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Balancing Internal and External R&D Strategies to Improve Innovation and Financial Performance

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Abstract

This research investigated the complementarity of internal and external R&D for innovation development and the effect of innovation on the financial performance of European manufacturing firms. Using multigroup structural equation modeling, this study partially supported that internal and external R&D are complementary in firms from high-technology industries, whereas they are not in firms from low-technology industries. For the two groups of firms, both internal and external R&D separately had a positive effect on innovation performance. These results suggested that if low-tech firms, which had lower absorptive capacity than high-tech firms, want to improve their innovation performance in the long term, they should start prioritizing internal R&D to improve their absorptive capacity while achieving a short-term satisfactory innovation outcome. As absorptive capacity rises, more complex strategies balancing internal and external R&D should be adopted. Contrary to expectations, the empirical analysis indicated that innovation performance did not influence short-term financial performance for the whole sample. However, in countries more affected by the 2008 crisis (for instance, Baltic countries, Portugal and Spain), this effect was detected, indicating that innovation helped firms to recover faster.

Key words: innovation performance; internal R&D; external R&D; financial performance; manufacturing firms.

Introduction

“Solve unsolved problems innovatively – previous 3M mission statement”
(Collins & Porras, 1996, p. 69)

It is commonly accepted that innovation is important for firms to help them reach their goals, but it is not exactly a goal itself. It is also a popular belief that innovative companies are better than ones that are not innovative. 3M seems to have noticed this fact and smartly used this belief as a marketing tool in a former mission statement. However, innovation development, besides having a strong marketing appeal, may help firms achieve better performance in many other ways.

Innovation helps in the acquisition of sustainable competitive advantages through the introduction of new successful products and services or innovative processes that improve a cost-leadership position by lowering costs and increasing profits (Ceccagnoli, 2009; Christensen & Raynor, 2013). Extensive literature about the effects of innovation on a firm’s financial performance exists. Many authors (*e.g.*, Cheng & Huizingh, 2014; Faems, Van Looy, & Debackere, 2005) empirically studied the influence of the level of firm innovation on financial performance and concluded that a positive relationship exists between them. Besides the impact on financial performance, innovation is essential for firm survival in today’s uncertain environment (Teece, 2007) and it is even more important in technology-based industries (Belderbos, Faems, Leten, & Van Looy, 2010). Concurrently, with the approach of the relationship between innovation and financial performance, research has emerged examining different innovation sources, which can be internal and external (Frenz & Ietto-Gillies, 2009).

Internal sources come mainly from R&D developed inside the boundaries of the company. On the other hand, external sources can be innovations acquired from other firms, mergers, acquisitions and collaboration with other players in the industry (Chesbrough, 2003; Faems *et al.*, 2005). Many studies examined the relationship among all these sources and innovation performance. The relationship between internal R&D and innovation is positive in many of them (Belussi, Sammarra, & Sedita, 2010; Faems *et al.*, 2005), although it is dependent on firm structure (Arora, Belezon, & Rios, 2014) and on the knowledge type developed (Pérez-Luño, Medina, Lavado, & Rodríguez, 2011). Another branch is formed by studies that look for the relationship between external sources of R&D and innovation. This relationship depends on the type of partner (Chatterji & Fabrizio, 2014; Soh & Subramanian, 2014), the type of knowledge sought (Pérez-Luño *et al.*, 2011) and firm absorptive capacity (Cohen & Levinthal, 1990). Absorptive capacity affects the relationship between external R&D and innovation performance positively. As absorptive capacity rises, with higher levels of internal R&D (Tsai, 2009), internal and external R&D would be complementary. In contrast, some papers found that they may be substitutes for each other (Hagedoorn & Wang, 2012).

The study of the relationship between innovation and financial performance is not as extensive as the studies associating R&D sources and innovation performance. Most studies of this type investigate only a specific country and focus more on developed economies (*e.g.*, Faems, De Visser, Andries, & Van Looy, 2010). However, according to some authors, the process of accumulating innovation capabilities and their application by firms from less developed economies might be different from the process in developed countries. While firms in the latter countries usually have resources and capabilities to develop radical product innovation from the beginning (Utterback & Abernathy, 1975), firms in the former countries start their process of accumulating capabilities by copying or licensing products from foreign firms and gradually adapt their production process while accumulating innovation capabilities. This process can allow them to catch-up to be able to implement more sophisticated innovations in the future (Kim, 1998).

These differences in the innovation process of firms from different countries must affect the relationship among the different sources of innovation, innovation performance and financial performance. So, the dearth of studies focusing on less developed countries justifies more investigation. European countries dominated the top positions of the 2016 ranking of the most innovative countries according to the Global Innovation Index (Dutta, Lanvin, & Wunsch-Vincent, 2016), with four of the top five countries in the ranking, and 15 countries among the 25 most innovative. However, they are not homogeneous in their innovative stage. While some of the world's most innovative countries are from Europe, the continent also has countries in moderate and low innovative development stages (European Union, 2015), which are less investigated by empirical studies than the top innovators.

Building on the literature mentioned above, this paper aims to answer the following research questions: **Do either internal or external sources of innovation impact on innovation performance? Are they complementary? And does innovation performance impact financial performance?** Although several studies have investigated these relationships, most of them focused only on the relationships among R&D sources and innovation performance or on the relationship between innovation and financial performance. This study proposed a model to investigate these relationships conjointly. Besides, different aspects are known to influence these relationships, such as the country and the industrial sector. Most studies investigate only limited scenarios, however, we believe that different outcomes may emerge from a study considering different dimensions. Using a sample of manufacturing firms from 14 European countries (Bulgaria, Cyprus, Czech Republic, Spain, Croatia, Portugal, Hungary, Slovenia, Norway, Lithuania, Romania, Italy, Slovakia and Estonia), this paper tested the proposed model to investigate the relationships among the constructs mentioned above controlling for industry technology intensity (high-tech manufacturing and low-tech manufacturing) and for groups of similar countries (which have different innovation development levels).

The proposed model, with some adaptations, is also being tested in other research projects considering other regions and industries, using different databases. The present study partially supported that internal and external R&D are complementary in firms from high-technology industries, whereas they are not in firms from low-technology industries. For the two groups of firms, both internal and external R&D separately had a positive effect on innovation performance. The relationship between innovation performance and financial performance could only be verified for Portugal, Spain, Estonia and Lithuania, countries that present some specificities provoked by how they are recovering from the 2008 global crisis.

The remainder of the article contains the literature review, presenting the hypotheses and the proposed model, followed by the methods section, which includes the description of the data, an explanation of the sample selection, a description of the variables and the statistical method. Then, we present the results, followed by a discussion and conclusions, which includes theoretical and managerial implications, limitations and suggestions for future studies.

Literature Review

Complementarity of internal and external R&D

Internal R&D is most often mentioned in innovation management literature as causing a positive impact on innovation performance (Belussi *et al.*, 2010; Frenz & Ietto-Gillies, 2009; Hagedoorn & Wang, 2012; Oerlemans, Knoben, & Pretorius, 2013). As internal R&D is mainly represented by proxies such as R&D expenditures and R&D intensity (Hagedoorn & Wang, 2012), this positive relationship indicates that the effort to produce internal knowledge is highly related to its effective generation. However, the level of impact internal R&D has on innovation performance depends on the type of innovation. Hall and Bagchi-Sen (2007) found that a high level of internal R&D is associated with high levels of research-based innovation, which is more associated with the patenting of new technologies, but not with high levels of product-based innovation, which is related to the introduction of or changes in products and services. Some studies found that internal R&D is more important for process innovation than external R&D (Tomlinson, 2010), although a positive relationship between internal R&D and new product development was found in some empirical studies (*e.g.*, Stam & Wennberg, 2009).

External knowledge sources and R&D also have a central role in innovation development. Several empirical studies confirmed that the relationship between external R&D and innovation performance is positive (Belussi *et al.*, 2010; Faems *et al.*, 2005; Faems *et al.*, 2010; Ritala, Olander, Michailova, & Husted, 2015). This positive relationship may be caused by the easier transference of tacit and codified knowledge, the access to new complementary assets or the sharing of R&D costs (Faems *et al.*, 2005). However, these results are not unanimous and some studies suggested that the relationship might be an inverted U-shape, with lower levels when the firm has few or many types of partners and higher levels for a moderate amount of partner types (Duysters & Lokshin, 2011). Other empirical studies did not find a significant relationship (Belussi *et al.*, 2010; Mowery, Oxley, & Silverman, 1996). These contrasting results may have been caused by the coordination and monitoring costs to avoid misappropriation, which increases with a greater number of partnerships and depends on the partner type (Hallen, Katila, & Rosenberger, 2014).

Based on the previous discussion, one may conclude that balancing internal and external R&D is necessary in order to have successful innovation performance. The complementarity of internal and external R&D has been discussed in the academy (*e.g.*, Cassiman & Veugelers, 2006). Complementary activities bring more return if implemented conjointly than if implemented alone (Milgrom & Roberts, 1995). The complementarity between internal and external R&D would lie in the necessity of the firms to build internal know-how to be able to identify possible projects and partners. This internal know-how may be built by internal R&D efforts, among other internal activities, and develops a capability called absorptive capacity (Cohen & Levinthal, 1990). According to these authors, absorptive capacity is a firm's capacity to recognize, acquire, assimilate and apply external knowledge. Empirical studies have found a positive moderation of the absorptive capacity, as represented by internal R&D expenses (Berchicci, 2013; Cohen & Levinthal, 1990; Hagedoorn & Wang, 2012) in the relationship of external R&D and innovation (Belussi *et al.*, 2010; Frenz & Ietto-Gillies, 2009; Hagedoorn & Wang, 2012; Oerlemans *et al.*, 2013). These led us to propose the following hypothesis.

Hypothesis 1. A firm's internal R&D level and its external R&D level are complementary in their contribution to improve the firm's innovation performance.

Innovation performance and financial performance

Innovating is currently viewed as an effective strategy to improve firm performance. The way a firm uses its internal and external knowledge sources to develop innovation, conjointly with the environment, the industry structure, the firm's characteristics and its overall strategies defines the amount of any innovation's rents it will appropriate, and the amount that will be appropriated by suppliers, clients and imitators (Hurmelinna-Laukkanen & Puumalainen, 2007). An effective introduction of process and product innovation followed by the correct use of appropriability mechanisms should promote a better financial performance for the innovative firm (Ceccagnoli, 2009).

Product innovation may be a source of sustainable competitive advantage and provide a better position in the market through the launching of better quality and lower cost products (Ateljević & Trivić, 2016), which allow the firm to fill gaps in demand (Galindo & Méndez, 2014) and increase its market-share (Leskovar-Spacapan & Bastic, 2007). Process innovation, in its turn may promote gains in productivity (Terjesen & Patel, 2017) and enables cost reduction by implementing improvements in the production process (Moutinho, Au-Yong-Oliveira, Coelho, & Manso, 2015). Radical innovations even have the power to change the whole industry, by transforming new ventures in industry leaders and moving incumbents out (Hill & Rothaermel, 2003; Schoenmakers & Duysters, 2006). For these reasons, among others, today's environment is very uncertain, and innovation is one of the strategies that may contribute to firm survival (Teece, 2007). Corroborating the previously presented arguments, several authors empirically detected a positive impact that innovation performance has on firm financial performance (Du, Leten, & Vanhaverbeke, 2014; Faems *et al.*, 2010; Tomlinson, 2010). Therefore, innovative products and services that effectively gain an important share in a firm's turnover could, consequently, guarantee a superior performance for the firm, reflected in some indicators such as revenue and market share growth. Process innovation, on the other hand, may increase productivity and lower production costs, promoting a growth in the firm's profits.

Hypothesis 2. The level of a firm's innovation performance positively influences its financial performance.

To test the two proposed hypotheses, we proposed the model in Figure 1, which is formed by the following constructs: (a) External R&D - Strategic Alliances; (b) Internal R&D - Absorptive Capacity; (c) Innovation Performance; and (d) Financial Performance.

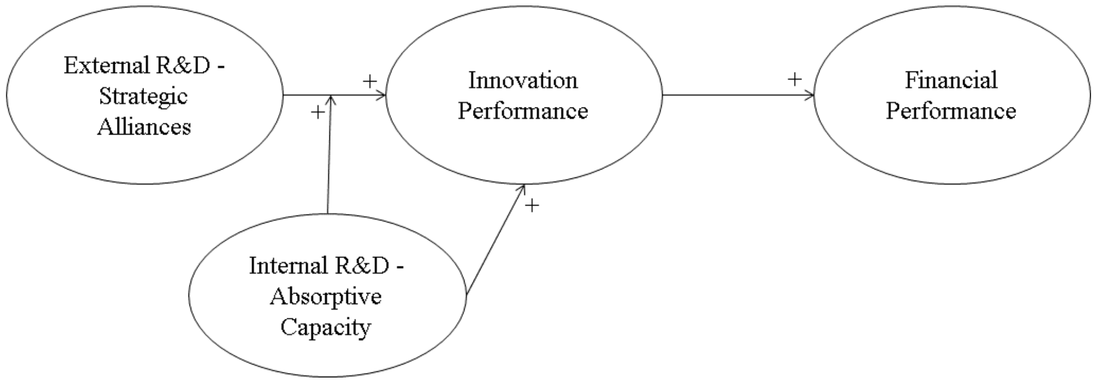

Figure1. Theoretical Model

Although the relationships presented in Figure 1 are supposed to be true in most cases, their intensity depends on the context. In some studies, complementarity among internal and external R&D was not found (*e.g.*, Mowery *et al.*, 1996). This relationship is dependent on several endogenous and exogenous factors (Zahra & George, 2002), such as the partner type, the type of innovation (Tsai, 2009), the industry and the country. Regarding industry, one of the most influential characteristics is technological intensity. Firms in high-technology industries face challenges that make more intense and radical innovation development a critical factor (Rothaermel & Deeds, 2006). Some of these factors are a faster technological progress, manufacturing complexity and stronger competition (Wang & Hsu, 2014). This reinforces the necessity of more intense use of R&D alliances by these firms (Hagedoorn, 1993; Hagedoorn & Duysters, 2002).

As internal R&D is necessary in order to improve absorptive capacity (Berchicci, 2013; Cohen & Levinthal, 1990), both internal R&D and alliances are necessary. However, the more internal R&D and the bigger network of partners for R&D a firm has, the higher its costs are to manage this complex system (Hallen *et al.*, 2014). Accordingly, the complementarity of internal and external R&D should be higher in high-tech industries, in which innovations are more radical and bring a greater financial return, a fact supported by several studies (Paula & Silva, 2017; Stam & Wennberg, 2009). On the other hand, in low-tech industries, a lower complementarity between these two types of knowledge sources is expected. This is because a lower management cost by choosing only one source of R&D (internal or external) should, at least partially, compensate for a possible higher level of innovation performance improvement caused by the implementation of a more complex strategy.

Regarding country influence, different levels of economic development should influence the innovation development process. Firms from developed country firms are more likely to have enough resources and capabilities to develop more complex and radical innovations (Utterback & Abernathy, 1975). On the other hand, ones from emerging countries are faced with higher barriers for AC (*e.g.*, managerial biases, weaker social integration mechanisms and weaker appropriability regimes) and weaker innovation systems that count on fewer researchers, lower R&D investment and fewer patents (Cuervo-Cazurra & Rui, 2017). Therefore, they need to catch-up to the technological leaders of more developed countries through a process that starts with imitation or licensing of an innovation from another firm, followed by efforts to implement incremental changes while the firm accumulates technological capabilities. Only after a certain level of accumulated capabilities, a firm catches-up to a level in which it can implement more radical innovations (Kim, 1998). In consequence of this accumulation process, firms from less technologically developed countries are supposed to be stages behind the ones from more developed countries. This should present a stronger complementarity between internal and external R&D, and any innovations developed should have a more rapid and strong influence on their financial performance.

Methods

Data source, sample and variable description

To test the model in Figure 1 for manufacturing firms of the cited European countries - Bulgaria, Cyprus, Czech Republic, Spain, Croatia, Portugal, Hungary, Slovenia, Norway, Lithuania, Romania, Italy, Slovakia and Estonia - we used data from Eurostat's CIS 2010 – Community Innovation Survey (Eurostat, n.d.a). This survey provides some indicators about innovation activities and financial performance of European firms for 2008, 2009 and 2010. For this study, we only considered manufacturing firms, based on the NACE Rev. 2.0 classification (Eurostat, 2016), that answered the survey with no missing values and which had declared that they had developed at least one product or process innovation in the period, had an ongoing innovation project by the end of 2010 or had abandoned or suspended some innovation project in the period between 2008 and 2010. As the firm response rate in CIS 2010 varied for each country, we calculated the number of firms by country in the final sample proportionally to a total number of manufacturing firms each country effectively has, based on the number of firms in the original sample divided by the response rates. The cases were randomly selected from each country. The total number of firms by country before (total sample) and after this final selection (weighted sample) is presented in Table 1.

Table 1

Sample of Manufacturing Firms by Country

Country	GII (country)	GII (group)	Total sample (country)	Weighted sample (country)	Group	Total sample (group)	Weighted sample (group)
Bulgaria	38	43	1,509	50	1	1,783	141
Romania	48		274	91	1		
Italy	29	29	731	731	2	731	731
Portugal	30	29	1,496	209	3	9,083	1,336
Spain	28		7,587	1,127	3		
Estonia	24	30	478	30	4	709	59
Lithuania	36		231	29	4		
Croatia	47	37	535	53	5	1,144	90
Cyprus	31		162	7	5		
Slovenia	32		447	30	5		

Continues

Table 1 (continued)

Country	GII (country)	GII (group)	Total sample (country)	Weighted sample (country)	Group	Total sample (group)	Weighted sample (group)
Czech Republic	27	33	1,094	202	6	1,976	306
Hungary	33		671	76	6		
Slovakia	38		211	28	6		
Norway	22	22	181	83	7	181	83
Total			15,607	2,746			

Table 2 lists the constructs with their respective proxies and presents a description of them and their formulas. All constructs are reflexive. The models were tested separately with two control variables (through a multigroup SEM analysis). The first control variable was the industry's technological intensity, which is central for testing hypothesis 1. Manufacturing industries were classified as high-tech (HT) or low-tech (LT), with HT representing the set of high-tech and medium high-tech industries according to NACE Rev. 2.0 and LT the set of low-tech and medium-low-tech industries (Eurostat, n.d.b). Table 3 shows the list of industries from NACE 2.0 classified into HT and LT groups.

Table 2

Constructs and Proxies

Construct	Proxy name	Proxy format
Innovation Performance (IP)	% Turnover from new products or services - %_TURN	0 to 100%
	Introduction of product innovation – PRODINOV	Yes/No
	Introduction of process innovation – PROCINOV	Yes/No
	Innovative degree of product innovation – RADPRODINOV	0- Did not introduce product innovation 1- New to the firm 2- New to the market
	Innovative degree of process innovation – RADPROCINOV	0- Did not introduce process innovation 1- New to the firm 2- New to the market
	Innovation impact: - Increase range of goods or services – ORANGE - Replace outdated products or processes - OREPL - Enter new markets or increase market share - ONMOMS - Improve quality of goods or services - OQUA - Improve flexibility for producing goods or services - OFLEX - Increase capacity for producing goods or services - OCAP - Reduce labour costs per unit output - OLBR - Reduce material and energy costs per unit output - ORME - Reduce environmental impacts - OREI - Improve health or safety of your employees – OHESY	0- Not relevant 1- Low 2- Medium 3- High

Continues

Table 2 (continued)

Construct	Proxy name	Proxy format
Innovation Performance (IP)	Importance of the partnership/source of information by partner type: - Suppliers - SSUP - Clients - SCLI - Competitors - SCOM - Consultants, commercial labs, or private R&D institutes - SINS - Universities - SUNI - Government - SGMT - Conferences, trade fairs and exhibitions - SCON - Scientific journals and other publications - SJOU - Professional and industry associations – SPRO	0- Not relevant 1- Low 2- Medium 3- High
Financial Performance (FP)	Turn. growth – turn_growth	Turn. 2010/Turn.2008-1
	Firm growth – emp_growth	Num. Emp.2010/Num. Emp.2008 – 1
Internal R&D - Absorptive Capacity (Int R&D)	Internal R&D spending/total turnover – rrdinx_rat	0 to 100%
	R&D training – RTR	Yes/No
	Importance of internal R&D as a source of information – SENTG	0- Not relevant 1- Low 2- Medium 3- High

Table 3

List of LT and HT Industries

Groups	Manufacturing Industries Classification	NACE 2.0 2-digit codes	Industry description
HT	High-technology	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
		26	Manufacture of computer, electronic and optical products
	Medium-high technology	20	Manufacture of chemicals and chemical products
		27 to 30	Manufacture of electrical equipment; Manufacture of machinery and equipment n.e.c.; Manufacture of motor vehicles, trailers and semi-trailers; Manufacture of other transport equipment
LT	Medium-low technology	19	Manufacture of coke and refined petroleum products
		22 to 25	Manufacture of rubber and plastic products; Manufacture of other non-metallic mineral products; Manufacture of basic metals; Manufacture of fabricated metals products, excepts machinery and equipment

Continues

Table 3 (continued)

Groups	Manufacturing Industries Classification	NACE 2.0 2-digit codes	Industry description
	Low technology	33	Repair and installation of machinery and equipment
		10 to 18	Manufacture of food products, beverages, tobacco products, textile, wearing apparel, leather and related products, wood and of products of wood, paper and paper products, printing and reproduction of recorded media;
		31 to 32	Manufacture of furniture; Other manufacturing

Note. Source: adapted from Eurostat. (n.d.b). *Aggregations of manufacturing based on NACE Rev. 2*. Retrieved January 20, 2016, from http://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf

Second, to control for country-specific effects, countries were grouped according to a mix of regional and economic characteristics (see Table 1 for the list of countries and their respective groups) as follows: Group 1 (Romania and Bulgaria) - Danubian countries that were considered modest innovators according to the 2015 Innovation Union Scoreboard (European Union, 2015); Group 2 (Italy) – Italy was considered alone due to its economic importance; Group 3 (Portugal and Spain) – the countries from the Iberian Peninsula; Group 4 (Estonia and Lithuania) – the Baltic states; Group 5 (Cyprus, Croatia and Slovenia) – Mediterranean countries, excluding Italy and the Iberian Peninsula; Group 6 (Czech Republic, Hungary and Slovakia) - Danubian countries that were considered moderate innovators according to the 2015 Innovation Union Scoreboard; and Group 7 (Norway) – a Scandinavian country. Norway is the only country in the sample that is not a member state of the European Union. However, we decided to include it in the research because it is part of the Schengen area, which has officially abolished passport and all other types of border control at mutual borders (European Commission, 2008). Table 1 also shows the average GII of each group, which varies from 22 (Norway) to 43 (Bulgaria and Romania). This variation demonstrates the differences in the innovative environment of the country groups, which should influence the relationships to be tested.

Statistical method

The first step of the analysis involved conducting an exploratory factor analysis (EFA) with all the model variables to check the existence of common-method bias. We considered a total variance explained in one common factor higher than 50% as a cut-off to consider common-method bias to be an issue (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). We also conducted a second test to detect common-method bias, proposed by the same authors, which consisted of running a CFA with an additional construct in which we made all variables load equally. The square of this load is the common variance and if it is high, common-method bias might be an issue.

As the second step, we conducted another EFA to verify the possibility for reducing the constructs' dimensions. The number of factors was chosen by the scree-plot method (checking for which number of factors a plot forms an elbow) and guaranteeing that the factors explain at least 60% of the variables' variance (Hair, Black, Babin, Anderson, & Tatham, 2006). After this, we applied a varimax rotation and calculated the final factors, whereupon the dimension reduction was applicable, with summated-scales of the variables with factor loadings equal or higher than 0.7 (Hair *et al.*, 2006). Following, we proceeded with validation of the measurement model by confirmatory factor analysis (CFA). We also conducted validity checks. For convergent validity, we tested if the standardized loads of the variables inside each construct were higher than 0.7 (Nunnally, 1978), and if their average variance extracted (AVE) was higher than 0.5 (Fornell & Larcker, 1981). For discriminant validity, the AVE of one construct is supposed to be higher than the squared estimated correlations between two constructs (Hair *et al.*, 2006). For nomological validity, the between construct covariances should be according to the theory. The construct reliability (CR) should be higher than 0.7 for each construct to indicate construct reliability (Fornell & Larcker, 1981).

To test the hypotheses and confirm the relationships among the constructs, we used Bayesian structural equation modeling (SEM). Bayesian Estimation was chosen to run the CFA and SEM as this estimation type has several advantages over others, such as maximum likelihood estimation. For instance, it: (a) is not based on the normality of the variables; (b) works better with smaller samples; (c) does not suppose a linear relationship; and (d) considers previous knowledge by demanding the imputation of a prior distribution, which may be a result of previous studies (Kruschke, Aguinis, & Joo, 2012). We used a convergence statistic below 1.1 as acceptable (Gelman, Carlin, Stern, & Rubin, 2014) and a confidence interval of 95% for the regression weights. We used the mean-centering technique (Little, Bovaird, & Widaman, 2006) to represent the effect of the moderation relationship between the constructs Internal R&D - Absorptive Capacity and External R&D - Strategic Alliances on the Innovation Performance. This moderation was used to test the complementarity of internal and external R&D.

According to this technique, we added a new moderation construct to the SEM that loaded the innovation performance construct. This constructs' variables were calculated by multiplying all factors of the construct absorptive capacity with the factors of strategic alliances and applying the Z-score. We also correlated the residuals of the variables that were formed by the product of a common original factor (*e.g.*, all variables formed by the multiplication of the first factor of absorptive capacity should have its residuals correlated) in the SEM. Because the firms from Italy do not have emp_growth information, we chose not to use Future Financial Performance as a latent variable, but instead ran two separate models using the variables turn_growth and emp_growth as endogenous variables representing financial performance. For the model that tested turn_growth, we used all firms in the weighted sample and for the one that tested emp_growth, we used the same sample, excluding the Italian firms.

Results

Table 4 shows the descriptive statistics for the total sample and for each country group (mean and standard deviation) and Table 5 shows the descriptive statistics for the HT and LT groups. For these two groups, we excluded firms competing in more than one industry with different technological intensities, ending up with 2,553 firms (805 HTs and 1,748 LTs). For all analysis, we excluded one case of group 6 (a firm from the Czech Republic) that was an extreme outlier for turn_growth. We also ran a one-way ANOVA with the post-hoc test Tamahhane T2, comparing country groups and HT versus LT industries, to identify differences in variables' means among the groups (Hair *et al.*, 2006). An analysis of Table 4 shows that all model's variables present significant mean differences among country groups. 95% of all sample firms (a total of 2,608) succeeded in introducing at least one product or process innovation. Post-hoc analysis could identify that group 7 (Norway), in which 100% of the sample firms introduced innovation, scored higher in this variable (INOV) than at least groups 3 (composed of Portugal and Spain), 6 (composed of Czech Republic, Hungary and Slovakia) and 2 (that represents Italy). The sample's levels of product and process innovators were similar (74% or 2,031 firms, and 75% or 2,059 firms). From these, 1,482 introduced both types during the period, with 549 only product innovation and 577 only process innovation. In both indicators, group 7 was identified superior to all other groups.

If we consider the three proxies of internal R&D, group 7 also scored higher than the other groups (with exception of the proxy rrdinx_rat, for which the group 7 average is not significantly different from group 5, composed of Croatia, Cyprus and Slovenia). In the case of the financial performance proxies, turnover growth between 2008 and 2010 was 56.20% on average and differences among groups were found. However, the post-hoc analysis did not identify significant differences between groups two by two. Group 1 (Bulgaria and Romania) has the highest average, followed by group 4 (Estonia and Lithuania). In the case of number of employee's growth, which was not measured for group 2, we could find a total average of -2.0% (negative), with group 4 scoring higher than the others and groups 1, 3 and 6 having a decrease of the number of employees in the period. Significant differences between groups two by two were hardly found by the post-hoc analysis for this indicator. Another interesting observation from the ANOVA analysis concerns the variables that represent External R&D – Strategic Alliances.

Group 7 scored higher or belongs to the group of firms that scores higher in most cases (for SSUP, SCLI, SCOM, SINS, SUNI, SGMT, SJOU and SPRO). From all these types of strategic alliances, collaboration with suppliers and with clients were considered the most important for the innovation process (1.72 and 1.66 respectively out of a maximum of 3). On the other hand, collaboration with the government (SGMT), with universities (SUNI) and with professional and industry associations (SPRO) scored less than 1, which indicates that they were considered somehow between irrelevant and of low relevance.

An analysis of Table 5 also shows significant mean differences between HT and LT firms. The HT group overcome the LT group in most of the variables of the constructs innovation performance, external R&D, and internal R&D. In the case of innovation performance, HT firms introduce more product innovation. In the case of process innovation, there is no significant difference. On external R&D, HT firms score higher than LT firms in all types of partners, with exception of suppliers (SSUP). Internal R&D is also higher in LT firms, considering all the three proxies. On the other hand, financial performance differences could not be observed between the two groups.

After, we checked the possible existence of common-method bias, using an EFA with all model variables to generate a unique factor. This factor presented a total variance explained of 28.9%, much lower than the limit of 50%. We also conducted a CFA with a construct representing the common-method variance. Its common load was 0.32, representing a common variance of 10.2%, low enough to discard the existence of common-method bias.

Table 4

Descriptive Statistics – All Firms and by Country Group

		All firms (n = 2,745)		Group 1 (n = 141)		Group 2 (n = 731)		Group 3 (n = 1,336)		Group 4 (n = 59)		Group 5 (n = 90)		Group 6 (n = 305)		Group 7 (n = 83)	
Construct	Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Innovation Performance	INOV	0.95*	0.23	0.97	0.17	0.95	0.21	0.93	0.25	0.95	0.22	0.96	0.21	0.94	0.23	1.00	0.00
	PRODINOV	0.74***	0.44	0.79	0.41	0.82	0.38	0.67	0.47	0.63	0.49	0.86	0.35	0.79	0.41	1.00	0.00
	PROCINOV	0.75***	0.43	0.76	0.43	0.76	0.43	0.77	0.42	0.69	0.46	0.78	0.42	0.63	0.48	1.00	0.00
	RADPRODINOV	1.22***	0.83	1.21	0.77	1.47	0.78	1.03	0.83	0.93	0.83	1.36	0.74	1.31	0.80	1.81	0.40
	RADPROCINOV	0.96***	0.68	1.09	0.76	1.16	0.79	0.83	0.52	0.95	0.75	0.97	0.84	0.74	0.80	1.67	0.47
	TURN	12.6%***	22.1%	10.0%	16.0%	27.1%	31.0%	6.8%	15.0%	4.7%	6.9%	7.4%	13.7%	8.5%	14.5%	8.5%	11.8%
	ORANGE	2.17***	1.02	2.50	0.78	2.31	0.88	1.96	1.12	2.17	1.05	2.53	0.80	2.41	0.89	2.58	0.74
	OREPL	1.87***	1.09	2.18	0.98	1.95	0.99	1.68	1.15	2.17	1.02	2.20	0.89	2.07	1.02	2.39	0.85
	ONMOMS	2.09***	1.05	2.32	0.90	2.16	0.90	1.96	1.16	2.22	0.89	2.32	0.90	2.16	0.99	2.58	0.61
	OQUA	2.25***	0.98	2.49	0.81	2.41	0.76	2.06	1.12	2.37	0.74	2.61	0.71	2.38	0.86	2.60	0.58
	OFLEX	1.86***	1.01	2.11	0.92	1.89	0.93	1.76	1.06	2.02	0.78	2.24	0.94	1.85	1.06	2.22	0.80
	OCAP	1.83***	1.05	2.11	1.02	1.79	0.96	1.77	1.11	2.08	0.84	2.11	0.98	1.83	1.07	2.11	0.81
	OLBR	1.73***	1.07	1.96	1.02	1.70	0.99	1.63	1.13	2.08	0.93	2.20	0.93	1.80	1.04	2.39	0.75
	ORME	1.68***	1.08	2.00	1.05	1.74	0.99	1.50	1.12	1.90	0.94	2.11	0.98	1.86	1.04	2.34	0.80
	OREI	1.64***	1.11	1.84	1.12	1.83	1.00	1.48	1.16	1.59	1.02	2.01	1.12	1.57	1.10	2.07	0.93
	OHESY	1.70***	1.13	2.00	1.06	1.95	0.99	1.51	1.19	1.49	1.06	2.06	1.06	1.60	1.12	2.16	0.93

Continues

Table 4 (continued)

Construct	Variable	All firms (n = 2,745)		Group 1 (n = 141)		Group 2 (n = 731)		Group 3 (n = 1,336)		Group 4 (n = 59)		Group 5 (n = 90)		Group 6 (n = 305)		Group 7 (n = 83)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
External R&D - Strategic Alliances	SSUP	1.72***	0.98	1.94	0.86	1.77	0.88	1.58	1.06	2.02	0.99	2.08	0.92	1.81	0.86	2.30	0.64
	SCLI	1.66***	1.09	2.02	0.94	1.61	1.05	1.50	1.12	1.36	1.06	2.07	1.00	2.07	1.01	2.51	0.67
	SCOM	1.24***	1.01	1.53	1.00	1.11	0.93	1.14	1.02	1.15	0.94	1.48	1.06	1.58	1.03	1.93	0.84
	SINS	1.07***	1.01	0.96	1.02	1.33	0.97	1.00	1.03	0.80	0.94	0.71	0.94	0.93	0.94	1.33	0.94
	SUNI	0.75***	0.96	0.73	0.96	0.85	0.98	0.69	0.96	0.36	0.71	0.50	0.80	0.76	0.92	1.31	0.90
	SGMT	0.67***	0.94	0.54	0.79	0.51	0.79	0.82	1.03	0.20	0.52	0.36	0.75	0.42	0.74	1.47	0.98
	SCON	1.26***	1.02	1.52	1.08	1.34	0.96	1.10	1.03	1.44	0.99	1.33	1.11	1.53	0.95	1.46	0.86
	SJOU	1.07***	0.94	1.38	1.03	1.08	0.89	0.93	0.93	0.88	0.83	1.23	1.01	1.30	0.88	1.90	0.78
	SPRO	0.88***	0.92	0.89	0.92	0.92	0.88	0.82	0.90	0.63	0.83	0.64	0.88	0.77	0.85	2.18	0.78
Internal R&D - Absorptive Capacity	rrdinx_rat	1.97%***	5.18%	1.03%	2.52%	1.75%	3.67%	2.11%	5.69%	0.64%	2.57%	1.59%	7.39%	1.81%	5.00%	5.10%	8.41%
	RTR	0.37***	0.48	0.50	0.50	0.44	0.50	0.21	0.41	0.61	0.49	0.58	0.50	0.55	0.50	0.89	0.31
	SENTG	2.22***	1.01	2.18	0.93	2.27	1.02	2.15	1.03	1.85	1.06	2.27	1.02	2.33	0.92	2.75	0.46
Financial Performance	turn_growth	56.2%*	1269.6%	385.7%	3140.5%	15.6%	516.6%	53.7%	1417.2%	224.2%	1539.0%	-1.7%	28.3%	11.0%	172.3%	4.5%	37.3%
	emp_growth	-2.0%***	39.9%	-4.5%	38.0%	-	-	-4.1%	27.6%	15.4%	63.8%	5.1%	29.0%	-1.4%	50.6%	12.9%	102.1%

Note. ANOVA - * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 5

Descriptive Statistics – HT and LT Industries

		HT (n = 805)		LT (n = 1,748)		
Construct	Variable	Mean	S.D.	Mean	S.D.	t test
Innovation Performance	INOV	0.96	0.19	0.94	0.24	**
	PRODINOV	0.86	0.35	0.69	0.46	***
	PROCINOV	0.74	0.44	0.76	0.43	n.s.
	RADPRODINOV	1.46	0.73	1.12	0.85	***
	RADPROCINOV	1.00	0.72	0.96	0.66	n.s.
	TURN	17.6%	24.8%	10.8%	21.2%	***
	ORANGE	2.32	0.94	2.09	1.05	***
	OREPL	2.04	1.00	1.78	1.11	***
	ONMOMS	2.27	0.95	1.98	1.08	***
	OQUA	2.36	0.91	2.20	1.00	***
	OFLEX	1.90	1.01	1.84	1.01	n.s.
	OCAP	1.85	1.03	1.82	1.05	n.s.
	OLBR	1.80	1.04	1.71	1.08	**
	ORME	1.75	1.06	1.64	1.09	**
	OREI	1.67	1.08	1.59	1.13	n.s.
	OHESY	1.77	1.09	1.64	1.15	***
External R&D - Strategic Alliances	SSUP	1.69	0.94	1.74	0.99	n.s.
	SCLI	1.85	1.06	1.56	1.10	***
	SCOM	1.34	0.99	1.18	1.02	***
	SINS	1.19	1.00	1.01	1.00	***
	SUNI	1.00	1.02	0.62	0.90	***
	SGMT	0.79	0.98	0.60	0.90	***
	SCON	1.35	0.99	1.22	1.03	***
	SJOU	1.24	0.92	0.99	0.94	***
	SPRO	0.97	0.91	0.83	0.92	***
Internal R&D - Absorptive Capacity	rrdinx_rat	3.5%	7.5%	1.2%	3.5%	***
	RTR	0.43	0.50	0.34	0.47	***
	SENTG	2.43	0.88	2,10	1.05	***
Financial Performance	turn_growth	53.0%	1,372.2%	56.4%	1,258.9%	n.s.
	emp_growth	-3.3%	39.5%	-1.7%	41.0%	n.s.

After applying the Z-core to all scalar variables to guarantee that we did not have scale problems, we followed the analysis with the EFA for the whole sample with a varimax rotation to reduce the constructs Innovation Performance and External R&D - Strategic Alliances. For the other two constructs, we decided not to reduce the variables as they have three or fewer variables and we tried to keep a minimum of three (for Financial Performance, the latent variable was exchanged for two models and only one indicator in each, as previously mentioned). We successfully reduced the two constructs for three variables each. In the case of Innovation Performance, the EFA presented a KMO of 0.82 and the Bartlett's test of sphericity was significant ($p < 0.01$), validating the reduction. The three factors had a cumulative variance of 62.5% of the original variables. For External R&D - Strategic Alliances, the EFA presented a KMO of 0.84 and the Bartlett's test of sphericity was significant ($p < 0.01$). The three factors had a cumulative variance of 67.7% of the original variables. In Table 6, we present the results of the EFA after the varimax rotation, with the proxies that formed each of the factors (which weighed 0.7 or higher in that factor) in bold.

Table 6

EFA Results – Varimax Rotation

Innovation Performance				External R&D - Strategic Alliances			
Variable	Factor 1	Factor 2	Factor 3	Variable	Factor 1	Factor 2	Factor 3
PRODINOV	0.06	**0.89**	-0.03	SSUP	0.77	0.21	0.65
RADPRODINOV	0.07	**0.89**	0.06	SCLI	0.11	0.17	**0.83**
TURN	-0.03	0.56	0.16	SCOM	0.18	0.19	**0.79**
PROCINOV	0.155	-0.14	**0.92**	SINS	**0.72**	0.21	0.24
RADPROCINOV	0.20	0.14	**0.90**	SUNI	**0.80**	0.25	0.08
ORANGE	0.46	0.55	-0.16	SGMT	**0.82**	0.21	0.06
OREPL	0.54	0.31	-0.03	SCON	0.13	**0.82**	0.28
ONMOMS	0.57	0.45	-0.17	SJOU	0.23	**0.83**	0.22
OQUA	**0.70**	0.28	-0.08	SPRO	0.36	0.69	0.19
OFLEX	**0.73**	-0.04	0.22				
OCAP	**0.73**	-0.01	0.21				
OLBR	**0.79**	-0.03	0.18				
ORME	**0.78**	0.04	0.12				
OREI	**0.74**	0.14	0.07				
OHESY	**0.76**	0.11	0.10				

Factor 1 of Innovation Performance was formed by a summated-scale of OQUA, OFLEX, OCAP, OLBR, ORME, OREI and OHESY, which are variables that measure the impact of the innovations for the firm. The other variables that represents innovation impact did not participate in any other factor. For that reason, we called factor 1 **Innovations' Impacts** (INNOV_IMP). Factor 2 was called **Product Innovation Introduction** (INTRO_PROD), as it was formed by the variables that indicate if product innovation was introduced (PRODINOV) and the degree of innovativeness of product innovation (RADPRODINOV). For a similar reason, Factor 3 was called **Process Innovation Introduction** (INTRO_PROC), as it was formed by the variables that indicate if process innovation was introduced (PROCINOV) and the degree of innovativeness of process innovation (RADPROCINOV). In the case of the construct External R&D - Strategic Alliances, Factor 1 was formed by collaboration with consultants and private research centers (SINS), the government (SGMT) and universities (SUNI), being called **Alliances with Formal Institutions** (ALL_INST); Factor 2 was formed by other external sources of information such as conferences (SCON) and journals (SJOU), being called **Alliances with the Academy** (ALL_ACAD); and Factor 3 was formed by alliances with clients (SCLI) and competitors (SCOM) and was called **Alliances with the Market** (ALL_MKT).

The next step of the analysis was the full-sample's CFA considering only the three model constructs, excluding Financial Performance. The following errors' correlations were added, according to the modification indexes' analysis: ALL_INST with ALL_MKT in the construct External R&D – Strategic Alliances, and INNOV_IMP with INTRO_PROC in the construct Innovation Performance. Tables 7 and 8 respectively show the results of the measurement model and the tests for discriminant validity. All the standardized regression weights of the measurement model should be 0.7 or above to guarantee the reliability of the individual index. INTRO_PROC for Innovation Performance and rrdinx_rat for Internal R&D – Absorptive Capacity are considerably below this value (0.37 and 0.24 respectively), but we keep them in the model as they are statistically significant ($p < 0.05$) and we want to keep a minimum of three proxies for each construct to guarantee that the model is identifiable. The minimum for the average variance extracted – AVE (0.5) and the composite reliability – CR (0.7) were only achieved for External R&D – Strategic Alliances. However, as some authors consider that the AVE is a very conservative criterion for convergent validity (Malhotra & Dash, 2011) and that the researcher may decide to continue even with more than 50% of the variance of the construct explained by error, we moved on.

The discriminant validity was not achieved, as Table 8 shows. The main diagonal, presenting the construct's AVE, is lower in all cases than the squared estimated correlations between the constructs, showed in the off-diagonal elements. However, as the criteria for the evaluation of discriminant validity depends on AVE, which as previously discussed is a very conservative criterion for validity check, and the choices of the proxies was based on a deep literature review which clearly stated the differences between internal and external sources of innovation and innovation performance, we considered that the proxies of one construct might not represent another better. For nomological validity, we expected to find significant covariances between constructs. It was found for all constructs. The covariance between Internal R&D – Absorptive Capacity and Innovation Performance was 1.00, between External R&D – Strategic Alliances and Innovation Performance was 0.98, and between Internal R&D – Absorptive Capacity and External R&D – Strategic Alliances was 0.88, all significant ($p < 0.05$). Even with some validity issues, we decided to follow with the analysis of the proposed model.

Table 7

Results of the CFA

Variable	S.R.W.	t-test (p < 0.05)	CR	AVE
INNOV_IMP	0.72	***	0.62	0.41
INTRO_PROD	0.75	***		
INTRO_PROC	0.37	***		
rrdinx_rat	0.24	***	0.52	0.35
RTR	0.75	***		
SENTG	0.67	***		
ALL_INST	0.83	***	0.81	0.67
ALL_MKT	0.84	***		
ALL_ACAD	0.78	***		

Table 8

Discriminant Validity

	IR&D	ER&D	IP
Internal R&D - Absorptive Capacity (IR&D)	**0.35**		
External R&D - Strategic Alliances (ER&D)	0.88	**0.67**	
Innovation Performance (IP)	1.00	0.98	**0.41**

Next, we ran the structural model using multigroup Bayesian estimation controlling by the technological intensity of the industry. The results were summarized in Table 9. The model presents a fourth construct, ExtR&D x IntR&D, representing the moderation of absorptive capacity (Int R&D) and the strategic alliances (Ext R&D), as previously explained.

Table 9

Results of the SEM – HT and LT Firms

	FP - turn_growth				FP - emp_growth			
	HT (n = 805)		LT (n = 1,748)		HT (n = 805)		LT(n = 1,748)	
Relationship	S.R.W.	Sig.	S.R.W.	Sig.	S.R.W.	Sig.	S.R.W.	Sig.
Ext. R&D → IP	0.383	***	0.391	***	0.301	***	0.387	***
Int. R&D → IP	0.069	***	0.042	n.s.	0.167	***	0.038	n.s.
Ext R&D x Int R&D → IP	0.010	***	-0.004	n.s.	-0.002	n.s.	-0.001	n.s.
IP → FP	-0.003	n.s.	-0.007	n.s.	-0.100	***	0.045	n.s.

Note. *** $p < 0.05$.

Examining the standard regression weights of the relationships in Table 9, we found that, with turn_growth as the measure of financial performance, hypothesis 1, which proposed a complementary relationship between internal and external R&D on innovation performance, primarily on the group of high-tech firms, was supported. The path coefficient between the moderation construct and financial performance is 0.010 and significant ($p < 0.05$) for the HT group and is not significant for the LT group. On the other hand, using emp_growth as the proxy of financial performance, the hypothesis was rejected, with both coefficients being non-significant. In consequence, hypothesis 1 was partially supported in this study. Hypothesis 2, which proposed that innovation performance has a positive influence on financial performance, was rejected for both firms' groups, using both turn_growth and emp_growth, as shows Table 9.

Next, we conducted a SEM analysis controlling by country group (see results in Table 10). The analysis in general did not support hypotheses 1 and 2, showing that the technological intensity of the industry is a better control variable, as the complementarity of internal and external R&D is contingent upon it. However, some groups presented differences regarding hypothesis 2. In the case of group 3 (Portugal and Spain), we found a positive influence of innovation performance on emp_growth as the proxy for financial performance (0.044 for $p < 0.05$). In the case of group 4 (Estonia and Lithuania), this influence was supported for turn_growth as the proxy for financial performance (0.059 for $p < 0.05$).

Table 10

Results of the SEM – by Country Group

	Group 1 (n = 425) Bulgaria and Romania				Group 2 (n = 731) Italy			
	FP – turn_growth		FP – emp_growth		FP – turn_growth		FP – emp_growth	
Relationship	S.R.W.	Sig.	S.R.W.	Sig.	S.R.W.	Sig.	S.R.W.	Sig.
Ext. R&D → IP	0.412	****	0.393	****	0.148	****	-	-
Int. R&D → IP	0.310	***	0.322	***	0.203	***	-	-
Ext. R&DxInt. R&D → IP	0.073	n.s.	0.061	n.s.	0.030	n.s.	-	-
IP → FP	0.011	n.s.	0.071	n.s.	0.014	n.s.	-	-
	Group 3 (n = 8,990) Portugal and Spain				Group 4 (n = 470) Estonia and Lithuania			
	FP – turn_growth		FP – emp_growth		FP – turn_growth		FP – emp_growth	
Relationship	S.R.W.	Sig.	S.R.W.	Sig.	S.R.W.	Sig.	S.R.W.	Sig.
Ext. R&D → IP	0.356	****	0.356	****	0.229	****	0.246	****
Int. R&D → IP	0.245	***	0.245	***	0.149	***	0.151	***
Ext. R&DxInt. R&D → IP	-0.128	n.s.	-0.131	***	-0.014	n.s.	0.012	n.s.
IP → FP	-0.009	n.s.	0.044	***	0.059	***	0.003	n.s.
	Group 5 (n = 909) Croatia, Cyprus and Slovenia				Group 6 (n = 1,657) Czech Republic, Hungary and Slovakia			
	FP – turn_growth		FP – emp_growth		FP – turn_growth		FP – emp_growth	
Relationship	S.R.W.	Sig.	S.R.W.	Sig.	S.R.W.	Sig.	S.R.W.	Sig.
Ext. R&D → IP	0.231	****	0.242	****	0.258	****	0.259	****
Int. R&D → IP	0.210	***	0.188	***	0.177	***	0.162	***
Ext. R&DxInt. R&D → IP	-0.027	n.s.	-0.010	n.s.	0.001	n.s.	-0.014	n.s.
IP → FP	0.035	n.s.	0.028	n.s.	0.001	n.s.	0.009	n.s.

	Group 7 (n = 141) Norway			
	FP – turn_growth		FP – emp_growth	
Relationship	S.R.W.	Sig.	S.R.W.	Sig.
Ext. R&D → IP	0.203	****	0.253	****
Int. R&D → IP	0.180	***	0.190	***
Ext. R&DxInt. R&D → IP	0.036	n.s.	0.043	n.s.
IP → FP	0.009	n.s.	0.029	n.s.

Note. *** $p<0.05$.

Discussion

This paper identified important differences in the influence diverse R&D sources have in innovation outcomes. In high-tech firms, internal and external R&D are complementary (in the model in which turn_growth represents financial performance), with each in isolation and their interaction having a positive influence on innovation performance. These findings corroborated the absorptive capacity theory and are in line with most empirical studies (*e.g.*, Belussi *et al.*, 2010; Cassiman & Veugelers, 2006; Frenz & Ietto-Gillies, 2009; Oerlemans *et al.*, 2013). On the other hand, in low-tech firms, external R&D from strategic alliances and internal R&D investments, such as R&D intensity and employee training, had a positive influence on the innovation performance directly, which is in line with much of the preceding literature (*e.g.*, Berchicci, 2013; Lin, Wu, Chang, Wang, & Lee, 2012; Schilling, 2015). However, the moderation of internal R&D on the relationship between external R&D and innovation performance was not found (rejecting the hypothesis of complementarity between them).

All proxies of the construct Internal R&D - Absorptive Capacity presented significantly lower values in the LT group than in the HT group (see Table 5). These findings corroborated the results of Hagedoorn and Wang (2012), which suggested that internal and external R&D are substitutes in firms with low level of absorptive capacity. As the countries in the study are moderate or modest innovators in the European and global context (Dutta *et al.*, 2016; Europe Union, 2015), their manufacturing industry is not in a world-leading position in innovation. This disadvantage is even more prominent in manufacturing industries of low technological intensity. The firms should invest in accumulating innovative capabilities internally, by improving their investments in internal R&D and capacitation of employees, in order to increase their absorptive capacity and the effectiveness of their collaboration efforts, as suggested by several studies (Bell & Figueiredo, 2012; Kim, 1998; Lee & Lim, 2001).

A positive effect of innovation performance on financial performance was not found in both groups of firms, leading us to reject hypothesis 2. Perhaps, the lack of a statistically significant relationship between innovation and financial performance derives from the fact that the effects of the introduction of innovative products, services or processes on firm performance may take some time to show up. The financial performance indicators had no time-lag compared to the innovation performance proxies, which didn’t allow capture of the expected relationship. It is expected that R&D investments and the innovations introduced take some time to mature. Increased revenues from new products and services takes time, as it is necessary to introduce them into the market, guarantee an appropriate distribution, and communicate with the consumer. Similarly, process innovations with the potential to reduce costs usually require training and operational adjustments that prevent an immediate positive result. On the other hand, in the short-term, the effect of the innovation introduction tends to be negative by the redirection of resources from marketing and sales to innovation activities, such as internal R&D, and of the managerial costs of the strategic alliances.

However, when we analyzed by country group, there were exceptions. In group 3 (Portugal and Spain), innovation performance positively influenced emp_growth. In group 4 (Estonia and Lithuania), innovation performance had a positive effect on turn_growth. The case of group 4 may be explained because the Baltic countries’ growth was more negatively affected by the 2008 global crisis than the rest of Europe on average, followed by a very intense growth (Staehr, 2015), that was possibly pushed by innovative firms. This suggests that an innovation strategy may position firms to better recover from country level or global crises and to take advantage from the country’s recovery. Portugal and Spain were also in an especially bad position after the 2008 crisis (Lin, Edvinsson, Chen, & Beding, 2013), but their economies did not present recovery as fast as the Baltic countries. The industry in these countries contracted during the crisis and the analysis shows that innovative firms had a better recovery, by growing faster to reach their sizes before 2008, regarding the number of employees. However, we still did not capture an effect in turnover growth as this indicator should take more time to recover.

Conclusion

This paper investigated how internal and external R&D influence the innovation performance as well as the influence of the latter on the financial performance of manufacturing firms from 14 European countries - Bulgaria, Cyprus, Czech Republic, Spain, Croatia, Portugal, Hungary, Slovenia, Norway, Lithuania, Romania, Italy, Slovakia and Estonia. We analyzed a sample of 2,745 firms which conducted innovation activities from 2008 to 2010, with success in the introduction of innovation or not, from CIS 2010 survey and found some interesting conclusions. The main conclusion is that internal and external R&D strategies are complementary in firms of more technologically intense industries, as they usually have a higher absorptive capacity. In the case of firms in industries of low intense technology, both strategies alone are effective for improving innovation performance, but the effect of their interaction is not significant. Innovation performance did not influence short-term financial performance. Product and process innovations take some time to mature and for that reason, their positive influence on financial performance takes some time to emerge. Even some innovations that may promote some results in the short term, such as incremental process innovations that reduce production costs, are compensated against by a negative effect promoted by the redirection of resources from marketing and sales to innovation activities and to manage strategic alliances. However, an analysis by country group identified that in countries facing a strong economic crisis, innovation may more quickly improve the firms' financial performance indicators.

There are some limitations in this research. First, we may point the tolerance with the low discriminant validity of the measurement model. Also, there are some risks of endogeneity that may affect the statistical analysis. Some exogenous construct that affects conjointly internal and external R&D, innovation performance and financial performance may exist and may be the real source of the effects found in the analysis. Another source of bias is a possible existence of reverse causality. A better financial performance, for example, may be the cause of a higher innovation performance, and not the contrary. Another limitation is that the CIS questionnaire mostly uses a four-point Likert scale, which is not the most appropriate according to the Theory of Scales of Measurement, and it may have implications for statistical analysis (Hand, 1996). We may also point that we only had access to data from the countries cited above, while some important European countries such as Germany, France and UK, and some of the most innovative countries such as Sweden, Denmark and Holland (European Union, 2015) are out of the analysis, which may limit the generalizability of the results. The last limitation is that the CIS database is subject to feelings and experiences of the respondents by the presence of some subjective questions, which may bias the results. Regardless of these limitations, this paper contributes to understanding the relationships among internal R&D, strategic alliances, absorptive capacity, innovation performance and financial performance of European manufacturing firms, especially from the countries studied.

As implications for practitioners, we may cite that high-tech firms should invest conjointly in internal and external R&D regardless of their goals. Low-tech firms, in turn, should focus on either internal or external R&D for an immediate improvement of their innovation performance levels. However, if the firm has long-term goals, starting with an internal R&D is effective to improve the firms' absorptive capacity while achieving a satisfactory innovation outcome. This will allow firms to adopt more complex strategies, balancing internal and external R&D, effectively in the future, when the absorptive capacity level becomes high. For future studies, we suggest conducting the analysis of manufacturing firms in more European countries at different innovative stages compared to the countries presented in this analysis and compare the results with their respective innovative levels. Another possibility is to test the model with firms from different sectors, such as service firms, which may present different results.

Contributions

1st author: concept, design, writing and analysis of the manuscript, discussion of results, final approval.
2nd author: concept, design, writing, discussion of results, final revision.

References

Arora, A., Belenzon, S., & Rios, L. A. (2014). Make, buy, organize: The interplay between research, external knowledge, and firm structure. *Strategic Management Journal*, *35*(3), 317-337. https://doi.org/10.1002/smj.2098

Ateljević, J., & Trivić, J. (2016). *Economic development and entrepreneurship in transition economies: Issues, obstacles and perspectives*. Switzerland: Springer. https://doi.org/10.1007/978-3-319-28856-7

Belderbos, R., Faems, D., Leten, B., & Van Looy, B. (2010). Technological activities and their impact on the financial performance of the firm: Exploitation and exploration within and between firms. *Journal of Product Innovation Management, 27*(6), 869-882. https://doi.org/10.1111/j.1540-5885.2010.00757.x

Bell, M., & Figueiredo, P. N. (2012). Building innovative capabilities in latecomer emerging market firms: Some key issues. In E. Amann & J. Cantwell, *Innovative firms in emerging market countries* (pp. 24-109). New York and London: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199646005.003.0002

Belussi, F., Sammarra, A., & Sedita, S. R. (2010). Learning at the boundaries in an “Open Regional Innovation System”: A focus on firms' innovation strategies in the Emilia Romagna life science industry. *Research Policy*, *39*(6), 710-721. https://doi.org/10.1016/j.respol.2010.01.014

Berchicci, L. (2013). Towards an open R&D system: Internal R&D investment, external knowledge acquisition and innovative performance. *Research Policy, 42*(1), 117-127. https://doi.org/10.1016/j.respol.2012.04.017

Cassiman, B., & Veugelers, R. (2006). In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Management Science*, *52*(1), 68-82. https://doi.org/10.1287/mnsc.1050.0470

Ceccagnoli, M. (2009). Appropriability, preemption, and firm performance. *Strategic Management Journal*, *30*(1), 81-98. https://doi.org/10.1002/smj.723

Chatterji, A. K., & Fabrizio, K. R. (2014). Using users: When does external knowledge enhance corporate product innovation? *Strategic Management Journal*, *35*(10), 1427-1445. https://doi.org/10.1002/smj.2168

Cheng, C. C. J., & Huizingh, E. K. R. E. (2014). When is open innovation beneficial? The role of strategic orientation. *Journal of Product Innovation Management*, *31*(6), 1235-1253. https://doi.org/10.1111/jpim.12148

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Boston, MA: Harvard Business School Press.

Christensen, C., & Raynor, M. (2013). *The innovator's solution: Creating and sustaining successful growth.* Boston, MA: Harvard Business School Press.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-152. https://doi.org/10.2307/2393553

Collins, J. C., & Porras, J. I. (1996). Building your company's vision. *Harvard Business Review, 74*(5), 65.

Cuervo-Cazurra, A., & Rui, H. (2017). Barriers to absorptive capacity in emerging market firms. *Journal of World Business, 52*(6), 727-742. https://doi.org/10.1016/j.jwb.2017.06.004

Du, J., Leten, B., & Vanhaverbeke, W. (2014). Managing open innovation projects with science-based and market-based partners. *Research Policy*, *43*(5), 828-840. https://doi.org/10.1016/j.respol.2013.12.008

Dutta, S., Lanvin, B., & Wunsch-Vincent, S. (Eds.). (2016). *The global innovation index 2016: Winning with global innovation*. Ithaca, Fontainebleau, and Geneva: Cornell University, INSEAD, & WIPO. Retrieved from http://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2016.pdf

Duysters, G., & Lokshin, B. (2011). Determinants of alliance portfolio complexity and its effect on innovative performance of companies. *Journal of Product Innovation Management*, *28*(4), 570-585. https://doi.org/10.1111/j.1540-5885.2011.00824.x

European Commission. (2008). *The Schengen area.* Retrieved from https://publications.europa.eu/en/publication-detail/-/publication/8b556648-c5fe-427a-b9fb-8e7de617e125/language-en. https://doi.org/10.2758/45874

European Union. (2015). *Innovation union scoreboard 2015*. Retrieved January 20, 2016, from https://publications.europa.eu/en/publication-detail/-/publication/b00c3803-a940-11e5-b528-01aa75ed71a1

Eurostat. (n.d.b). *Aggregations of manufacturing based on NACE Rev. 2*. Retrieved January 20, 2016, from http://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf

Eurostat. (n.d.a). *Community innovation survey (CIS).* Retrieved January 20, 2016, from http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey

Eurostat. (2016, February 24). *Glossary: Statistical classification of economic activities in the European Community (NACE).* Retrieved October 8, 2016, from http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Statistical_classification_of_economic_activities_in_the_European_Community_(NACE)

Faems, D., De Visser, M., Andries, P., & Van Looy, B. (2010). Technology alliance portfolios and financial performance: Value-enhancing and cost-increasing Effects of open innovation. *Journal of Product Innovation Management*, *27*(6), 785-796. https://doi.org/10.1111/j.1540-5885.2010.00752.x

Faems, D., Van Looy, B., & Debackere, K. (2005). Interorganizational collaboration and innovation: Toward a portfolio approach. *Journal of Product Innovation Management*, *22*(3), 238-250. https://doi.org/10.1111/j.0737-6782.2005.00120.x

Fornell, C., & Larcker, D. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39-50. https://doi.org/10.2307/3151312

Frenz, M., & Ietto-Gillies, G. (2009). The impact on innovation performance of different sources of knowledge: Evidence from the UK community innovation survey. *Research Policy*, *38*(7), 1125-1135. https://doi.org/10.1016/j.respol.2009.05.002

Galindo, M. Á., & Méndez, M. T. (2014). Entrepreneurship, economic growth, and innovation: Are feedback effects at work?. *Journal of Business Research*, *67*(5), 825-829. https://doi.org/10.1016/j.jbusres.2013.11.052

Gelman, A., Carlin, J. B., Stern, H. S., & Rubin, D. B. (2014). *Bayesian data analysis* (Vol. 2). Boca Raton, FL, USA: Chapman & Hall/CRC.

Hagedoorn, J. (1993). Understanding the rationale of strategic technology partnering: Nterorganizational modes of cooperation and sectoral differences. *Strategic Management Journal*, *14*(5), 371-385. https://doi.org/10.1002/smj.4250140505

Hagedoorn, J., & Duysters, G. (2002). Learning in dynamic inter-firm networks: The efficacy of multiple contacts. *Organization Studies*, *23*(4), 525-548. https://doi.org/10.1177/0170840602234002

Hagedoorn, J., & Wang., N. (2012). Is there complementarity or substitutability between internal and external RandD strategies? *Research Policy*, *41*(6), 1072-1083. https://doi.org/10.1016/j.respol.2012.02.012

Hair, J., Black, W., Babin, B., Anderson, R., & Tatham, R. (2006). *Multivariate data analysis*. Upper Saddle River, NJ: Pearson Prentice Hall.

Hall, L. A., & Bagchi-Sem, S. (2007). An analysis of firm-level innovation strategies in the US biotechnology industry. *Technovation*, *27*(1-2), 4-14. https://doi.org/10.1016/j.technovation.2006.07.001

Hallen, B. L., Katila, R., & Rosenberger, J. D. (2014). How do social defenses work? A resource-dependence lens on technology ventures, venture capital investors, and corporate relationships. *Academy of Management Journal*, *57*(4), 1078-1101. https://doi.org/10.5465/amj.2012.0003

Hand, D. J. (1996). Statistics and the theory of measurement. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, *159*(part 3), 445-492. https://doi.org/10.2307/

Hill, C. W. L., & Rothaermel, F. T. (2003). The performance of incumbent firms in the face of radical technological innovation. *The Academy of Management Review*, *28*(2), 257-274. https://doi.org/10.2307/30040712

Hurmelinna-Laukkanen, P., & Puumalainen, K. (2007). Nature and dynamics of appropriability: Strategies for appropriating returns on innovation. *R&D Management*, *37*(2), 95-112. https://doi.org/10.1111/j.1467-9310.2007.00460.x

Kim, L. (1998). Crisis construction and organizational learning: Capability building in catching-up at Hyundai motor. *Organization Science*, *9*(4), 506-521. https://doi.org/10.1287/orsc.9.4.506

Kruschke, J. K., Aguinis, H., & Joo, H. (2012). The time has come: Bayesian methods for data analysis in the organizational sciences. *Organizational Research Methods*, *15*(4), 722-752. https://doi.org/10.1177/1094428112457829

Lee, K., & Lim, C. (2001). Technological regimes, catching-up and leapfrogging: Findings from the Korean industries. *Research Policy*, *30*(3), 459-483. https://doi.org/10.1016/s0048-7333(00)00088-3

Leskovar-Spacapan, G., & Bastic, M. (2007). Differences in organizations' innovation capability in transition economy: Internal aspect of the organizations' strategic orientation. *Technovation*, *27*(9), 533-546. https://doi.org/10.1016/j.technovation.2007.05.012

Lin, C., Wu, Y.-J., Chang, C., Wang, W., & Lee, C.-Y. (2012). The alliance innovation performance of R&D alliances — the absorptive capacity perspective. *Technovation, 32*(5), 282-292. https://doi.org/10.1016/j.technovation.2012.01.004

Lin, C. Y.-Y., Edvinsson, L., Chen, J., & Beding, T. (2013). Impact of the 2008 global financial crisis. In C. Y.-Y. Lin, L. Edvinsson, J. Chen, & T. Beding, *National intellectual capital and the financial crisis in Brazil, Russia, India, China, Korea, and South Africa* (pp. 7-20). New York: Springer-Verlag New York. https://doi.org/10.1007.978-1-4614-6089-3_2

Little, T. D., Bovaird, J. A., & Widaman, K. F. (2006). On the merits of orthogonalizing powered and product terms: Implications for modeling interactions among latent variables. *Structural Equation Modeling: A Multidisciplinary Journal*, *13*(4), 497-519. https://doi.org/10.1207/s15328007sem1304_1

Malhotra, N. K., & Dash, S. (2011). *Marketing research: An applied approach*. London: Pearson Publishing.

Milgrom, P., & Roberts, J. (1995). Complementarities and fit strategy, structure, and organizational change in manufacturing. *Journal of Accounting and Economics*, *19*(2/3), 179-208. https://doi.org/10.1016/0165-4101(94)00382-f

Moutinho, R., Au-Yong-Oliveira, M., Coelho, A., & Manso, J. P. (2015). The role of regional innovation systems (RIS) in translating R&D investments into economic and employment growth. *Journal of Technology Management & Innovation*, *10*(2), 9-23. http://dx.doi.org/10.4067/S0718-27242015000200002

Mowery, D. C., Oxley, J. E., & Silverman, B. S. (1996). Strategic alliances and interfirm knowledge transfer. *Strategic Management Journal*, *17*(S2), 77-91. https://doi.org/10.1002/smj.4250171108

Nunnally, J. (1978). *Psychometric theory*. New York: McGraw-Hill.

Oerlemans, L. A. G., Knoben, J., & Pretorius, M. W. (2013). Alliance portfolio diversity, radical and incremental innovation: The moderating role of technology management. *Technovation*, *33*(6/7), 234-246. https://doi.org/10.1016/j.technovation.2013.02.004

Paula, F. D. O., & Silva, J. F. D. (2017). Innovation performance of Italian manufacturing firms: The effect of internal and external knowledge sources. *European Journal of Innovation Management, 20*(3), 428-445. https://doi.org/10.1108/ejim-12-2016-0119

Pérez-Luño, A., Medina, C. C., Lavado, A. C., & Rodríguez, G. C. (2011). How social capital and knowledge affect innovation. *Journal of Business Research*, *64*(12), 1369-1376. https://doi.org/10.1016/j.jbusres.2011.01.014

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *The Journal of Applied Psychology*, *88*(5), 879-903. https://doi.org/10.1037/0021-9010.88.5.879

Ritala, P., Olander, H., Michailova, S., & Husted, K. (2015). Knowledge sharing, knowledge leaking and relative innovation performance: An empirical study. *Technovation*, *35*(1), 22-31. https://doi.org/10.1016/j.technovation.2014.07.011

Rothaermel, F. T., & Deeds, D. L. (2006). Alliance type, alliance experience and alliance management capability in high-technology ventures. *Journal of Business Venturing*, *21*(4), 429-460. https://doi.org/10.1016/j.jbusvent.2005.02.006

Schilling, M. A. (2015). Technology shocks, technological collaboration, and innovation outcomes. *Organization Science, 26*(3), 668-686. https://doi.org/10.1287/orsc.2015.0970

Schoenmakers, W., & Duysters, G. (2006). Learning in strategic technology alliances. *Technology Analysis & Strategic Management*, *18*(2), 245-264. https://doi.org/10.1080/09537320600624162

Soh, P.-H., & Subramanian, A. M. (2014). When do firms benefit from university-industry RandD collaborations? The implications of firm RandD focus on scientific research and technological recombination. *Journal of Business Venturing*, *29*(6), 807-821. https://doi.org/10.1016/j.jbusvent.2013.11.001

Staehr, K. (2015). Economic growth and convergence in the baltic states: Caught in a middle-income trap? *Intereconomics*, *50*(5), 274-280. https://doi.org/10.1007/s10272-015-0551-1

Stam, E., & Wennberg, K. (2009). The roles of R&D in new firm growth. *Small Business Economics*, *33*(1), 77-89. https://doi.org/10.1007/s11187-009-9183-9

Teece, D. (2007). Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319-1350. https://doi.org/10.1002/smj.640

Terjesen, S., & Patel, P. C. (2017). In search of process innovations: The role of search depth, search breadth, and the industry environment. *Journal of Management*, *43*(5), 1421-1446. https://doi.org/10.1177/0149206315575710

Tomlinson, P. R. (2010). Co-operative ties and innovation: Some new evidence for UK manufacturing. *Research Policy*, *39*(6), 762-775. https://doi.org/10.1016/j.respol.2010.02.010

Tsai, K.-H. (2009). Collaborative networks and product innovation performance: Toward a contingency perspective. *Research Policy*, *38*(5), 765-778. https://doi.org/10.1016/j.respol.2008.12.012

Utterback, J. M., & Abernathy, W. J. (1975). A dynamic model of process and product innovation. *Omega*, *3*(6), 639-656. https://doi.org/10.1016/0305-0483(75)90068-7

Wang, C.-H., & Hsu, L.-C. (2014). Building exploration and exploitation in the high-tech industry: The role of relationship learning. *Technological Forecasting and Social Change*, *81*, 331-340. https://doi.org/10.1016/j.techfore.2013.04.008

Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *The Academy of Management Review*, *27*(2), 185-203. https://doi.org/10.2307/4134351

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