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Innovation and export performance: do young and mature innovative firms differ?

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Abstract The relevant literature is conflicted about the direction of causality between innovation and exports. In this paper we attempt to shed light on this relationship by setting a theoretical framework where a two-way causality is hypothesized to exist between these two firm activities. In addition, the role of firm age is highlighted as firms at different stages of their life cycle may face different prospects and constraints and thus develop different strategies to survive and grow. Such differential patterns may be even more intense due to the different knowledge and capabilities portfolio possessed by young and mature firms. Employing a sample of Greek Manufacturing R&D active firms for the year 2010, we estimate a multi-group path analysis for young and mature firms. Even though empirical results do not support the existence of a two-way causality between innovation and export performance, when we account for the moderating role of age it becomes evident that the direction of causality differs between young and mature firms. Also the indirect and direct effect of firms' R&D stock is confirmed as an intermediate link within the innovation-export nexus.

Keywords Innovation performance · Export performance · Endogeneity · Group analysis

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1 Introduction

Firms of European small open peripheral economies, such as Greece, face an increasing globalization of markets, a strengthening of global value chains, a well documented knowledge and technological gap and all these in conjunction to the ongoing Greek crisis. These conditions compose a demanding and complex environment within which firms attempt to grow and survive. In this direction, boosting exporting activities and investments in innovation are considered of the outmost importance since they are seen as drivers of productivity, growth and competitiveness. Especially with respect to Greece's economic outlook, as it has been documented in several European policy documents and analyses, the country's innovation performance has been consistently characterized as "moderately following" (Hollanders and Es-Sadki 2013) the EU's innovation leaders. The same picture is sketched with respect to Greek firms' export performance (European Competitiveness Report 2012).

Examining more closely the relationship between firms' exporting activities and innovation dynamism, the theoretical and empirical evidence suggests that firms which are engaged in innovation activities are more likely to export and generate growth compared to non-innovating firms (Golovko and Valentini 2011; Love and Roper 2013). In other words, innovation and export performance are directly linked with the creation of a sustainable competitive advantage and are considered as a primary precondition for economic growth. It is worth mentioning that exporting activities are viewed as the primary internationalization mode (Johanson and Vahlne 1977, 2009), and firms' knowledge and learning processes are expected to play a pivotal role in such internationalization process; firms need to be in a position to apprehend and assimilate new knowledge in order to compete and grow in highly competitive markets in which they have little or no previous experience (Autio et al. 2000).

At the same time, in spite the fact that *the causality direction*, too closely related to endogeneity issues, between exporting and R&D activities has been quite extensively investigated, it still remains an issue of debate. The relevant literature has documented two distinct hypotheses, namely the *Self Selection* (SSH; Wagner 2007) and the *Learning by Exporting* (LEH; Clerides et al. 1998; Salomon and Shaver 2005) hypotheses which assume inverse causality direction between innovation and exporting activities. More specifically, the *SSH* favours the argument that exporters have superior performance characteristics compared to non-exporters, while the *LEH* argues that exporting firms' access to foreign markets provides them with feedback from their suppliers and/or customers, which gives them the opportunity to transform this knowledge into innovation. Although both the above hypotheses seem plausible and have been empirically tested, the relevant literature has provided contradictory results. However, it would only make sense to assume that this causality direction may be not so straightforward since *causality may run in both directions*; *that is a two-way linkage between a firm's exporting and innovating activities may exist* (Filipescu et al. 2013; Arvanitis et al. 2014).

The investigation of such a potentially endogenous relationship should take into consideration that firms differ in many respects and thus, an appropriate context should be adopted. In this line, the relevant literature has devoted much attention on the influencing role of firm *age* and *size* in determining firms' strategic orientation and behavior. Despite the vast theoretical evidence on the role of firm *size* in determining firms' innovative behavior, there is considerably much less research effort put in the direction of investigating if and how *firm age* determines firms strategic choices (Coad et al. 2013). Especially with respect to firms' innovation performance, firm age may play a determining role, since it is closely associated with firms' accumulated static and dynamic capabilities and life cycle (Klepper 1996; von Tunzelmann and Wang 2003; Huergo and Jaumandreu 2004; Coad et al. 2013). Furthermore, it has been argued that young firms need to be more innovative than incumbents in order to establish themselves and increase the probabilities to survive in the long run (Audretsch 1991; Bartelsman et al. 2005). At the other end, and considering the potential influence of firm age on firms' exporting orientation, the relevant literature has provided mixed results. On one hand, it is has been suggested that firms begin their internationalization strategy in a stepwise manner as they grow in size and age (Johanson and Wiedersheim-Paul 1975); on the other hand, it has been documented that some small firms engage in exporting activities shortly after their establishment, also known as 'born global' (Knight and Cavusgil 2004).

In this paper, we argue that young and mature innovative companies behave differently, since they face different market and technological opportunities and pursue different strategies. Therefore, the relationship between export and innovation performance needs to be investigated under this light. More importantly, young and mature firms may differ with respect to knowledge and capabilities which are closely associated with their firm size and technology vintage. Hence, *this paper is focused on the investigation of the existence of a two-way causality,* via *feedback loops, between innovation and export performance of young and mature innovative companies.* In addition, firms' size and knowledge capital are considered as important determinants of both innovation and export performance. We employ a unique cross-section dataset of Greek Manufacturing R&D active firms for the year 2010, and conduct *multiple group an*alysis in the wider context of Structural Equation Modelling (SEM).

Empirical findings suggest that while the two-way causality is not confirmed, young and mature firms exhibit different causality directions. More specifically, for young firms we provide empirical evidence supporting the LEH, while for mature firms empirical results confirm the SSH. In addition, cumulative investments in R&D are found to indirectly influence both young and mature firms' export performance, thus, highlighting the filtering role of firms' knowledge base for both groups.

The rest of this paper is organized as follows; Sect. 2 reviews the relevant literature on the relationship between export and innovation performance and focuses on the determining role of age and knowledge capital. In this line, we formulate testable hypotheses in the context of an extended structural model. The next section presents the adopted methodological approach. Section 4 presents the information employed for estimation of the multi-group analysis. Section 5 is devoted in presenting and discussing the estimation results and Sect. 6 concludes this paper.

2 Literature review, theoretical underpinnings and hypotheses formulation

A considerable amount of research effort has been devoted in the investigation of the export-innovation nexus. In the heart of this research lies the investigation for the direction of causality between these two firm strategic activities. On one hand, the SSH (Wagner 2007) stipulates that more robust firms self-select into export markets since they can afford the associated (sunk) costs with their decision to export. From this perspective, exporting firms are expected to exhibit higher innovation performance compared to their non-exporting counterparts, which is a determining factor to their exporting decision and performance. At the other end, the LEH (Clerides et al. 1998) argues that export market participation provides an opportunity for exporting firms to improve their performance due to knowledge flows from international sources.

More recently, Costantini and Melitz (2008) put forward a theoretical framework which endogenized firm's decision to export and engage in innovation activities. Such an endogenous relationship is then reflected in firms' productive performance differentials. Therefore, the decision to export may be driven from the current state of the firms' competencies and capabilities but it may also affect their future development in the sense that patterns of innovation also affect firm's productive performance (Harris and Li 2009; Gkypali et al. 2012; Antonelli and Scellato 2013; Mohnen and Hall 2013). In this line, the mechanism which integrates the relationships among R&D investments, productive performance gains, and exporting orientation, has been introduced (Lileeva and Trefler 2010; Cassiman et al. 2010; Aw et al. 2011; Máñez et al. 2015). However, in all these approaches it is implicitly assumed that (1) the differential gains of R&D investments are symmetrically distributed among innovators and (2) export orientation is solely dependent on the productive performance gains induced by R&D activities. Gkypali and Tsekouras (2015) provided empirical evidence suggesting that low-tech R&D active firms endogenously self-select (ESS) into an exporting status based on the anticipated net benefits from such a decision in terms of R&D based productive performance gains.

Nevertheless, it would only make sense to assume that this causality direction between innovation and exports may also run the other way. Specifically, Crespi et al. (2008) provide qualitative and quantitative empirical evidence that exporting firms learn from foreign clients which is in turn reflected in their productivity differentials; however, the reverse does not apply. In addition, Love and Ganotakis (2013) employ a sample of UK high-tech SMEs and provide empirical evidence of the learning by exporting effects. Hence, the causality direction between export-innovation performance may not be so straightforward since causality may run in both directions; that is a two-way linkage between a firm's exporting and innovating activities may exist (Filipescu et al. 2013; Arvanitis et al. 2014).

In more detail, export performance has been considered as a crucial part in firm's strategy, because it results in a widening of the penetrated markets and thus, augments innovation yields and firm growth (Kylaheiko et al. 2011). In addition, being engaged in exporting activities extends the pool of sources for new ideas, know-how and other important knowledge resources from which firms can draw the necessary elements for their own innovation process (Kobrin 1991; Kafouros et al. 2008). It could also be argued that innovation performance influences export performance since it is the outcome of firms' efforts to diversify, compete and distinguish themselves from competitors and create or sustain their competitive advantage. Hence, the following hypothesis is formed:

H_1: Firms' export and innovation performance are endogenously related exhibiting a two-way causality direction.

However, it is reasonable to assume that firms face different production possibilities sets, strategic priorities, and constraints depending on the stage of their life cycle. In this respect, the relationship between export and innovation performance may be potentially viewed in a different context for younger and more mature firms or for smaller and larger firms. Despite the vast theoretical evidence on the role of *firm size* in determining firms' innovative behavior, there is considerably much less research effort put in the direction of investigating if and how *firm age* determines firms strategic choices (Coad et al. 2013; Quevedo et al. 2014). Especially with respect to firms' innovation performance, firm age may play a determining role since it is closely associated with firms' business and product life cycle (Klepper 1996; Huergo and Jaumandreu 2004; Coad et al. 2013). In this line, it has been argued that young firms need to be more innovative than incumbents in order to establish themselves and increase the probabilities to survive in the medium-, and long- run (Bartelsman et al. 2005).

From a different perspective, and considering the potential effect of firm age on firms' exporting orientation, the relevant literature has provided mixed results. On one hand, it is has been suggested that firms begin their internationalization strategy in a stepwise manner as they grow in size and age (Johanson and Wiedersheim-Paul 1975); on the other hand, it has been documented that some small firms engage in exporting activities shortly after their establishment, also known as 'born global' (Knight and Cavusgil 2004). Based on the above the following hypothesis is formed:

H_2: The endogenous relationship between innovation and export performance is moderated by firm's age.

While various empirical studies (Wilmore 1992; Wakelin 1998; Wagner 2001; Lachenmaier and Woessmann 2006; Pla-Barber and Alegre 2007; Girma et al. 2008; Esteve-Pérez and Rodríguez 2013) have acknowledged technology and innovation as major factors contributing in facilitating entry into global markets, boosting export performance and maintaining competitiveness thereafter, there is considerably less attention devoted in identifying the intermediating links between them. In this respect, it is widely acknowledged that R&D capital is a crucial parameter in determining export and innovation activities. However, Harris and Moffat (2011) note the lack of empirical evidence at the micro level, in identifying the role of R&D capital within the export and innovation performance nexus.

More specifically, R&D capital is considered a vital input in the innovation process; R&D investments are undertaken not just to support innovation performance but also to increase the firm's knowledge assets, and thus, the firm's ability to assimilate and internalize external knowledge (Rosenberg 1990). In other words, R&D investments positively influence absorptive capacity (Cohen and Levinthal 1989; 1990). More recently, Gkypali et al. (2012) argue that in the case of the global R&D leader firms, their R&D capital serves as the filtering, and storing mechanism of outside knowledge stimuli. However, R&D capital may not be as important to mature and established firms compared to newer ones due to organizational agility and ambidexterity (March 1991). In line with this consistent finding we aim at testing the following hypothesis:

H3: Firm's knowledge capital is a mediator of the innovation-export performance nexus for both young- and mature- firms.

Summarizing, Fig. 1 sketches the theoretical framework and presents figuratively the abovementioned testable hypotheses. It becomes evident that the structural relationships among firms are quite complex and an appropriate methodology needs to be employed that can account for simultaneity in the context of a non- recursive system of equations and at the same time, control for firm level heterogeneity. In this line, multi-group analysis is adopted in order to investigate and test the abovementioned hypotheses.

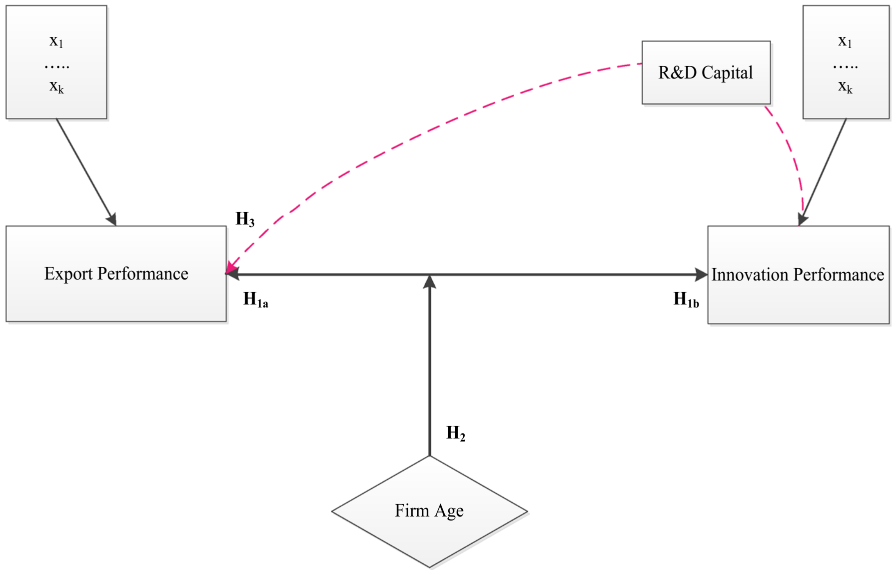

Fig. 1 Graphical representation of the structural model with respect to young and mature innovative companies

3 Methodology

The pivotal element of the paper at hand is the moderating effect of firm age on the innovation and export performance nexus. In order to examine empirically this issue we follow closely the corresponding framework presented in Bollen (1989); two subsamples $(g = new, old)$ are defined and form two groups, the young and the mature firms, where the relationship between export and innovation performance is modeled for both young and mature firms as follows:

$$y_{ip}^g = a_{ip} + B_{ep}^g y_{ep}^g + \Gamma^g x_{ip}^g + \varepsilon_{ip}^g \quad (1)$$

$$y_{ep}^g = a_{ep} + B_{ip}^g y_{ip}^g + \Gamma^g x_{ep}^g + \varepsilon_{ep}^g \quad (2)$$

Equation (1) models firm's innovation performance (y_{ip}^g) as a function of the firm's export performance (y_{ep}^g) and a set of control variables (x_{ip}^g) with an error term (ε_{ip}^g) both for young and mature firms. Further, Eq. (2) models firm's export performance (y_{ep}^g) as a function of the firm's export performance (y_{ip}^g) and a set of control variables (x_{ep}^g) with an error term (ε_{ep}^g) both for young and mature firms. It should be noted that Eqs. (1) and (2) form a non-recursive system of equations where the $\mathbf{B}^g$ matrix is not lower triangular and the covariance matrix of the error terms $\mathbf{\Psi}^g$ is not diagonal for both young and mature firms.

The basic hypothesis of the general structural equation modeling is $\mathbf{\Sigma}^g = \Sigma^g(\boldsymbol{\theta}^g)$, where $\mathbf{\Sigma}$ is the population covariance matrix which is a function of the model parameters $\boldsymbol{\theta}^g$. This hypothesis implies that each element of the $\mathbf{\Sigma}$ is a function of one or more model parameters. $\mathbf{\Sigma}^g(\boldsymbol{\theta}^g)$ is partitioned in three components: (1) the covariance matrix of $\mathbf{y}_{ip,ep}^g$, (2) the covariance matrix of $\mathbf{x}^g$ with $\mathbf{y}_{ip,ep}^g$ and (3) the covariance matrix of $\mathbf{x}^g$.

Let us consider first $\mathbf{\Sigma}_{\mathbf{y_{ip}y_{ep}}}(\boldsymbol{\theta}^g)$ for each group g, that is the implied covariance matrix of $\mathbf{y}^g$:

$$\begin{aligned}
\Sigma_{\mathbf{y_{ip}y_{ep}}}^g(\boldsymbol{\theta}^g) &= E^g(\mathbf{yy}') \\
&= E^g\left[(\mathbf{I} - \mathbf{B}^g)^{-1}(\Gamma^g\mathbf{x}^g + \varepsilon^g)\Big((\mathbf{I} - \mathbf{B}^g)^{-1}(\Gamma^g\mathbf{x}^g + \boldsymbol{\varepsilon}^g)\Big)'\right] \\
&= E^g\left[(\mathbf{I} - \mathbf{B}^g)^{-1}(\Gamma^g\mathbf{x}^g + \boldsymbol{\varepsilon}^g)\left(\mathbf{x}^{g'}\Gamma^{g'} + \varepsilon^{g'}\right)(\mathbf{I} - \mathbf{B}^g)^{-1'}\right] \\
&= (\mathbf{I} - \mathbf{B}^g)^{-1}\Big(E^g\left(\Gamma^g\mathbf{x}^g\mathbf{x}^{g'}\Gamma^{g'}\right) + E^g\left(\Gamma^g\mathbf{x}^g\boldsymbol{\varepsilon}^{g'}\right) + E^g\left(\varepsilon^g\mathbf{x}^{g'}\Gamma^{g'}\right) \\
&\quad + E^g\left(\boldsymbol{\varepsilon}^g\boldsymbol{\varepsilon}^{g'}\right)\Big)(\mathbf{I} - \mathbf{B}^g)^{-1'} \\
&= (\mathbf{I} - \mathbf{B}^g)^{-1}\left(\Gamma^g\Phi^g\Gamma^{g'} + \Psi^g\right)(\mathbf{I} - \mathbf{B}^g)^{-1'} \quad (3)
\end{aligned}$$

where $\mathbf{\Phi}^g$ is the covariance matrix of $\mathbf{x}^g$, and $\mathbf{\Psi}^g$ is the covariance matrix of $\boldsymbol{\varepsilon}^g$. In this line, the covariance matrix of $\mathbf{x}^g$,$\mathbf{\Sigma}_{\mathbf{x_{ip}x_{ep}}}(\boldsymbol{\theta}^g)$ is equal to $\mathbf{\Phi}^g$ or

$$\begin{aligned}\Sigma^g_{\mathbf{x_{ip}x_{ep}}}(\theta^g) &= E^g(\mathbf{xx}')\\ &= E^g\left[\mathbf{x}^g\left((\mathrm{I}-\mathrm{B}^g)^{-1}(\Gamma^g\mathbf{x}^g+\varepsilon^g)\right)'\right]\\ &= \Phi^g\Gamma^{g'}(\mathbf{I}-\mathbf{B}^g)^{-1'}\end{aligned} \tag{4}$$

Combining Eqs. (3) and (4) the implied covariance matrix of $\mathbf{y}$ and $\mathbf{x}$ may be expressed as

$$\boldsymbol{\Sigma}^g(\boldsymbol{\theta}^g) = \begin{bmatrix} (\mathrm{I}-\mathrm{B}^g)^{-1}(\boldsymbol{\Gamma}^g\boldsymbol{\Phi}^g\boldsymbol{\Gamma}^{g\prime}+\Psi^g)(\mathrm{I}-\mathrm{B}^g)^{-1'} & (\mathrm{I}-\mathrm{B}^g)^{-1}\boldsymbol{\Gamma}^g\boldsymbol{\Phi}^g \\ \boldsymbol{\Phi}^g\boldsymbol{\Gamma}^{g'}(\mathbf{I}-\mathbf{B}^g)^{-1\prime} & \boldsymbol{\Phi}^g \end{bmatrix} \tag{5}$$

In practice, the population covariances, variances and parameters are unknown. The task is then to formulate estimates of the unknown parameters based on the observed sample covariance matrix $\mathbf{S}^g$ In this line, each group's sample covariance matrix $\mathbf{S}^g$ is the object of analysis. More specifically, the "closer" $\boldsymbol{\Sigma}^g(\boldsymbol{\theta}^g)$ is to $\mathbf{S}^g$ for both groups, the better the model fits. The fit function is a weighted combination of the fit for all groups:

$$F = \sum_{g=1}^{G}\left(\frac{N^g}{N}\right)F^g(S^g, \Sigma^g(\theta^g)) \tag{6}$$

where F is a general fit function, N_g is the sample size of the i-th group and $F^g(S^g, \Sigma^g(\theta^g))$ is the fit function for the young and mature firms. The F^g is fitted employing a Full information maximum likelihood estimator with robust standard errors[1] that is robust to non-normality and non-independence of observations (Yuan and Bentler 2000). Such an approach is a two stage method (Brown 1983; Finkbeiner 1979). In the first stage, estimates of $\boldsymbol{\mu}^g$ and $\boldsymbol{\Sigma}^g$ are obtained through the EM algorithm based on a multivariate normality assumption. In the second step, the analysis is going further as in the complete data case, treating $\bar{X}^g_n$ and S^g_n as the mean and covariance matrix of the sample groups. In this stage, $\tilde{\theta}^g$ of θ^g_0 estimates are derived by minimizing the likelihood ratio function. The ML function is defined as:

$$\begin{aligned}F_{ML} = tr\left(S^g_n\Sigma^{g^{-1}}(\theta)\right) - \log\left|S^g_n\Sigma^{g^{-1}}(\theta)\right| \\ +\left(\bar{X}^g_n-\mu^g(\theta)\right)'\Sigma^{g^{-1}}(\theta)\left(\bar{X}^g_n-\mu^g(\theta)\right) - p^g\end{aligned} \tag{7}$$

where p is the number of variables for both young and mature firms. Letting $\boldsymbol{\sigma}^{\mathbf{g}} = vech(\Sigma^g)$ and $\beta^g = \left(\boldsymbol{\sigma}^{\mathbf{g}'}, \boldsymbol{\mu}^{\mathbf{g}'}\right)$, the investigation of the asymptotic distribution of $\tilde{\theta}$ demands the distributions of $\bar{X}^g_n$ and S^g_n to be known.

The advantage of adopting a group analysis approach lies in the fact that it allows for testing equality or invariance of estimated coefficients across groups, and thus, it enables the examination of whether different groups behave similarly (Hayduk

[1] Standard errors are computed using the Huber-White sandwich estimator thus, accounting for heteroscedasticity issues.

1987). In other words, group analysis is a moderation model whereby the dichotomous groups are thought to moderate the endogenous relationship between innovation and export performance as well as the rest of exogenous independent variables. Essentially, in order to decide whether the estimated coefficients differ across groups we test the following hypotheses:

$$H_{\mathrm{B}\Gamma} : \mathrm{B}^{(y)} = \mathrm{B}^{(o)}, \quad \mathbf{\Gamma}^{(y)} = \mathbf{\Gamma}^{(o)} \tag{8}$$

In the case where no statistically significant differences among coefficients are identified between the two groups, we do not reject the hypothesis the same model operates in both groups, i.e. there are no moderation effects of firm age on the innovation-export performance nexus.

4 Data and Variables definition

The information employed in the present paper comes from the Greek Observatory of R&D Active firms' (GORDA) database.[2] GORDA database is the combination of an extensive survey, at the Greek national level, which was carried out in 2011 and a balanced panel of firms' financial performance concerning the period 2001–2010. It provides information on Greek Manufacturing firms' R&D, exporting and financial performance. Such information can be decomposed in (1) information about financial indices and R&D expenditures as they are drawn from firms' annual balance sheets; and (2) comprehensive and detailed information about R&D and exporting activities at the firm level for the entire Greek Manufacturing sector. The sample consists of three hundred (300) Manufacturing firms of all ages that have been engaged in R&D activities either consecutively or intermittently within the period 2001–2010. The combination of the abovementioned information sources resulted in the employed database which is of cross section type and concerns the year 2010.

The central issue of the theoretical and methodological framework sketched in previous sections, illustrated in Fig. 1, is the distinction between young and mature firms. Given the main research question posed in the framework of the paper at hand, an age threshold needs to be established, so as to divide the full sample into young and mature firms. From the descriptive statistics presented in the upper part of Table 1, it becomes evident that firms entailed in the sample are exhibiting a right skewed distribution. Hence, we opted to define the age threshold at 15 years, in order to obtain a good degree of representativeness in the subsample of young firms, albeit without increasing the age threshold too far.[3] The full sample of Greek R&D active Manufacturing firms ($n = 300$) is therefore divided in young firms ($n = 74$) and mature firms ($n = 226$).

[2] Gkypali and Tsekouras (2015) present in detail of the survey design and methodology.

[3] In order to determine the age threshold robustness checks have been performed using alternative age thresholds either greater or lower than 15 years and results are available upon request. Estimation results are robust for alternative age thresholds however for firm age lower than 15 years the model fit deteriorated.

Table 1 Variables definition and descriptive statistics

Definition		Descriptive statistics			
		Young firms group		Mature firms group	
		Average[a] (St. Dev.)	Min (max)	Average (St. Dev.)	Min (max)
Grouping variable					
Firm age		10.622 (3.342)	3 (15)	35.407 (18.794)	16 (110)
Dependent variables (y_i)					
Export performance	The percentage of firm sales from its foreign activities as a percentage of its total sales	0 = 40.5 %	–	0 = 15.0 %	–
		1 = 37.8 %		1 = 48.7 %	
		2 = 9.50 %		2 = 12.4 %	
		3 = 5.40 %		3 = 11.5 %	
		4 = 6.80 %		4 = 12.4 %	
Innovation performance	The percentage of the firm's total sales that is due to significantly improved or new products or created due to firms' R&D activities	0.426 (0.314)	0.000 (1.000)	0.421 (0.310)	0.000 (1.000)
Independent variables (x_i)					
Export market spread Eurozone	The percentage of exports destinated to Eurozone Countries	0.312 (0.403)	0.000 (1.000)	0.349 (0.318)	0.000 (1.000)
Export market spread rest of Europe	The percentage of exports destinated to European Countries outside Eurozone	0.127 (0.270)	0.000 (1.000)	0.181 (0.238)	0.000 (1.000)
Export market spread North America	The percentage of exports destinated to the Region of North America (including Canada)	0.039 (0.128)	0.000 (0.775)	0.047 (0.112)	0.000 (0.700)
Firm's size	Firm's size: log of total number of employees	1.550 (0.551)	0.477 (3.176)	1.900 (0.617)	0.477 (3.699)
R&D stock	The accumulated 'knowledge' stock as it has been approximated by firms' yearly R&D expenditures	0.115 (0.290)	0.000[b] (2.067)	0.115 (0.217)	0.000 (1.642)

Table 1 continued

Definition		Descriptive statistics			
		Young firms group		Mature firms group	
		Average[a] (St. Dev.)	Min (max)	Average (St. Dev.)	Min (max)
Tehnological intensity	Dummy variable which takes the value 1 if the firm belongs to High and Medium–High tech sectors and 0 otherwise	1 = 33.8 % 0 = 66.2 %	–	1 = 40.3 % 0 = 59.7 %	–
Absorptive capacity	Firm's absorptive capacity defined as the ratio of employees with tertiary education to total number of employees	0.280 (0.252)	0.000 (1.000)	0.261 (0.189)	0.000 (1.000)
Patent application	A dummy variable that takes the value of 1 if the firm has applied for a patent and 0 otherwise	1 = 16.2 % 0 = 83.8 %	–	1 = 23.5 % 0 = 76.5 %	–

[a] In the case of binary and ordinal variables the relative frequencies are presented

[b] Actually smaller that 0.001

Focusing on the causal and reciprocal relationships between innovation and export performance variables of young and mature firms, the former is a continuous variable indicating the revenues due to innovation activities as a percentage of total revenues; while the latter is an ordered categorical variable with five categories ranging from no exporting activities to exporting the entire production abroad. In order to control for potential confounding effects on the relationship of innovation and exporting performance, we have included in the estimated model control variables following the dictations of the relevant literature. Two criteria have guided the identification of the best model describing the determinants of firms' innovation and exporting performance. Firstly, we looked for a meaningful and informed set of explanatory variables among the available information. Secondly, we looked for the model with the best econometric properties among alternative models. This implies that some variables with no statistical significant results have been included in our final model, as they are also regarded to be an important finding. In the lower part of Table 1, control variables' definitions along with some basic descriptive statistics are presented.

At this point some further additional issues regarding the present empirical application need to be addressed. First of all, one limiting factor common to most firm-level studies, is that the dataset employed is of a cross section type, and thus, we are not able to include lagged variables in order to investigate the time persistence of innovation and exporting activities. Furthermore, the employed information refers to R&D active firms' belonging to the Manufacturing sector; there is not information available for other sectors and firms not engaged in R&D activities and thus, one should be cautioned for the generalization of the estimation results.

5 Results and discussion

The non recursive system of equations, presented in Eqs. (1) and (2), was estimated using MPlus 7.3 software in a single and multiple-group framework. More specifically, all path coefficients were simultaneously estimated, controlling for confounding effects for the total sample and by subgroups. In this respect, we were able to examine and test whether differences in the structural parameters across groups were statistically significant. The non-recursive system of equations was fitted by the robust maximum likelihood (MLR) estimator for continuous variables, accounting for missing data, heteroskedasticity and non-normality. A threefold advantage of the adopted approach is that it allows us to investigate *(1) the existence of feedback loops in the relationship between innovation and export performance, (2) the moderating effect of firm age not only with respect to a key variable but with respect to the overall model specification and (3) the indirect effect of firms R&D capital on export performance through its direct influence on innovation performance.* Table 2 presents estimation results for the full sample of Greek Manufacturing R&D active firms where there is no moderating role of age. Based on the estimation results *the existence of a feedback loop between innovation and*

Table 2 Empirical results for the full sample estimation, i.e. no moderation model

Full sample			
Export performance		Innovation performance	
Innperf	2.955***	Expperf	0.041
	(1.136)		(0.031)
Size	0.211***	RDSTOCK	0.196***
	(0.060)		(0.061)
Mspreuro	1.097***	Size	−0.029**
	(0.205)		(0.014)
Msproe	0.951***	Abscap	−0.038
	(0.224)		(0.058)
Msprnam	2.728***	Patapp	0.079**
	(0.716)		(0.038)
Techintens	0.456***	Tecintens	−0.056
	(0.155)		(0.037)
Cons	−1.528***	Cons	0.477***
	(0.591)		(0.063)
	$Cov(e_{ip}, e_{ep})$	−0.302***	
		(0.113)	

Standard errors are reported in parentheses

***, and ** statistical significance at 1 %, and 5 % level respectively

Table 3 Model fit indices for the young and mature firms' model, the no moderation model and the moderation model

	Ch. Sq., df	*P* value	CFI	TLI	RMSEA
Young firms	1.051, 4	0.902	1.000	1.252	0.000
Mature firms'	4.796, 4	0.309	0.985	0.935	0.030
No moderation	2.226, 4	0.694	1.000	1.046	0.000
Moderation model	4.699, 8	0.790	1.000	1.138	0.000
Wald test for equality restrictions	10.148, 5				
	(0.071)^				

^ *p* value is denoted in the parenthesis

exporting performance is not confirmed. On the contrary, the Self Selection Hypothesis is supported by the empirical results.

In order to investigate whether firm age moderates the export-innovation nexus the multi-group analysis allows for testing for cross-group invariance by comparing two nested models: (1) a baseline model wherein no constraints were imposed across groups and therefore, *all* structural parameters differ, and (2) a second model where critical structural parameters were constrained to be invariant between the two groups. Comparison of the two models is performed by employing a Wald test imposing equality restrictions in structural parameters. However, before proceeding with estimating the two nested models, we need to ensure that the same model fits separately not only with the full sample, but also with the samples of young and mature firms respectively. In Table 3 model fit indices for the separate estimations of the full and both sub-samples of young and mature firms as well group model are presented. All estimated model specifications indicate a good fit and therefore, we can proceed with the examination of the moderating role of age in firms' export-innovation performance nexus. Essentially, the Wald test indicates whether firm age has a moderating effect on Greek Manufacturing firms by testing for equality constraints of the structural coefficients between the group of young and mature firms, respectively. Equality constraints were imposed to the estimated coefficients of innovation and export performance, R&D stock and export market spread.

The Wald test statistic indicates the statistical significance of the imposed equality constraints, thus rejecting the hypothesis that the restricted (invariant) model matches the data. Hence, *estimation results confirm the moderating role of firm age in the export-innovation performance nexus.*

Based on the estimation results of the multi-group analysis presented in Table 4, the causality direction between innovation and export performance differentiates with respect to firm age. While innovation performance is not a determining factor of export performance for young firms, the opposite holds for mature firms. *In other words, for young Greek Manufacturing R&D active firms empirical evidence supports the LEH while for mature firms, the SSH is confirmed.*

In terms of the rest of the determining factors influencing the export-innovation performance relationship it is interesting to note that a differentiating pattern with respect to young and mature firms emerges. In particular, for the group of young firms export market destination is found to exert a positive and statistically significant influence in determining their export performance. Hence, it could be argued that young firms' export market destination is an important component in the context of their internationalization strategy. Shifting to the mature firms' group, while export market destination is a statistically significant determinant of export performance, the magnitude of the exerted influence is smaller than the corresponding influence of these variables in the group of young firms. In addition, firm size and sectoral technological intensity exert positive and statistically significant influence on export performance, suggesting that in the context of industrial dynamics the firms belonging to a routinized regime may exploit their size in order to enhance their exporting performance (Audretsch 1991; Malerba and Orsenigo 1993, 1997).

Turning to the control variables of innovation performance for both groups, young firms exhibit a rather idiosyncratic behavior. Specifically, export performance seems to be the only driving factor of their innovation performance. This finding may suggest that relatively young firms with immature knowledge bases - R&D capital is not a statistical significant driving factor- rely heavily on knowledge flows from abroad in order to improve their innovation performance. However, such knowledge flows contribute in inducing localized technical change (Gkypali et al. 2012) or in other words and quite surprisingly, young Greek Manufacturing R&D active firms rely heavily on their exploitation capabilities in order to boost their innovation performance (Choi and Shepherd 2004; Cavusgil and Knight 2004, 2014).

On the contrary, for mature firms group, it seems that cumulative investments in new knowledge are an important determining factor for increasing innovation

Table 4 Estimation Results of the multi-group path analysis, i.e. the moderation model

	Young firms group	Mature firms group
Export performance		
Innperf	2.173	3.457**
	(1.453)	(1.849)
Size	0.108	0.224***
	(0.113)	(0.075)
Mspreuro	1.275***	1.019***
	(0.420)	(0.328)
Msproe	1.421***	0.581*
	(0.569)	(0.335)
Msprnam	1.222***	0.126*
	(0.516)	(0.068)
Techintens	0.152	0.449**
	(0.259)	(0.201)
Cons	−0.988	−1.515
	(0.787)	(0.975)
Innovation performance		
Expperf	0.107**	−0.007
	(0.047)	(0.067)
Rdstock	0.197	0.200**
	(0.147)	(0.093)
Size	−0.030	−0.022
	(0.027)	(0.018)
Abscap	−0.029	−0.086
	(0.077)	(0.099)
Patapp	0.060	0.090*
	(0.071)	(0.049)
Tecintens	−0.052	−0.034
	(0.076)	(0.047)
Cons	0.420***	0.518***
	(0.114)	(0.095)
$Cov(e_{ip}, e_{ep})$	−0.279**	−0.296
	(0.145)	(0.190)

Standard errors are reported in parentheses

***, ** and * statistical significance at 1, 5 and 10 % level respectively

performance. In this line, patent applications play a positive and statistically significant role in determining innovation performance. These findings reveal that mature Greek Manufacturing firms rely on their innovation capabilities and invest in technology vintages which force them to devote resources in protecting the outcome of their innovation activities (Audretsch 1997; Kafouros et al. 2008). *In sum, empirical results highlight significantly different patterns between young and mature firms with respect to innovation-export nexus. This in turn reinforces the argument that firm age indeed plays a moderating role suggesting the firms at*

Table 5 Indirect effects of R&D Capital on Export performance

Source	Mediator	Outcome	Young firms group	Mature firms group
Rdstock	Innperf	Experf	0.724*	0.660**
			(0.406)	(0.281)

Standard errors are reported in parentheses

** and * statistical significance at 5 and 10 % level respectively

different stages of their life cycle face different prospects and constraints and thus, exhibit different strategic orientation.

In the context of the multi group analysis, we have estimated the indirect effect of R&D stock on export performance via its direct impact on innovation performance with the aim of unveiling a potential intermediating link between innovation and export performance.[4] Table 5 presents estimation results of the estimated indirect effect both with respect to young and mature firms group. In both groups, there is a statistically significant indirect influence of R&D capital on export performance, suggesting that the existence of an augmented knowledge base reinforces the firms' competencies and capabilities required to succeed in foreign market penetration.

6 Conclusions

This paper contributes in the relevant literature as it investigates the innovation-export performance nexus by setting a theoretical framework where a two way causality direction is hypothesized to exist between the two firm activities. In this vein, the potentially moderating role of firm age has been highlighted were it is argued that firms at different stages of their life cycle may face different prospects and constraints and thus, may have different strategic orientation and goals. Firms cumulative R&D investments are considered an intermediating link between innovation and export performance which provide filtering and ambidextrous capabilities to cope successfully with both activities at the same time.

We employ a unique dataset of Greek Manufacturing R&D active firms, and adopt a multi-group analysis in the context of a non-recursive system of equations which is simultaneously estimated for two groups of firms, namely young and mature firms. The adopted econometric strategy allowed us to address (1) the existence of a feedback loop in the relationship between innovation and export performance, (2) the moderating effect of firm age not only with respect to a key variable but with respect to the overall model specification and (3) the indirect effect of firms R&D capital on export performance through its direct influence on innovation performance.

[4] It should be noted that with respect to the estimation of indirect effects, MPlus uses the Sobel test to calculate indirect effects and employs the Delta method to calculate standard errors of the indirect effects. Simulation studies suggest parameter estimates and standard errors using MLR would be identical to those obtained with the bootstrapping procedure (Muthen and Muthen 2014).

Empirical results do not provide support for the existence of a two-way causality between innovation and export performance, however, when accounting for the moderating role of firm age, differentiating patterns emerge with respect to this relationship. In particular, for the group of young firms empirical evidence supports the Learning by Exporting Hypothesis, while for the group of mature firms, the opposite holds, that is empirical evidence supports the Self Selection Hypothesis. In addition, R&D capital is a strong link for innovation and export nexus for both young and mature firms.

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