag{3}$$

$$exp = \delta_4 + \delta_4 TFP + \delta_4 X_4 + e_4. \tag{4}$$

Equation 1 investigates the firm's decision to invest in innovation input (I_{input}). This discrete variable shows the combine effect of innovation inputs if the firm engages in either R&D, marketing and organizational innovation, while X are explanatory variables firm size, age (are logged), obstacles to innovation[3] and foreign owned firms (dummy coded 1 if firm is foreign owned, otherwise 0). Equation 2 considers the dependent variable as product innovation sales per employee (I_{output}). In

[3] Several researchers (e.g., Reddy 2007) examined the negative impact of long term obstacles (access to finance, skills shortage etc.) on the firms' performance. This study used 8 major obstacles (finance, competition, trade regulation, political instability, skills shortage etc.) and examined their association with firm innovation; productivity and export performance. Principal component factor analysis is used to extract the core information from these variables and Kaiser–Meyer–Olkin test value of 0.82 validates the factor model (See Appendix A3).

Table 2 Simultaneous equations with 3 stage least square (3SLS)

1 Variables	2 Innovative output	3 TFP	4 Export intensity
Innovation input (lagged) (predicted)	0.0464***	–	–
	(0.0075)		
Innovative output	–	0.9877***	–
(log)		(0.3152)	
TFP	–	–	0.2385***
(log)			(0.0143)
Export intensity	0.0083***	0.7954***	–
(log)	(0.0029)	(0.0241)	
Export intensity		–	0.0624***
(lagged)			(0.0143)
Log size	−0.0170***	−0.9555	0.8754***
	(0.0061)	(0.6451)	(0.2135)
Log age	−0.0138***	−0.7440***	1.4561***
	(0.0046)	(0.0835)	(0.1345)
Foreign owned	0.0381**	0.7151**	0.7049***
	(0.0153)	(0.3765)	(0.4454)
Obstacles	−0.0101***	−0.8335**	−0.9117***
	(0.0033)	(0.3514)	(0.1193)
Constant	0.1943***	−1.1241***	−0.5278***
	(0.0135)	(0.3564)	(0.0573)
R^2	0.112	0.329	0.481
Observations	6655	7394	7394

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

addition, the predicted value of innovation input has been used as regressor and lagged one period for mainly two reasons. First, to connect Eq. 1 with Eq. 2 as part of the system of equations and second, predicted value of innovation input is used as an instrumental variable to eliminate the potential endogeneity and reverse causality with innovation output variable (see e.g., Viroj and Tavassoli 2014). To correct the selection bias, inverse Mills ratio (IMR) is used (see Heckman 1979). The problem of selection bias arises when innovative or exporting firms are not selected randomly from a population or selected according to specific criteria, i.e., it usually occurs in surveys because of self-selection rules: some respondents refuse to answer specific questions. Equation 3 shows the determinants of total factor productivity (TFP). The predicted value of innovation output (lagged one period) is used from the previous equation as an independent variable. Further, export sale per employee (exp) is included to estimate the LBE hypothesis. For estimating the SS hypothesis, Eq. 4 has been developed. In addition, firm earlier export experience (lagged one period) has been added as an explanatory variable (X_4), because this strategy would represent the firms' past export experience on the firm's decision to export the following year. Overall, this empirical model has been estimated in two stages. In the first stage: the selection equation i.e., innovation input and innovation output equation have been estimated jointly, while in the second stage, the three Eqs. 2–4 have been estimated simultaneously using 3-stage-least-squares (3SLS).

Table 1 provides information related to the selectivity bias using the Heckman simultaneous selection model. The selection equation and the equation of interest are jointly estimated by maximum likelihood (see Hill et al. 2007). This model jointly estimates the two equations by using the maximum likelihood method. Column 2 is the selection equation that determines the variable of interest which is innovation input (as dependent variable). Foreign-owned firms are more likely to invest in innovation activities compared to domestic firms because of their absolute cost advantage over local firms (see Todo 2006). Similarly, larger and older firms are more likely to invest in innovation due to their economies of scale. In comparison, obstacles reduce the likelihood of a firm's decision to invest in innovation activities. In column 3, the dependent variable is innovative product sale per employee. The predicted value of innovation input from the previous period showed a positive association with innovation output. This indicates that past innovation input has a significant impact on current innovation output. The inverted Mills ratio is statistically insignificant and indicates that no selectivity bias is present in the least squares.

Table 2 reports the results of 3SLS using three Eqs. 2–4. This method shows maximum efficiency advantage over 2SLS by considering the correlations of the unobserved factors between equations. This estimation procedure examines the SS and LBE hypotheses. Innovation input positively influences the firms' innovation output (see Column 2), while in the next column, innovation output presents a statistical relationship with productivity (TFP). This outcome indicates that innovation has a positive impact on the firms' productivity. To investigate the SS hypothesis, a 1% increase in productivity would be likely to increase the exports by 23% (see Column 4). This suggests that productivity significantly improves the firms' export performance and accepted the SS hypothesis. This finding is in line with the empirical studies of Cassiman and Golovoko (2007), Lopez (2009) and Caldera (2010). In order to estimate the LBE hypothesis, with a 1% increase in export intensity, the innovation output rises by 0.8%, while productivity rises by 79% with a 1% increase in exports (see columns 2 & 3). Overall, this outcome indicates that exporting positively influence the firms' innovation output and productivity. Hence, this outcome has accepts the LBE hypothesis.

To conclude, this empirical paper has supported the SS and LBE hypotheses for 29 countries from Eurasian and CEE firms using micro-level data. In other words, the paper has answered the research question; that is reverse causality exists between innovation, productivity and exporting. Moreover, this empirical study has corrected the selectivity and simultaneity biases. Similarly, past export experience has a positive impact on the firms' next year export intensity. This suggests that prior export experience significantly improves the firms' current export decision (see Column 4). In other words, this finding has supported the sunk cost hypothesis (hysteresis effect), which states that firms' previous export performance would likely to increase the following year's export performance.

Firms' size, age and innovation output relationships suggest that for firms', being smaller and younger firms' has a positive impact on the innovation output. In comparison, larger and older firms are more likely to export than smaller and younger firms because larger and older firms have sufficient resources (both financial and physical) to meet the sunk costs of entry into the international markets, while smaller and younger firms can be innovative or productive but prefer to stay in domestic markets due to possessing fewer resources to face international competition. Similarly, the parameter of foreign-owned firms shows a statistical association with innovation output, productivity and exporting. This outcome suggests that foreign-owned firms are superior in technology and management capabilities to local firms (Todo 2006; Fosfuri et al. 2001). Lastly, obstacles negatively affect the innovative, productivity and export performance of these firms. This outcome implies that removing barriers to trade may accelerate the innovation, productivity and export performance between these countries. In the sub Sect. 3.3, the data are split into Eurasian and CEE firms and effect of innovation indicators on exporting is examined separately. Previous studies used few innovation indicators, whether for product or process innovation, but this present study used multiple proxies of innovation to provide a deeper analysis of the relationship between innovation and exporting.

3.3 Eurasian and CEE: innovation-by-exporting hypothesis

This sub-section has analyzed the innovation by exporting hypothesis by splitting the Eurasian and CEE firms' micro-level data. These two major economic blocs have strong historical, cultural and trade linkages. For example, CEE countries such as Bulgaria, Czech Republic, Estonia, Hungary, Poland etc. (EU members) and Eurasian economies such as Albania, Armenia, Belarus, Turkey, Tajikistan and Russia have economic integration with each other as well as with the rest of the world.[4] One the one hand, Turkey is a member of custom union (trade links with Western Europe) and also has economic ties with Eurasian economies such as Uzbekistan, Tajikistan and Azerbaijan (see Ageliki and Ioannis 2015; Seker 2010). On the other hand, Russia is a major supplier of hydro-carbon-related products to the European countries and an active member of Eurasian economies. Consequently, economic growth has been impressive in both Eurasian and CEE economies in recent years with positive trends in human capital, employment rate including rising real wages, increasing literacy rate and decreasing infant mortality rates (see Sprout and Murphy 2006). Economic reforms are the major agenda for Eurasian and CEE countries, with a focus on trade liberalization and better integration into the world economy. It is important to mention that, CEE economies have achieved a strategic position in terms of democracy and international trade (Bertarelli and Lodi 2015) and foreign capital (FDI) is one of the major sources of

[4] The selection of Eurasian economies is based upon their geographical proximity and it is assumed that the countries more closely located to Europe have more economic integration than countries in distant locations.

productivity growth and technological diffusion for these economies (Bijsterbosch and Kolasa 2010).

In spite of the trade links between Eurasian and CEE economies, Radosevic and Kravtsova (2012) provided empirical evidence related to the low innovation and productivity performance of CEE countries. They argued that inefficiencies exist within the broader national innovation system of CEE countries. One the one hand, CEE economies are struggling in terms of conversion of their R&D output into productivity due to their low level of absorptive capacity (low education and vocational training systems). On the other hand, the global financial and economic crisis in 2008–2009 hit the CEE economies hard because they went through a negative GDP growth rate (−14%) and experienced massive imbalances in current and public accounts (huge deficits) and; a drop in real wages with a double digit unemployment rate (15%) (Kattel 2010). Kattel (2010) study suggests that CEE economies need to establish effective industrial and innovation policies to enhance their domestic competitiveness through improving productivity and exports. In short, this present empirical study investigates the innovation-by-exporting hypothesis for Eurasian and CEE firms. The estimation results could help policy makers to focus on improving the trade links between these two economic blocs in terms of innovation and export performance.

3.3.1 Innovation by exporting—2SLS

In the past, the innovation-by-exporting hypothesis was investigated by numerous researchers (e.g., Caldera 2010; Monreal-Perez et al. 2012; Damijan et al. 2010; Lachenmaier and Wobmann 2006; Crepon et al. 1998) and the endogenous link between innovation and exporting was identified using 2SLS method. A recent study by Imbriani et al. (2014) used multiple proxies of innovation such as technological (product and process) and non-technological (marketing and organizational innovation). They examined the positive association between innovation and exporting by using micro-level data on Italian manufacturing SMEs. However, this study failed to address the endogenous link between innovation and exporting. This present study focused on the endogenous link between innovation and exporting using multiple proxies of innovation such as product and process innovation, R&D, marketing and organizational innovation. Each proxy of innovation is estimated separately with exporting by using an instrumental variable approach (2SLS). This strategy provides an in depth analysis of the endogenous relation between innovation and exporting. For estimation, probit models have been used to examine Eurasian and CEE firms' innovation and exporting performance. In Eq. 5, innovation is the endogenous variable, so using the OLS method would result in biased and inconsistent estimators. Thus, this study has used two instrumental variables, which are denoted by 'z' in Eq. 6. Here, z represents formal training of permanent employees and business support for innovation as instrumental variables in the model. The two important characteristics of a valid instrument are that it should be strongly related to endogenous explanatory variable—innovation in this case, while at the same time it must be uncorrelated to the error term of the exports equation. Thus, training and business support are reasonably exogenous to the error

Table 3 Summary statistics of mean values

	CEE $\bar{x}$	Eurasia $\bar{x}$	Manufacturing $\bar{x}$	Services $\bar{x}$
R&D (1676)	28.28	71.72	57.82	42.18
Product innovation (3821)	30.23	69.77	50.09	49.91
Process innovation (3119)	27.12	72.88	50.88	49.12
Organizational innovation (4654)	27.50	72.50	41.04	58.96
Exports (2973)	37.84	62.16	64.82	35.18

Number of observations is in parentheses

Table 4 Test of association between innovation and exporting

Innovation	Exports (%)		
	Yes	No	*Chi square*
Product innovation (3821)	28.87	71.13	340.6056***
Process innovation (3119)	27.32	72.68	188.5960***
R&D (1676)	38.90	61.10	501.7224***
Organizational innovation (4654)	24.99	75.01	170.1584***

Number of observations that are engaged in innovation is in parentheses). **** Indicates 0.01 significance level

term and does not have direct effect on exports but could have indirect effect through innovation. These two equations are estimated jointly through the 2SLS method.

$$Exports_{i,j} = \beta_0 + \beta_1 Innov_{i,j} + \beta_2 \log TFP_{(t-1)i,j} + \beta_3 FO_{i,j} + \beta_4 Obstacles_{i,j} + \beta_5 \log Size_{i,j} + \beta_6 \log Age_{i,j} + \beta_7 Sector_{i,j} + \epsilon_{i,j} \; (1st\ stage) \tag{5}$$

$$Innov_{i,j} = \gamma_0 + \gamma_1 z_{i,j} + \gamma_2 \log TFP_{(t-1)i,j} + \gamma_3 FO_{i,j} + \gamma_4 Obstacles_{i,j} + \gamma_5 \log Size_{i,j} + \gamma_6 \log Age_{i,j} + \gamma_7 Sector_{i,j} + e_{i,j} \; (2nd\ stage) \tag{6}$$

In the aforementioned models, exports is a dummy variable and subscripts *i, j* show number of observations and the type of industry. Similarly, innovation (*Innov*) is a dummy variable and codified 1 if firms engage in product/process innovation, R&D and organizational innovation. Marketing innovation is merged with organizational innovation because marketing innovation is a process of organizational innovation activities. Earlier empirical studies (e.g., Banri and Ayumy 2013; Halpern and Murakozy 2012) neglected to use multiple proxies of innovation and this research study will fill that narrow research gap. The total factor productivity (TFP) has been lagged for one period because it is assumed that earlier productivity positively influences a firm's decision to export and innovate in the current year. Lagging TFP for one

Table 5 Probit models (innovation as endogenous—2SLS)—Eurasian firms'

Exports as dependent-dummy	Model 1	Model 2	Model 3	Model 4
Product innovation (PI)	0.8811***	–	–	–
	(0.1369)			
Process innovation (PCI)	–	0.5649***	–	–
		(0.1011)		
R&D	–	–	1.1060***	–
			(0.0693)	
Organizational innovation (OI)	–	–	–	0.6622***
				(0.1028)
Log TFP_{t-1}	0.0008	0.0021	0.0030	0.0009
	(0.0031)	(0.0032)	(0.0032)	(0.0032)
Foreign owned	0.1668***	0.1766***	0.3842***	0.3712***
	(0.0168)	(0.0163)	(0.0820)	(0.0817)
Obstacle	−0.1044***	−0.1615***	−0.1595***	0.1199**
	(0.0332)	(0.0226)	(0.0229)	(0.0256)
Log size	0.1668***	0.1766***	0.1650***	0.1632***
	(0.0168)	(0.0163)	(0.0168)	(0.0168)
Log Age	0.1044***	0.1095***	0.1113***	0.1091***
	(0.0332)	(0.0332)	(0.0333)	(0.0332)
Sector-dummy	0.6790***	0.6852***	0.6780***	0.7450***
	(0.0438)	(0.0427)	(0.0435)	(0.0421)
Constant	−2.1300***	−2.0844***	−2.0562***	−2.1595***
	(0.0933)	(0.0928)	(0.0939)	(0.0933)
Innovation as dependents-dummy	Two stage least squares (2SLS)			
	PI	PCI	R&D	OI
Training-IV	0.1055***	0.0771***	0.0721***	0.1595***
	(0.0115)	(0.0089)	(0.0083)	(0.0118)
Business support-IV	0.3513***	0.5411***	0.3066***	0.4703***
	(0.0168)	(0.0140)	(0.0119)	(0.0169)
$LogTFP_{t-1}$	0.0019**	0.0014***	0.0002	0.0024***
	(0.0008)	(0.0006)	(0.0005)	(0.0008)
Foreign owned	0.0705***	−0.0041	0.0214	0.0424*
	(0.0225)	(0.0032)	(0.0061)	(0.0231)
Obstacle	−0.0590***	−0.0320***	−0.0165***	−0.0792***
	(0.0057)	(0.0048)	(0.0040)	(0.0058)
Log size	0.0024	−0.0059	0.0066***	0.0083*
	(0.0042)	(0.0036)	(0.0030)	(0.0043)
Log age	0.0119	0.0115	0.0054	0.0106
	(0.0085)	(0.0071)	(0.0061)	(0.0087)
Sector-dummy	0.0452***	0.0586***	0.0447***	0.0295
	(0.0106)	(0.0089)	(0.0076)	(0.0108)

Table 5 continued

Innovation as dependents-dummy	Two stage least squares (2SLS)			
	PI	PCI	R&D	OI
Constant	0.0800***	−0.0424**	−0.0182	0.1267***
	(0.0229)	(0.0193)	(0.0164)	(0.0234)
Wald test (Exogeneity)-χ^2	13.81***	13.25***	8.91***	12.53***
Observations	5344	5344	5344	5344

Robust standard errors are in parentheses

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$ significance levels

period also overcomes the potential endogeneity issue between exporting and innovation (see e.g., Sharma and Mishra 2012). Lopez (2009) argued that highly productive firms self-select into export markets so that exporters can afford the sunk costs of entry into foreign markets. Similarly, before exporting, firms' require to increase productivity in order to invest in innovation because exporters need to sell high- quality products abroad. In addition, it is assumed that foreign-owned firms' (FO) are more likely to export and innovate due to their technological superiority over domestic firms. Age, firm's size and obstacles are continuous variables. For sectoral comparison, an additional dummy variable is introduced and is codified 1 if the firm's belongs to the manufacturing sector otherwise it is codified 0. Further, this study has split the micro-level data into two economic blocs i.e., Eurasia and the CEE (see Appendix A1). Before regression analysis, Table 4 shows the mean values of the CEE and Eurasian economies in terms of exporting and innovation. It is observed that Eurasian economies have higher mean values compared to the CEE countries. Overall, the mean values for innovation and exporting is high for the manufacturing sector (see Table 3). Overall, the results shown in Table 3 suggest that Eurasian countries are dominant in terms of innovation activities and export performance.

Furthermore, Table 4 presents the test of association between innovation and exporting variables. Of the total 3821 product innovation firms, approximately 29% are involved in exporting. The Chi square test value shows the statistical link between product innovation and exporting. Nearly 27% of 3119 process innovators are engaged in exporting, while the Chi square test presents the statistical relationship between process innovation and exporting. Overall, the Table 4 results provide statistical evidence regarding the relationship between innovation and exporting. This suggests that firms that are engaged in innovation are more likely to export than are non-innovators.

3.3.2 2SLS results

Table 5 reports the probit estimation results of Eqs. 5, 6 using the 2SLS method for Eurasian countries.[5] Regarding the innovation and exporting link, all innovation indicators, whether product or process innovation, R&D and organizational innovation, show a statistical association with exporting, at 1% significance level. This outcome suggests that innovation drives firms' exporting and supports the innovation-by-exporting hypothesis. This finding is consistent that of Bravo-Ortega et al. (2014) empirical study. Similarly, total factor productivity (lagged one period) presents no association with exporting.

In addition, foreign-owned firms are more likely to export than domestic firms due to their technological and skills superiority and better contacts in international markets. Obstacles show a negative relationship with exporting. This outcome indicates that trade regulations, political instability, the lack of a skilled labour force etc. are more likely to reduce the export performance of Eurasian firms. Larger and older firms are more likely to export than smaller or younger firms due to their economies of scale (experience in technology) (see Imbriani et al. 2014). Further, firms in the manufacturing sector are more likely to undertake innovation activities. Furthermore, Table 6 shows the statistical association between IVs and innovation (as dependents) (see bottom part of Table 6). This indicates that firms' employees with formal training and business support positively affect innovation activities of Eurasian firms. Past productivity positively affects the innovation activities. This suggests that a high level of past productivity would encourage firms to undertake innovation activities such as product and process innovation and organizational innovation in the current year. Similarly, foreign-owned firms are more likely to undertake innovation activities than are domestic firms. To summarize, for Eurasian firms, innovation variables significantly improve the export performance and this supports the innovation-by-exporting hypothesis.

Additionally, Table 6 provides information on the endogenous link between innovation and exporting for CEE firms. Firms that are engaged in product/process innovation, R&D and organizational innovation are more likely to export than non-innovators. This finding indicates that with a 1% increase in product, process, R&D and organizational innovation, the exports rise by 61, 37, 89 and 46%. Overall, CEE countries rely more on capital transfers from Western European countries (e.g., Germany, France) which are the major sources of technological innovation for CEE firms (see Radosevic and Kravtsova 2012).

Previous year TFP (lagged one period) positively influences following year exporting. This outcome suggests that prior high productivity significantly improves the firm's exporting the following year because it covers the sunk costs of entry into international market. Similarly, foreign-owned firms' are more likely to export than domestic firms due to higher innovation and human skills capacity than domestic firms. In comparison, obstacles show no statistical relationship with exporting. This

[5] Correlation matrix is calculated to examine the multicollinearity issue. Only one variable, i.e., innovative product sales showed a high correlation value (>0.8) and it was dropped from the analysis (see Appendix A4).

Table 6 Probit models (innovation as endogenous—2SLS)—CEE economies

Exports as dependent-dummy	Model 1	Model 2	Model 3	Model 4
Product innovation (PI)	0.6175***	–	–	–
	(0.1940)			
Process innovation (PCI)	–	0.3749***	–	–
		(0.1275)		
R&D	–	–	0.8995***	–
			(0.2917)	
Organizational innovation (OI)	–	–	–	0.4631**
				(0.1437)
Log TFP_{t-1}	0.0215***	0.0241***	0.0210***	0.0226***
	(0.0041)	(0.0048)	(0.0050)	(0.0048)
Foreign owned	0.4877***	0.5346***	0.5227***	0.5010***
	(0.0890)	(0.0868)	(0.0880)	(0.0879)
Obstacle	0.0035	0.0559	0.0213	0.0008
	(0.0290)	(0.0180)	(0.0273)	(0.0295)
Log size	0.1696***	0.2309***	0.1472***	0.1538***
	(0.0228)	(0.0254)	(0.0256)	(0.0238)
Log age	0.0236***	0.0265	0.0135	0.0247
	(0.0511)	(0.0515)	(0.0518)	(0.0513)
Sector-dummy	0.8582***	0.9070***	0.8769***	0.9465***
	(0.0677)	(0.0584)	(0.0668)	(0.0567)
Constant	−1.5599***	−1.4783***	−1.4119***	−1.5195***
	(0.1485)	(0.1481)	(0.1509)	(0.1483)

Innovation as dependents-dummy	Two stage least squares (2SLS)			
	PI	PCI	R&D	OI
Training-IV	0.0864***	0.0537***	0.0611***	0.1373***
	(0.0183)	(0.0151)	(0.0138)	(0.0180)
Business support-IV	0.3446***	0.5948***	0.2332***	0.4523***
	(0.0257)	(0.0210)	(0.0193)	(0.0252)
ln TFP_{t-1}	0.0039***	0.0035*	0.0038***	0.0030***
	(0.0015)	(0.0012)	(0.0011)	(0.0014)
Foreign owned	0.0422	−0.0149	0.0054	0.0413
	(0.0282)	(0.0231)	(0.0212)	(0.0279)
Obstacle	−0.0394***	−0.0304***	−0.0069	0.0595***
	(0.0084)	(0.0009)	(0.0063)	(0.0083)
Log size	−0.0098	0.0051	0.0213***	0.0053
	(0.0073)	(0.0060)	(0.0055)	(0.0072)
Log age	0.0039	0.0055	0.0159	0.0057
	(0.0162)	(0.0133)	(0.0122)	(0.0159)
Sector-dummy	0.1286***	0.1105***	0.0864***	−0.0043
	(0.01861)	(0.0159)	(0.0139)	(0.082)

Table 6 continued

Innovation as dependents-dummy	Two stage least squares (2SLS)			
	PI	PCI	R&D	OI
Constant	0.4401***	0.0602*	−0.0514*	−0.0302
	(0.0061)	(0.0308)	(0.0341)	(0.0727)
Wald test (exogeneity)-χ^2	3.00	0.81	1.72	2.86
Observations	2596	2596	2596	2596

Robust standard errors are in parentheses

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$ significance levels

result may imply that CEE firms face no obstacles when exporting to the nearest European markets. In addition, the positive relationship between size and exporting shows that large firm's are more likely to export than small firms due to their economies of scale. Manufacturing firms are more likely to export because of their investment in technologies.

Furthermore, Table 6 presents the two-stage results of Eq. 6. Instruments such as training and business support show a positive association with innovation proxies (as dependent variables). Firms with high productivity in the previous period are more likely to undertake innovation activities. In comparison, obstacles such as access to credit, trade regulations, and political instability negatively influence the innovation activities of CEE firms. Overall, Table 6 results are in line with the previous findings from Table 6. To conclude, using micro-level data, this study has identified that innovation activities drive exporting in both Eurasian and CEE firms and confirmed the innovation by exporting hypothesis.

4 Conclusion

This study has examined the SS and LBE hypotheses for 29 countries using micro level data. Using the modified CDM model, this empirical paper supports the SS and LBE hypotheses. The results showed that productivity significantly improve the firms' exports, while innovative product sales enhance the firm's productivity. Overall, the outcome supports the SS hypothesis. In comparison, exports showed a statistical link with productivity and accepted the LBE hypothesis. To estimate the innovation by exporting hypothesis for Eurasian and CEE firms, the data were divided into two economic blocs based on their geographical proximity. Previous studies neglected to use multiple indicators of innovation and failed to examine the separate effect of each proxy (product/process, R&D and organizational innovation) of innovation on exporting. Overall, the findings suggest that firms' engagement in product or process innovation, R&D and organizational innovation positively influences the firms' exporting. This finding is robust across Eurasian and CEE firms.

This study has important implications. The outcome of the SS hypothesis implies that prior high level productivity and innovation investment boost the export performance of Eurasian and CEE firms. This outcome suggests that economic policies could be directed towards the improvement of productivity performance (via economies of scale) and investment in technological and non-technological innovation activities for high export performance. The result could be generalized to the parts of the world. Specifically, countries with geographical proximity and with similar economic and demographic characteristics can benefit from international trade. More specifically, international trade between developed and developing countries significantly boosts the innovation activities and absorptive capacity (learning effect) of developing countries. In developed countries, firms 'operate with superior technology and have human capital skills. The LBE hypothesis further implies that export policies in developing economies should enhance the export performance through export subsidies which may increase the trade volume between countries. Firms participating in foreign competition experience better productivity and innovation performance than non-exporters. Moreover, foreign direct investment (FDI) could also play a vital role in the economic development of emerging and developing countries. Foreign firms (multinationals) are the major source of technology spillover for domestic firms through the establishment of forward and backward linkages. Lastly, for better economic integration between developing and emerging economies, they should remove or minimize the barriers to trade. It is evident from the empirical analysis that obstacles to exports significantly reduce the export performance of Eurasian and CEE firms.

This study has certain limitations. The use of cross-sectional data on 29 countries may not capture the long-term effects of innovation, productivity and exporting variables. In future, a panel study could better investigate the economic relationships between innovation, productivity and exporting variables. Further, due to the lack of information on price indices for each country, this study has not deflated the financial information (TFP).

Appendix A1

See Table 7.

Table 7 Sample size across the European and non European countries by exports and innovation

No.	Country name	Observations	Exports (yes)	Innovation (yes)[a]
1	Russia	4220	345	1927
2	Turkey	1344	490	422
3	Ukraine	1002	177	321
4	Kazakhstan	600	29	192
5	Poland[b]	542	114	291
6	Romania[b]	540	130	379
7	Uzbekistan	390	35	25
8	Azerbaijan	390	6	27
9	Albania	360	69	53
10	Belarus	360	90	235
11	Georgia	360	29	58
12	Serbia	360	116	195
13	Moldova	360	59	152
14	Bosnia Herzegovina	360	90	193
15	Macedonia	360	101	194
16	Armenia	360	33	86
17	Mongolia	360	29	190
18	Croatia[b]	360	120	225
19	Tajikistan	359	47	138
20	Latvia¤	336	106	113
21	Hungary[b]	310	60	115
22	Bulgaria[b]	293	73	155
23	Estonia[b]	273	107	102
24	Lithuania[b]	270	98	107
25	Slovenia[b]	270	141	148
26	Slovak Republic[b]	268	60	90
27	Czech Republic[b]	254	116	169
28	Kosovo	202	45	148
29	Montenegro	150	23	42
	Total	15,883	2973	6643

[a] Indicates that country engaged at least in one innovation activity (i.e., product, process, RD and OI)

[b] Represent the European Union (EU) member states and most of them are CEE economies. The rest of the countries are treated as Eurasian economies which are not the members of EU

Appendix A2: measuring total factor productivity

This study has estimated total factor productivity (TFP) using firm-level data on Eurasian and CEE firms. In addition, this study has followed the TFP estimation procedure of Harris and Li (2008) and Harris (2005). The model is described by a

Cobb-Douglas production function of the following form where all variables are used in natural logarithms:

$$y_{it} = \beta_0 + \beta_1 l_{it} + \beta_2 m_{it} + \beta_3 k_{it} + \alpha_T t + \gamma X_{it} + e_{it}, \tag{7}$$

where y, l, m, k and t refer to the sales as output, labour, intermediate input (electricity cost only) capital stock (i.e., fixed assets) and the time trend, which shows technological change in firm i in time t. While X is included as vector variables, X, that determines total factor productivity (see Harris and Li 2008; Harris 2005). In other words, X consists of exporting status of the firm and the sector to which it belongs to. Overall, the sales output and inputs e.g., labour, electricity, capital etc. are measured in costs for each factor. However, one major drawback of using the cost information is estimates are not deflated due to insufficient financial information. To obtain the estimate of TFP, TFP in growth terms is defined as (dropping subscripts).

$$\ln TFP \equiv \hat{\alpha}_T + \hat{\gamma} X = y - \hat{\beta}_1 l - \hat{\beta}_2 m - \hat{\beta}_3 k. \tag{8}$$

The preferred approach to estimating the TFP is to directly include the inputs determining output (TFP) into the production function and this methodology avoids the problems of inefficiency and omitted variable bias compared to estimating the two stage model. The estimates of lnTFP from Eq. (8) would require regression with two stage model. Using lnTFP estimates based on Eq. (8) in second stage model would result in (1) inefficient parameters (potentialy inconsistent standard errors and t-values) (2) biased estimates because of omitted factors in Eq. (7) that identifies output. Thus the estimates of $\hat{\beta}$ will suffer omitted variable bias and thus lnTFP is incorrectly measured (see Harris 2005). Briefly, the preferred method is to directly include the determinants of output into Eq. (8), as this approach avoids the problems of inefficiency and bias. Since, TFP is defined as any change in output not because of changes in factor inputs; these explanatory variables should be included directly into the model (Eq. 7) that measures TFP.

Appendix A3

See the Table 8.

Table 8 Principal component factor analysis of obstacles

Obstacles	Factor loadings
Access to finance	0.5896
Competition	0.4743
Trade regulations	0.5505
Taxation	0.6197
Political instability	0.6008
Inadequate skilled labour force	0.6298
Labour regulations	0.5938
Telecommunication	0.5446

Overall Kaiser–Meyer–Olkin measure of sampling adequacy is 0.8282

Appendix A4: correlation matrix

See the Table 9.

Table 9 Correlation matrix of all variables

No.	Variables	1	2	3	4	5	6	7	8	9	10	11
1	Exports-dummy	1										
2	TFP	0.05	1									
3	Size (log)	0.26	0.41	1								
4	Age (log)	0.13	0.07	0.25	1							
5	Foreign owned	0.15	0.10	0.14	−0.02	1						
6	Obstacles	0.13	0.01	0.07	0.05	0.01	1					
7	Product innovation	0.16	0.08	0.11	0.06	0.07	0.21	1				
8	Process innovation	0.12	0.10	0.12	0.05	0.04	0.20	0.41	1			
9	RD	0.20	0.09	0.15	0.06	0.05	0.14	0.33	0.33	1		
10	Org. innovation	0.11	0.13	0.14	0.05	0.07	0.25	0.42	0.45	0.32	1	
11	Innovative sales[a]	0.05	**0.80**	0.02	−0.03	0.04	−0.02	0.03	0.04	0.02	0.06	1

Bold value indicates the higher correlation value and it is dropped from the 2SLS square estimation

[a] Innovative product sales (logged) are dropped in probit models due to multicollinearity issue

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