RESEARCH PAPER

The paradox of open innovation in Slovenian firms

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ABSTRACT
Innovation and open innovation are expected to strengthen firm performance. The learning process and inbound activities are particularly important for catch-up countries and firms. The empirical evidence, though, is incomplete and provides inconclusive results. This paper studies the role of open innovation activities in a sample of Slovenian firms. Using a combination of survey data and official registry financial statements data, we investigate the differences in the role of open innovation across firms with different productivity. The results show that open innovation is more important in less productive firms. This is consistent with the theoretical ideas that stress the role of learning, capacity building and knowledge transfer. However, these firms also invest less in open innovation activities, which is a paradox in itself, introducing an important challenge for managers as well as questions for future research.

Introduction

This paper explores the relationship among open innovation in firms, their innovative performance and productivity in Slovenia. The concept of innovation, where companies rely primarily on their internal sources and R&D to support their development process, has changed over the last 15 years, with open innovation increasingly gaining in importance. The paradigm of open innovation was first introduced by Chesbrough (2003) to emphasize the importance of using external sources to stimulate the internal growth of a company. External factors, such as cooperation with partners, the search for externally available sources or scanning for new technologies are seen as important inputs for innovative performance (see Paasi *et al.*, 2013). In open innovation theory, the contribution of such external factors to firm-level innovation is referred to as inbound open innovation activities. While it is characterized mainly by relationships among businesses, it also has clear implications for firms that search for relevant knowledge inputs in relationships with universities (Hughes, 2011). Chesbrough *et al.* (2006) stress the role of outbound activities, where firms can distribute their unused technology, share knowledge or license to promote innovation activity in other firms.

Open innovation is gaining increasing attention in the literature (Bogers *et al.*, 2017), most concentrating on its impact on innovative performance (Zhao *et al.*, 2016). However, empirical research indicates that its complexity and heterogeneity make the effects of open innovation on firm performance hard to investigate (Ahn *et al.*, 2015). In theory, open innovation in firms will increase their overall innovation performance, which either increases value added through better products (product innovation) or lower costs (process innovation). Consequently, open innovation is expected to impact firm productivity positively. Yet, empirical results have been far from unanimous and the topic requires further research (Lopes and de Carvalho, 2018).

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ACCEPTING EDITOR: Martin Meyer

The goal of this paper is to broaden the existing literature by studying the role of the open innovation activities of firms in Slovenia[1] and their relationship with general innovative performance and productivity. Our analysis draws on a survey of open innovation in 220 Slovenian firms. The data were merged with data from registry-based financial statements to obtain a full overview of firm performance. The study examines (1) the characteristics of open innovation in Slovenian firms and possible effect of open innovation activities on firms' general innovative performance, and (2) the effect of open innovation on firm productivity.

The results show that the impact of open innovation on productivity differs by productivity class, with less productive firms exhibiting a larger impact. The results are consistent with the catch-up model: the less advanced have more to learn (see Prašnikar, 2010, for a discussion on Slovenia). Interestingly, these less productive firms also invest less in open innovation activity.

The remainder of the paper consists of five sections. First, we outline the relationship of open innovation, innovation and productivity, based on the review of the existing empirical literature. Then we examine the links among open innovation, innovative performance and productivity of firms in Slovenia. To do this, we first explain the methodology and present some characteristics of the open innovation model in Slovenia. This is followed by the discussion of the empirical model and results on the impact of open innovation on productivity in Slovenia.

Open innovation, innovation and productivity

The impact of open innovation on the capacity of firms to innovate and grow has been a flourishing research topic over the last decade. In this section, we outline the state of research to date. This will serve as the baseline for the development of our model and hypothesis.

The relationship between open innovation and innovation performance

First, we want to analyse the relationship between open innovation and firm innovation performance. Firm innovation performance refers to the success obtained by enterprises through such innovations as new products, technologies and services (Baregheh *et al.*, 2009). A considerable body of literature covers this topic, but the results are mixed. For example, Greco *et al.* (2016) find diminishing marginal returns to open innovation in industrial and economic innovation; Hernandez-Vivanco *et al.* (2018) suggest that open innovation might even hinder innovation efficiency. Analysing data on inbound and outbound open innovation (OI) processes and performances of 110 worldwide top R&D spending bio-pharmaceutical firms, Caputo *et al.* (2016) report a negative effect of open innovation on R&D productivity and revenues to patents (as measures of innovation performance). Patent growth is not influenced by open innovation or its components. Mixed results were also reported by Cheng and Shiu (2015), who estimate a positive impact of inbound activities on radical innovation, but a negative one on incremental innovation, as well as Lazzarotti *et al.* (2010) and Wagner (2013). who estimate the effect of several sources of open innovation on innovation performance. Similarly, Vanhaverbeke *et al.* (2016) discover that OI modes are not always beneficial in enhancing innovation performance.

The relationship between OI and innovation performance is also shown to be non-linear. This means open innovation increases innovation performance only up to a certain point because relying heavily on external technology sourcing also increases costs of search and coordination (e.g., Katila and Ahuja, 2002). Laursen and Salter (2006) confirm in their study of 2707 British manufacturers that there may be a cut-off point at which openness can generate a negative impact

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[1]Slovenia is a small open economy which has relied on the export-led model of growth since gaining its independence in 1991. Exports were roughly 86% of GDP in 2020 (Statistical Office of the Republic of Slovenia, 2021).

on innovation performance. Berchicci (2013) comes to the same conclusion, while Caputo *et al.* (2016) could not confirm this hypothesis.

On the other hand, many other contributions report a positive effect of different open innovation activities on innovation performance, including, for example, Harison and Koski (2008), studying the impact of open-source software; and Chiang and Hung (2010) and Ebersberger *et al.* (2012), who find a strong positive impact of OI both on the capacity for novel innovation and on actual innovation). Examining innovation activities in 2,743 Korean enterprises, Lee *et al.* (2010) find that SMEs can share funds and risks via an intermediated network model to achieve rapid and flexible production as well as enter new markets. Ito and Tanaka (2013) report a positive relationship between technology transfer and innovation in Japan. In a recent survey of 236 manufacturing SMEs in China, Lu *et al.* (2020) show that both OI breadth and depth are positively related to the innovation of SMEs. Finally, in their review of the open innovation performance literature, Zhao *et al.* (2016) find that the vast majority of empirical studies estimate a positive relationship between open innovation and innovative performance of firm (13 positive and three inverse U-shaped relationships).

Open innovation and firm performance

Our second key research question is the link between open innovation and firm performance. According to the World Intellectual Property Report (WIPO, 2011), studies systematically show that innovation explains up to 80% of productivity growth and productivity growth is the main driver of output growth in developed countries. The strong and positive relationship between productivity and innovation can be explained through openness, knowledge and information transfer (e.g., Love *et al.*, 2011), consequent competitive drive for investment in R&D (Ghosal and Nair-Reichert, 2009), enhancement of the knowledge base (Jensen, 2007) and other internal and external factors, such as sales and employment (Vega-Jurado *et al.*, 2008). Since open innovation is a part of firms' innovation activities, we could expect the positive relationship to apply in this case too. However, extensive research over the last decade reports mixed results. In their recent meta-analysis based on 171 studies published between 2003 and 2018 and a dataset of 2,377,123 firms and sub-firm units, Nguyen *et al.* (2021) attribute the non-uniform OI–performance relationship to three key factors: performance measure, OI approach and level of analysis.

Most of the available research points to a positive impact of open innovation on firm performance, such as the ability to increase return on sales (Lichtenthaler, 2009) and sales growth (Chaston and Scott, 2012). Examining SMEs in the Chinese service sector more recently, Vincenzi and da Cunha (2021) conclude that companies with a greater orientation toward open innovation score better in terms of net sales per employee. The results are also dependent on the mode of open innovation. Studying Korean innovative SMEs, Ahn *et al.* (2015) report that broad and intensive engagement in OI and cooperation with external partners are positively associated with firm performance, as is joint R&D and market sourcing, but not all OI modes exhibit a positive impact. Similarly, Mazzola *et al.* (2012), examining the effect of twelve different OI modes, report a positive impact on firm financial performance for the majority, but also point to insignificant and negative results.

Other studies discovered a non-linear relationship between specific OI modes and firm performance. Hwang and Lee (2010) find a U-relationship between external search breadth and productivity while the effect of OI depth revealed an inverse U-relationship. Ahn *et al.* (2013) find four OI capacities positively associated with sales, while connective and innovative capacity are negatively associated. Similarly, Caputo *et al.* (2016) observe an inverted U-relationship between inbound open innovation activities and operating profit, while the outbound innovation is U-shaped. On the other hand, Noh (2015), studying the effect of open innovation announcements made by 671 firms, concludes that open innovation activities of firms have a positive effect on even their long-term profitability, production process and market benefits. Finally, a recent review by Bigliardi *et al.* (2020) concludes that the impact of open innovation was positive for the majority of firms.

Methodology and data

Data collection and sample structure

The analysis of open innovation and its relationship with overall innovation performance in Slovenia relies on a combination of survey data and firm balance sheet and profit and loss data for the period between 2014 and 2020. The questionnaire for the study of innovation activities in Slovenian firms was based on the Open Innovation Network[2] survey, supplemented by a questionnaire on intangible assets (Prašnikar, 2010; Prašnikar *et al.*, 2012; Prašnikar and Knežević Cvelbar, 2012). The questionnaire with the descriptive statistics is available in the Appendix and briefly described here. The first two questions addressed open innovation activities in the firm (13 in total), examining which activities were being conducted (q.1) and which should, in the opinion of firms, be intensified (q.2). The third question dealt with the problem of building open innovation competencies in the firm (q.3). The current state of open innovation was measured separately (q.5). Innovation success was measured by several different variables, namely by innovative performance of the company (q.4), number of innovations and their novelty (q.6), product innovation (q.7), product launch (q.8), ways of conducting product innovation (q.9) and success in process innovation (q.10).

The data were collected in autumn 2014 with the assistance of the Chamber of Commerce and Industry of Slovenia, using an online questionnaire sent to 2,076 companies. In total, 446 companies responded, 212 surveys were completed, representing a 10.2% response rate. Innovation differences by both firm size and industry were also considered. There were 73 micro-firms, 80 small, 33 medium and 19 large companies.[3] Manufacturing firms dominated in the sample (64 firms), followed by trade (42) and professional services (26). The sample also comprised firms from transport, construction, ICT, agriculture, utilities, tourism, finance and education. In no case did the number of firms from these other sectors exceed 20. In order to investigate the open innovation and innovation results, we constructed new variables, presented in Table 1.

In a second step, survey data were merged with financial statements data provided by Agencija Republike Slovenije Za Javnopravne Evidence In Storitve (2021), which include complete financial records for the whole population of firms. In total, between 198 and 225 firms were included in the empirical analysis in the period between 2014 and 2020.

Empirical strategy

To investigate whether there is a relationship between productivity and open innovation activities as well as activities that support open innovation, a quantile regression was used. The choice of methodology is also supported by the fact that the distribution of value added per employee (and value added in general) is not normal, but skewed (a mean value added per employee of €26,148 and standard deviation of €36,376). The methodological literature (Koenker and Hallock, 2001) claims that skewness is an argument for applying quantile regression, in that quantile regression facilitates the use of an 'individualized' approach to each group of productivity along the

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[2]The Open Innovation Network was a European-financed project that studies the characteristics of open innovation in partner countries, 15 in total. More about the project can be found on the project's website: http://www.oi-net.eu/. The data collection was partly financed from the EU project (https://oi-net.eu/).

[3]A micro company is defined as a company that meets at least two of the following three criteria: average number of employees in the specified year does not exceed ten, revenues do not exceed €2 million, balance sheet value does not exceed €2 million. A small company is defined as a company that meets at least two of the following three criteria: average number of employees in the specified year does not exceed 50, revenues do not exceed €7.3 million, balance sheet value does not exceed €3.65 million. A medium company is defined as a company that meets at least two of the following three criteria: average number of employees in the specified year does not exceed 250, revenues do not exceed €29.2 million, balance sheet value does not exceed €14.6 million. A large company is neither a micro, small or medium one (*Zakon o gospodarskih družbah*, ZGD-1, 2006).

Table 1. Open innovation and innovation result variable composition

	Variable composition
OI_1 (broad open innovation variable)	Average value of answers to ○ Q1l external technologies acquisition ○ Q1h participating in standardisation ○ Q3c the borders of our company are open for knowledge flow … ○ Q3k we apply interactive collaboration … to facilitate OI ○ Q3m our competitive advantage lies in collaborating with external partners ○ Q3n we have sufficient knowledge to compete in our marketplace ○ Q3o (top) management strongly supports open innovation activities …
OI_2 (narrow open innovation variable)	Average value of answers to ○ Q1l external technologies acquisition ○ Q3c the borders of our company are open for knowledge flow … ○ Q3o (top) management strongly supports open innovation activities …
Product innovation P_IN	Cascade prepared from answers to Q6: 1–4 (1 if all 0, plus one for each additional Yes (see Prašnikar, 2010) ○ significant number new to relevant market ○ majority of them new to the market ○ also novelty in the global markets
Process innovation PR_IN	Sum of answers to questions Q10a–d: values 0–4, each Yes (1) or No (0) ○ introduced process innovation in past 5 years ○ improved production processes ○ improved logistics, delivery, distribution ○ improved support services (maintenance, sales, IT, accounting etc.)

distribution by using a weighted variance-covariance matrix (Koenker and Hallock, 2001; Koenker, 2005). But the most important argument for using quantile regression in this case is provided by the descriptive statistics. It seems that the importance of open innovation activities and activities related to open innovation might differ in various productivity groups.[4]

Two different specifications were used. In accordance with the methodology of Segarra Blasco and Teruel Carrizosa (2008), the conditional quantile is determined as a linear combination of covariates. The dependent variable (y) is determined by vector x of independent variables, where β_θ represents a vector of regression coefficients for each quantile and $\varepsilon_{\theta i}$ are the error terms (equation *1*). First sales were used as the dependent variable (y). Since sales were used, the material costs were added to the RHS of the equation to obtain the value added. The sum of absolute deviations is minimized (in contrast with OLS). As the second dependent variable value added per employee was used.

$$y_i = x'\beta_\theta + \varepsilon_{\theta i} \tag{1}$$

Vector *x*, representing the explanatory variables, was composed based on variables suggested by economic theory and the aforementioned innovation results. According to the production function ($Y = f(K,L)$), production per worker depends on capital per worker. To control for size, employment was used. In addition, we were interested in the contribution or impact of open innovation activities. To measure innovation, we employed several possible specifications. Four variables were used (Table 2). Industry was controlled for. To test for differences in the importance of factors for productivity, primarily the importance of factors linked to innovation and open innovation, an

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[4]This methodology was also used in a study of innovative property in relation to intangible capital and productivity in Slovenia by Prašnikar *et al*. (2017). In this case, it was found that the choice of methodology was good: the impact of explanatory variables indeed differed, including in the case of innovation (but that was a standard innovation theory).

interquartile regression was used. Following the specifications (Davino *et al.*, 2013), an interquantile model with two independent variables would have the following specification:

$$Q_{.25}(y) = a_{.25} + b_{1,.25}x_1 + b_{1,.25}x_2 \qquad (2)$$

$$Q_{.75}(y) = a_{.75} + b_{1,.75}x_1 + b_{1,.75}x_2 \qquad (3)$$

The interquantile regression is based on estimating the differences between the coefficients in these two quantiles:

$$Q_{.75}(y) - Q_{.25}(y) = (a_{.75} + b_{1,.75}x_1 + b_{1,.75}x_2) - (a_{.75} + b_{1,.75}x_1 + b_{1,.75}x_2) \qquad (4)$$

In the estimation, a log specification was used with the following variables:

- Sales: sales per company
- Value added per employee: sales-material costs
- Number of employees
- Or log of employees
- Material costs (also in log form)
- Industry dummies (the companies were divided into six categories: agriculture, manufacturing, retail, business services, public services and other services)
- Size dummies

Results

Slovenian companies differ in the intensity of their innovation inputs and activity as well as in their innovation output or innovation performance. While one group of companies invests significantly in innovation and R&D activities and strategically supports them (both process and product innovation), other companies approach innovation with less ambition. Those working in lower value-added industries and competing primarily on costs invest less in systematic support for innovation, focus more on process innovation and also invest less in their employees (Prašnikar, 2010; Prašnikar *et al.*, 2017).

Open innovation in Slovenian firms

Figure 1 shows that Slovenian companies focus mainly on inbound activities (scanning for external ideas, acquiring external technologies, collaborating on innovation with external partners, using external networks). This (anticipated) result is a consequence of orientation to developed markets, but it also reflects these companies operating as suppliers within strong international production chains. Results also show that more productive firms are more active in open innovation activities in general. The most productive quartile stands out in particular in the acquisition of external technologies and using external networks, while the bottom two quartiles generally lag behind. In contrast, the outbound activities needed to stimulate knowledge transfer are less relevant in Slovenian companies. However, the companies report their intention to increase their outbound activities, which would benefit the general innovative performance of firms in Slovenia.

These findings are not surprising for at least two reasons. First, Slovenia is a catching-up economy with per capita GDP at purchasing power parity of 74% of the EU average (Eurostat, 2021). In addition, it is a very open economy; exports represent around 86% of its GDP, with the majority of exports going to the EU, primarily Germany, Austria and Italy (Eurostat, 2021), where firms often act as suppliers to large international manufacturing chains (e.g., the automotive industry) and are highly exposed to advanced external knowledge sources, having a significant opportunity to absorb and learn and innovate based on information from developed external markets (Porter, 1990; Stiglitz and Greenwald, 2014; Forbes and Wield, 2000).
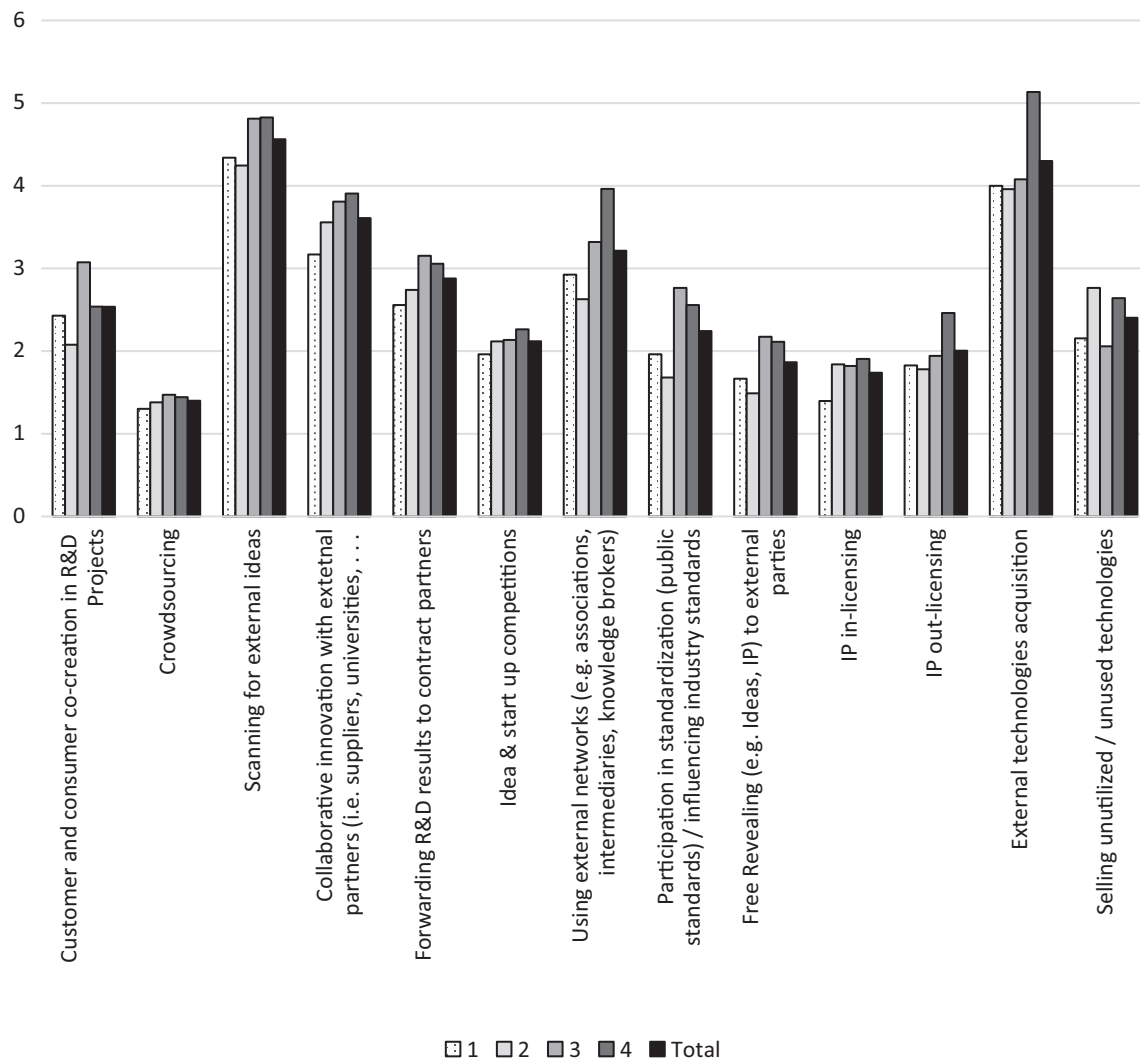
Figure 1. Open innovation activities in firms by productivity quartile (1-4) and in total: the intensity of using a selected open innovation activity evaluated on a 1–7 scale

The scale is 1–7, where 1 means strongly disagree and 7 strongly agree. The value 0 is assigned to do not know. However, the value 0 (do not know) was excluded from the calculation of averages.

Firms generally support the implementation of open innovation (OI) activities (Table 2). These support activities spanning from educating employees about OI, general training for employees to keeping the company open to available outside knowledge. In particular, external sourcing, a strategically positive attitude and support for innovation were found to be relevant (see Prašnikar *et al.*, 2017). In Slovenia, firms differ in their support for open innovation activities, but among the activities of most importance are those that relate to obtaining and utilizing external knowledge.

Interestingly, less productive quartiles give less attention to open innovation activities. Firms try to accept new ideas and disseminate them in the firms. The companies are also quite assured in their abilities, as revealed by their confidence in being able to compete in their marketplace. Even the lower two quartiles are quite confident in their abilities. Moreover, firms believe that employees have a positive attitude to externally obtained knowledge absorbed in their products (again, inward activities) and (importantly) firms also accept the risks related to absorbing ideas from the outside. Collaboration with external partners and the support of top management are also very important. Again, all these activities are less supported in the less productive firms.

Table 2. Activities firms undertake to support the open innovation model: the intensity of use evaluated on a 1–7 scale

Open innovation support activity by / quartile	1	2	3	4	Total
We provide education and training on open innovation for our employees.	4.07	4.16	4.59	4.86	4.43
Open innovation skills and awareness are fostered within our organization.	4.06	4.12	4.44	4.87	4.38
The borders of our company are open for knowledge flow from outside-in and from inside-out.	4.85	4.77	5.01	5.32	**5.00**
New external ideas are easily accepted and disseminated in our organization.	5.34	5.20	5.51	5.84	**5.48**
Relevant departments are actively participating in knowledge sourcing and knowledge sourcing.	4.45	4.56	4.88	5.18	4.78
We accept the possibility of mistakes in external knowledge sourcing.	4.87	5.03	5.28	5.53	**5.18**
Our employees have positive attitudes for applying ideas and technologies from outside the company.	4.92	4.99	5.26	5.46	**5.16**
Our employees have positive attitude to having other companies receiving and using our knowledge and technologies.	4.77	4.73	4.90	4.85	4.82
Open innovation activities of our employees are rewarded.	4.09	4.15	4.40	4.36	4.25
Organizational structure in our company is designed according to our needs to be open.	4.44	4.55	4.69	5.05	4.69
We apply interactive collaboration tools and methods to facilitate open innovation.	4.09	3.86	4.06	4.33	4.10
Externally obtained knowledge is integrated into our products, processes and services.	4.98	4.78	5.31	5.57	**5.17**
Our competitive advantage lies in collaborating with external partners.	4.75	4.70	5.20	5.59	**5.07**
We have sufficient knowledge in our organization to compete in our marketplace.	5.07	5.00	5.27	5.83	**5.31**
(Top) management strongly supports open innovation activities (by allocation enough resources).	4.75	4.91	5.14	5.37	**5.05**
Average	4.63	4.63	4.93	5.20	4.86

The scale is 1–7, where 1 means strongly disagree and 7 strongly agree. The value 0 is assigned to do not know. However, the value 0 (do not know) is excluded from the calculation of averages.

While it is not necessary that firms which engage in more open innovation activities are also more innovative, the literature shows that open innovation is positively correlated with innovation. Generally, the results show that Slovenian firms are quite innovative. More than half of respondents had introduced a significant number of new products/services to their target market in the previous five years, in 45% of firms the introduced products were new not just to the firms but also to the relevant markets and in 20% of firms the products were also global novelties.[5] The most productive quartile stands out as almost 60% introduced novelties to relevant markets, and a quarter also novelties to global markets. Interestingly, the third quartile does not lag far behind.

Table 3 presents the relationship between the open innovation activities that support the open innovation model (Figure 1) and an innovation performance indicator which measures the introduction of new products. The innovation performance indicator was calculated from a cascading set of

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[5]Compared with our previous research (Prašnikar *et al.,* 2017), the percentages are slightly lower in this case. In the earlier research, we focused on 100 companies from the population of the 400 biggest Slovenian companies. The larger firms are more innovative and consequently the innovation results (new products) are also better: 84%, 56% and 28% respectively for the same questions. Because of space limitations, descriptive statistics by size etc. are not included, but are available in Farčnik *et al.* (2014).
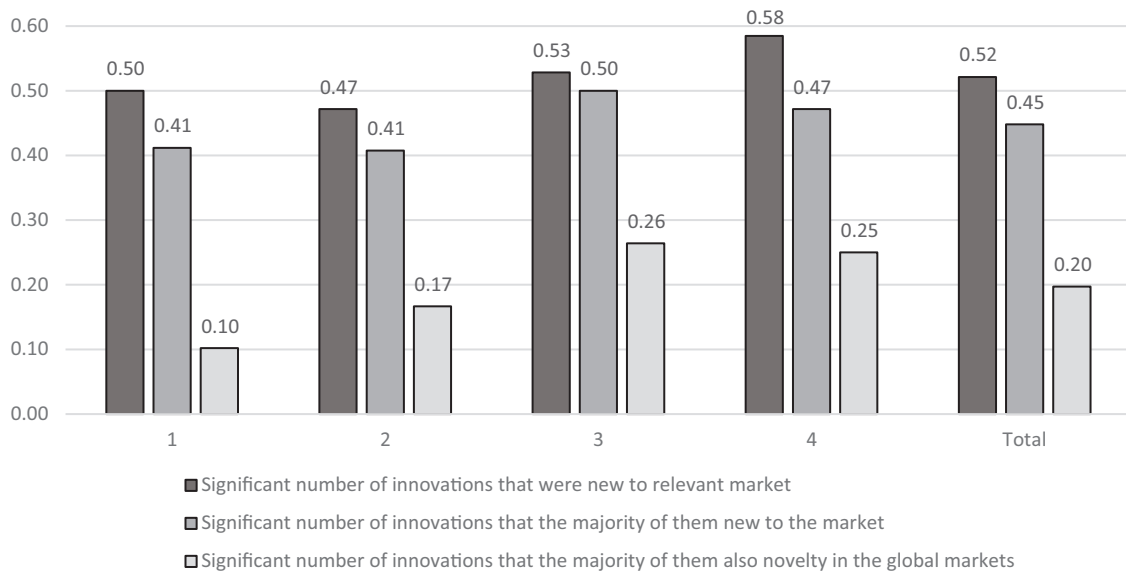
Figure 2. Introducing new products to target market: percentage of firms replying positively (yes) (Q13) by productivity quartile

Table 3. Innovation performance and open innovation: chi^2*

	(Q13) Innovation performance indicator: introduction of new products (chi^2)	p-value
Q1l External technology acquisition	52.4114	0.000
Q1h Participating in standardisation	42.5903	0.004
Q1c The borders of our company are open for knowledge flow from outside-in and from inside-out	26.8585	0.082
Q1k We apply interactive collaboration tools and methods to facilitate open innovation	26.1483	0.096
Q1m Our competitive advantage lies in collaborating with external partners	29.8669	0.039
Q1n We have sufficient knowledge in our organisation to compete in our marketplace	26.9867	0.079
Q1o (Top) management strongly supports open innovation activities (by allocating enough resources)	32.1607	0.021

N=197–207 (not all companies answered all questions)

*Chi^2 is calculated to assess the relationship between the innovation result (introduction of new products, Q6) and open innovation activities (in the first column).

questions (Figure 2) and by applying the Miyagawa (2010) transformation.[6] Chi^2 and its significance is presented in the last two columns. The results reveal that open innovation is related to general innovation performance.

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[6]According to Miyagawa *et al.* (2010), a cascading variable, scaled 1–4, is calculated by increasing the value of the variable by 1 for each consecutive Yes answer. The initial value of *1* represented the fact that the company did not introduce a significant number of new products in its own market, *2* that it did, *3* that the products were new to the relevant market, while *4* indicates they were also globally new.

Open innovation and productivity: quantile regression approach

Open innovation activities are related to general innovative output. Since the literature relates innovation to productivity, we are interested in whether open innovation activities are related to productivity. In the productivity literature, innovation is expected to be closely related to productivity because it increases value added, but empirical results do not always confirm this relationship at a level of significance due to econometric and measurement issues (see Hall, 2011, for an extensive discussion).

   To analyse the relationship between open innovation activities and productivity, we first divide companies by productivity into four groups (quartiles) in order to examine very descriptively the relationships between the two variables in question. Productivity was calculated as value added per employee. As the reference year, data for 2013 were used.

   Table 4 presents the groups' descriptive statistics for 2013 and results of the survey questions. Interestingly, the biggest companies have the lowest value added per employee, while the highest value added is produced by companies with 70 to 90 employees on average. In addition, Table 4 presents the results of the test of differences between the value added per employee group, and selected indicators of open innovation activity and activities supporting open innovation in companies. The selection was based on the strength and significance of open innovation activity for innovation in general. Chi^2 and its significance are presented in the last two columns. The results indicate that in fact there might be a relationship between open innovation activities and productivity.

Table 4. Descriptive statistics for quantiles and the relationship between corporate performance (value added per employee) and open innovation: chi^2*

Variables/quantiles	Quantile 1	Quantile 2	Quantile 3	Quantile 4	Value added (chi^2)	p-value
average sales per employee (EUR)	81472	108376	130769	305501		
average capital per employee (EUR)	76652	102218	116046	311215		
average value added per employee (EUR)	12054	26334	35383	78232		
average number of employees	42.7	151.5	131.0	79.9		
Q1l external technology acquisition	4.0	4.8	4.1	4.4	30.48	0.083
Q1h participating in standardisation	2.2	2.0	2.2	2.6	26.53	0.187
Q3c the borders of our company are open for knowledge flow …	5.0	5.1	5.4	4.6	25.29	0.117
Q3k we apply interactive collaboration … to facilitate OI	4.1	4.1	4.3	4.0	23.02	0.190
Q3m our competitive advantage lies in collaborating with external ...	4.7	5.0	5.4	5.3	27.42	0.129
Q3n we have sufficient knowledge to compete in our marketplace	4.9	5.2	5.7	5.4	24.87	0.129
Q3o (top) management strongly supports open innovation activities …	4.7	5.2	5.5	4.9	38.38	0.003

*N=197–207 (not all companies answered all questions). Descriptive statistics on key performance indicators include averages for the entire observed period (2014-2020).

Table 5 presents the results of eight varying model specifications with two different dependent variables: sales and value added per employee. The coefficients present the differences in the coefficients between the 75th and 25th percentile, which should be considered when interpreting the coefficients. The results show that more productive firms (the 75th compared with the 25th percentile) have a stronger impact of capital, regardless of whether it is measured as per employee or in total. In all cases, the impact of capital is significantly stronger in more productive firms. On the other hand, labour is significantly less important in more productive firms. This result overall implies that less productive firms are more labour intensive, which is to be expected. In the study of the impact of value added, exports are more important in more productive firms; however, differences are not always significant.

The impact of open innovation was measured using two specifications, broader (open innovation 1) and narrower (open innovation 2). Open innovation also has a larger coefficient in less productive firms and the difference is significant. This implies that the exposure to outside information and knowledge (because the inward component of open innovation prevails in Slovenian firms and was thus also used in creation of the variables) has a more important impact in less productive firms. Both the narrower definition (open innovation 2 variable), which stresses the importance of

Table 5. Open innovation and innovation result variable composition

	Log sales	Log sales	Log sales	Log value added per employee	Log value added per employee	Log value added per employee
Log of material cost	−0.0863***	−0.0986***	−0.0977***			
	(0.0209)	(0.0208)	(0.0193)			
Log of capital	0.253***	0.252***	0.258***			
	(0.0340)	(0.0376)	(0.0419)			
Log of employment	−0.205***	−0.182***	−0.217***			
	(0.0397)	(0.0442)	(0.0460)			
Log of capital per worker				0.0907***	0.101***	0.103***
				(0.0342)	(0.0328)	(0.0299)
				0.179**	0.0998	0.126
Exports share				(0.0738)	(0.0984)	(0.0770)
Open innovation 2	−0.0470**		−0.0625***	−0.0361*		
	(0.0197)		(0.0241)	(0.0212)		
Open innovation 1		−0.0443**			−0.0645**	
		(0.0208)			(0.0273)	
Product innovation			0.0316			−0.0607***
			(0.0252)			(0.0190)
Process innovation			0.00435			0.0121
			(0.0148)			(0.0119)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Size dummy	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−1.188***	−1.076*	−1.121**	−0.654	1.173	−0.891
	(0.426)	(0.582)	(0.534)	(0.929)	(1.015)	(0.807)
Observations	1,234	1,147	1,234	533	494	616
Standard errors in parentheses						

*** p<0.01, ** p<0.05, * p<0.0
Source: Authors' calculation

external sources and management's support for open innovation, and the broader definition of open innovation (open innovation 1), which also focuses on collaboration, lead to similar conclusions, suggesting that open innovation is more important in less productive firms.

In addition, to capture the impact of actual innovation (because open innovation activities are only a support to generating actual innovation), we tested the impact of product and process innovation on sales and value added. The differences are not significant. This result could suggest the importance of innovation activity regardless of productivity quartile. And if combined with the stronger role of open innovation in less productive firms, this speaks in favour of strengthening open innovation activities in such firms, where their contribution is bigger (and also enhances innovative activity).

Discussion

Contributions

This study adds to the body of literature on open innovation in several ways. First, it extends the evidence on the relationship between innovative performance and open innovation activities, where studies have so far reported mixed results. Second, it introduces the analysis of the relative importance of open innovation for differently successful firms. As already stressed in Kim (1997) and Forbes and Wield (2000), knowledge transfer is important and can help firms grow and improve. Open innovation, especially the more utilized inbound practices, knowledge transfer and absorption, is key to catching up. Our results confirm that open innovation practices are in fact significantly more important in laggard firms. Third, the study relies on a combination of survey data, accompanied by detailed financial statement data, which provide very reliable performance indicators. Fourth, the paper studies the case of Slovenia, a small, export-oriented economy, catching up with the most developed in the EU. This catch-up has been stimulated by knowledge transfer and cooperation in global value chains, especially in firms where systematic promotion of knowledge transfer and complementary strengthening of company's competences have been supported by management (Prašnikar *et al*., 2017). This carries an important message for other similar catch-up regions and companies.

Implications

The results reveal that open innovation is particularly important for catch-up firms. The link remains under-investigated in the literature, and the existing body of literature offers inconclusive results. Our analysis focuses on the differences between less and more productive firms. The results also show that less productive firms are less active in open innovation activity, although the literature stresses the importance of inbound activities, knowledge transfer and learning (Forbes and Wield, 2000). Although the body of literature does not unanimously confirm that open innovation practices have a positive impact on innovation performance (Wagner, 2013; Cheng and Shiu, 2015; Caputo *et al*., 2016), our results suggest that they do. In addition, development literature has confirmed a number of times the importance of knowledge transfer. Even if results on the actual innovation performance are mixed (with our discussion adding to the positive impact), managers should consider the benefits of open innovation practices and stimulate them. This is particularly so not only because less productive, laggard firms do not rely so much on open innovation practices, but also because open innovation, according to our empirical results, contributes more to such firms' performance than in more productive firms.

Limitations and challenges for future research

Innovation, and open innovation in particular, are challenging in empirical research, especially because of the lack of reliable systematic data that would allow either comparative or panel research.

In addition, survey data usually rely on smaller samples, not population data, which makes generalization of results much harder. Although the results here show that open innovation is more important for less productive firms, it would be interesting to form an efficient panel that would allow monitoring firms over a longer period of time. A cross-country comparison could add to the reliability and generalization of the results. In addition, the transmission mechanism from open innovation to actual innovation should be investigated further, especially in view of firms' absorptive capacity and their technological competencies (Prašnikar *et al.*, 2017). Research shows that the more productive firms invest more in complementary resources, which allows them to distil strong results. In particular, this includes managerial attitudes, which could help explain the paradox that, while open innovation is important for productivity, the support to innovation activity is weaker in less productive firms.

Conclusions

The paper discussed the characteristics of open innovation activities in a sample of Slovenian firms, based on survey data combined with financial statement data. The results reveal that open innovation practices are currently important in Slovenia, especially their inward component. Firms are very active in absorbing available sources, information, knowledge and technology from the outside. This is also to be expected as a result of the Slovenian economy's relative development compared with its target markets (exports to developed EU states). Moreover, it is a positive result, given the fact that learning can contribute strongly to actual innovation and productivity.

The empirical analysis indicates the greater importance of learning for the less productive firms in the sample, which is consistent with the above result. In addition, it is important to note that the variable on open innovation comprises managerial support for open innovation, which was also found to be important. The result is consistent with Prašnikar *et al.* (2017) concerning the relationship between competence building in the firm, the absorption of knowledge and innovation. This relationship presents a challenge for future research.

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Appendix

Table A1. Questionnaire with descriptive statistics

Q1: Do you carry out the following activities in your company? (0 no activity to 7 very intensively)

Activity	Companies reporting activity (n)	Mean	Sd
Customer and consumer co-creation in R&D projects	96	3.26	1.96
Crowdsourcing	28	2.46	1.90
Scanning for external ideas	171	4.17	1.93
Collaborative innovation with external partners (i.e., suppliers, universities, competitors …)	147	3.61	2.05

(Continued)

(Continued)

Activity	Companies reporting activity (n)	Mean	Sd
Forwarding R&D results to contract partners	119	3.14	1.87
Idea and start up competitions	82	2.78	1.85
Using external networks (e.g., associations, intermediaries, knowledge brokers)	135	3.38	1.79
Participation in standardization (public standards)/influencing industry standards	82	2.91	1.81
Free revealing (e.g., ideas, IP) to external parties	69	2.62	1.82
IP in-licensing	54	2.83	1.93
IP out-licensing	66	3.00	1.84
External technologies acquisition	154	4.25	1.88
Selling unutilized/unused technologies	96	3.02	1.95

Q2: Which of the following activities should you reduce or increase? (1 significantly reduce, 5 significantly increase)

Activity	Mean	Sd
Customer and consumer co-creation in R&D projects	3.69	0.80
Crowdsourcing	3.37	0.75
Scanning for external ideas	4.10	0.78
Collaborative innovation with external partners (i.e., suppliers, universities, competitors …)	3.90	0.75
Forwarding R&D results to contract partners	3.39	0.71
Idea and start up competitions	3.64	0.77
Using external networks (e.g., associations, intermediaries, knowledge brokers)	3.83	0.74
Participation in standardization (public standards)/influencing industry standards	3.43	0.74
Free revealing (e.g., ideas, IP) to external parties	3.43	0.69
IP in-licensing	3.32	0.66
IP out-licensing	3.36	0.69
External technologies acquisition	4.03	0.79
Selling unutilized/unused technologies	3.59	0.80

Q3: Please indicate to what level you agree with the following statements. (1 completely disagree, 7 completely agree, do not know missing)

Statements	Mean	Sd
We provide education and training on open innovation for our employees	4.39	1.77
Open innovation skills and awareness are fostered within our organization	4.37	1.74
The borders of our company are open for knowledge flow from outside-in and from inside-out	4.96	1.51
New external ideas are easily accepted and disseminated in our organization	5.45	1.25
Relevant departments are actively participating in knowledge sourcing and knowledge sourcing	4.74	1.56
We accept the possibility of mistakes in external knowledge sourcing	5.17	1.40
Our employees have positive attitudes for applying ideas and technologies from outside the company	5.15	1.19
Our employees have positive attitude to having other companies receiving and using our knowledge and technologies	4.79	1.32
Open innovation activities of our employees are rewarded	4.28	1.63

Statements	Mean	Sd
Organizational structure in our company is designed according to our needs to be open	4.68	1.63
We apply interactive collaboration tools and methods to facilitate open innovation	4.11	1.59
Externally obtained knowledge is integrated into our products, processes and services	5.18	1.45
Our competitive advantage lies in collaborating with external partners	5.07	1.47
We have sufficient knowledge in our organization to compete in our marketplace	5.29	1.43
(Top) management strongly supports open innovation activities (by allocation enough resources)	5.07	1.46

Q4: Please asses the innovative performance of the company in the last three years. (1 - significantly decrease, 5 - significantly increase)

	Mean	Sd
Success of brand new or significantly improved products and service development	3.94	0.91
Risks of innovative activities (risks on a financial, technological and market basis)	3.61	1.04
Time to develop new products and services	3.60	1.07
Acceptance of innovative products and services in the market	3.79	0.94
Return on investment (ROI) of innovative activities	3.73	1.16

Q5: Please rate your current state of open innovation. Choose one of the options.

	Share (%)
We have not adopted/introduced an open innovation model and we do not plan to do so	64.89
We do not currently use the open innovation model, but we plan to introduce it in the near future	22.87
We are at an early stage of introducing the activities of the open innovation model	5.32
We are in the process of designing open innovation model activities and designing programmes that will help establish OI best practices	2.66
We are experienced users of the open innovation model (processes, procedures and best practices are already underway)	3.72
We carried out the activities of the open innovation model, but decided to discontinue use	0.53