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Assessing the Relationship between Firm Collaboration, Trade Publications, Patent Publications and Firm Innovation Performance: Knowledge Production Function Perspective.

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Abstract
Current studies acknowledge that firms' knowledge sources spur innovation performance and economic growth in emerging European economies. A study on which firms' knowledge sources and the context in which the sourced knowledge impacts firm innovation performance is under-explored. Our study draws on the axioms of the knowledge production function, the logistic regression method, the two-stage least square robust method and data from the Community Innovation Survey 2018 to analyse the relationship between firm knowledge sources (firm collaboration, patent publication and trade publication) and innovation performance moderated by government funding. For our study, we sampled 89605 micro and medium firms, mainly from emerging European economies. We found that (i) trade and patent publications positively and significantly impact product and process innovations, but the effect is stronger on process innovation compared to product innovation; (ii) intellectual property acquisition from universities negatively impacts product and process innovations in the average countries, but the effect was positive for economically limited countries; (iii) government funding positively and significantly moderates the impact of firm general collaboration on intellectual property and innovation performance. The moderation effect was more substantial in economically limited countries than in economically averaged countries for product and process innovations. We further discussed implications for practice, theory, and policy.

Keywords
Trade publications; Patent publications; Intellectual property rights; Innovations; Government funding

JEL Classification
O31, O32, O34, O36, O52

Introduction

The determinants of the knowledge production function are a knowledge hub for firm innovation (Link & Scott, 2021). Knowledge acquisition, management, and transfers are crucial for firm innovation enhancement (Prokop & Stejskal, 2015; Radicic et al., 2020). Several factors influence the exploitation of knowledge production function as a knowledge source to harness firm innovation performance. They include firm collaboration, patent publications and trade publications. Prior studies have established the relevance of new knowledge in collaborating with other firms and public institutions (Haus-Reve et al., 2019). Park et al. (2020) argue that some firms' smallness (market size, technical abilities, and funding capacity) prevents them from collaborating with other firms and public institutions. This situation mainly affects micro and medium firms and hinders them from benefiting from the prospects of firm collaborations. Patent publications and trade publications have gained much attention in the innovation literature. They remain a great source of new knowledge for firms (Ndubuisi, 2020). The challenge is that most micro and medium-sized firms cannot benefit from trade and patent publications due to a lack of membership in trade and industry associations (25%-30 % and 50%-60% of SMEs are members of trade associations in the USA and Europe, respectively) and lack of capacity to access trade publications (Ghauri et al., 2021). This issue is due to the complexity of patent documents, lack of expertise, cost of accessing the patent databases, and lack of awareness of the benefits of trade associations. Current studies have acknowledged how critical knowledge sourcing could create an enabling climate for innovation activities.

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However, existing studies in firm collaboration, trade publications, patent publications and innovation are fraught with setbacks that must be addressed. Odei and Hamplová (2022) examined the effect of firm collaboration on firm innovation performance in the Czech Republic. They found that innovation collaborations promote major and minor innovations among small businesses in the Czech Republic. However, they used single-country analysis, did not consider the role of the knowledge production function, and did not consider contingent factors that could impact the established relationship. Studies on patent publication and innovation present contradictory conclusions. Patent publications diffuse knowledge globally, reduce technology duplications, and spur innovation (Hegde et al., 2023). On the other hand, patent disclosures have an insignificant impact on innovation and R&D spillovers (Roin, 2005). Although this study acknowledged the value of firm collaboration and publications (patent and trade) in innovation performance, the issue of contingent factors, internal and external to the firm, which can affect the relationship, is not addressed. Contingent factors refer to internal and external contextual factors in the firm's business environment, potentially influencing the firm's knowledge-based activities for innovation performance (Brandon-Jones et al., 2014). Firms' operational excellence is contingent on the internal and external context of the business environment (Ahmed, 2020). Prior studies use firm collaboration, patent, and trade publications to study innovation without considering the perspective of knowledge production function and overemphasising single-country analysis. This does not reveal the effect of substitutability and combination of firm collaboration, patent, and trade publications on innovation. A study involving several countries gives a broader understanding for generalising the findings.

Our main aim is to address the shortcomings of the existing literature and fill the gaps described above. To address the research gap in the current literature, we adopt a contingency approach, open innovation theory and a knowledge production function. Our study examines the impact of firm collaboration, patent, and trade publications on firm innovation performance in the context of knowledge production function and contingency factors. Understanding how firm collaboration, patent and trade can be combined or effectively substituted in a single model to influence firm innovation performance is essential. Firms' innovation activities are susceptible to the environment in which they operate (Arthur & Stejskal, 2022). Again, this study uses the open innovation theory to support the stated hypothesis because it emphasises on collaboration with external entities to source new knowledge for innovation. This aligns with our study because firm collaboration, trade, and patent publications are sources of external knowledge firms gain to innovate. The knowledge production function also links the values of knowledge creation and utilisation in the innovation process.

Our study provides both theoretical and practical contributions. First, we extend knowledge production function, contingency, and open innovation theories by showing that inputs such as trade and patent publications, general firm collaboration on IPR, and firm collaboration with universities on consultancy services positively influence firms' innovation performance. Second, our study confirms that government funding positively and significantly moderates the effect of IPR acquisition on innovation performance. This contributes to contingency and open innovation theories by including government funding as a contingency factor for firms to acquire intellectual property to improve innovation performance. Firms have open systems sensitive to environmental conditions (Victer, 2020). External activities, such as the role of government, can influence the activities of firms. Third, from a practical point of view, we pointed out the importance of introducing policies to facilitate information sourced from trade and patent publications. Finally, we highlight the importance of university-industry collaboration (Onuferova et al., 2020) for innovation in economically limited countries but not economically averaged countries.

We organised the rest of the studies as follows: Section 2, the theoretical background, and hypotheses; Section 3, data source and measurement methodology; Section 4, analysis, and results; Section 5, discussion; and Section 6, conclusions and limitations.

Literature Review

Open innovation theory

The theory of open innovation, introduced by Henry Chesbrough in 2003, states that superior innovation performance does not lie solely in the activities of internal, vertically integrated R&D labs, but instead requires co-location within vice-disintegrated innovation networks that link firms to suppliers, customers, universities, research labs, consultants, and start-ups (Chesbrough & Bogers, 2014; West & Bogers, 2017). Thus, open innovation encourages firms.

to collaborate with external partners to co-create new technologies, products, and services (Bartello et al., 2024). Open innovation focuses on the innovation process and emphasises acquiring and using knowledge from external sources. The strategic intent of inbound innovation is to integrate external insights into the company's R&D processes, which can lead to more sophisticated, market-responsive innovations. This study adopts the open innovation approach because its axioms align with the study aim. Our study aim is to examine how firms could improve innovation performance through external factors such as firm collaboration, patents, and trade publications. We suggest that firms are open systems and accept knowledge from sources outside their (firm's) system, which improves internal resources, makes the firm viable for innovation, and remains competitive.

Knowledge production function model

The primary input factors of the Cobb-Douglas production function are capital and labour. Griliche expanded the input factors of the Cobb-Douglas production function to include knowledge (Link & Scott, 2020). This laid the foundation for the knowledge production function, technological advancement, and innovation. It is mathematically expressed as

$$Q = f\ (x_1, x_2, x_3 \ldots x_m) \tag{1}$$

where

Q	innovation;
$x_1, x_2, x_3 \ldots$	general determinants of knowledge production function.

In recent years, studies have adopted several knowledge-based inputs as factors of production function. For our study, we refer to factors or inputs of the knowledge production function as determinants of the knowledge production function. The determinants of knowledge production function play an integral role in firm innovation performance. Such roles include creating, managing, and disseminating knowledge to firm innovation performance (Švarc, 2006). The current study classifies the determinants of the knowledge production function into collaboration and networks, knowledge spillovers, R&D expenditure, and human capital (Ege & Ege, 2019). This implies that the determinants of knowledge production function must be able to create, store, transfer, and share new knowledge within and among firms. This is realised through collaborations, networks, training and development, investment in R&D and ICT penetration. We linked our study to the knowledge production function because the explanatory variables (firm collaboration, patent, and trade publications) used in our research could be a knowledge-sourcing hub for micro and medium forms. Firms can enhance their innovation performance through the new knowledge gained from firm collaboration, patent, and trade publications. The output factors are a function of input factors in the production function ecosystem. This is represented as

$$IP = f\ (PP, TP, FGC, IPR, CON) \tag{2}$$

where

IP	firm innovation performance,
PP	patent publications,
TP	represents trade publications,
FGC	firm general collaboration,
IPR	firm collaboration with the university on intellectual property rights,
CON	collaboration with the university on consultancy services.

The equation (2) shows that firm innovation performance (PI) is a function of patent publication (PP), trade publication (TP), firm general collaboration (FGC), firm collaboration with university on intellectual property rights (IPR and firm collaboration with universities on consultancy services (CON). Thus, variations of the inputs in the knowledge production function result in changes in innovation performance. Ackerberg et al. (2006) examined the structural identification of determinants of knowledge production functions. They recognised that endogeneity issues arise when determining the determinants of a production function. They suggest using instrumental variable (IV) and fixed effect (FE) estimations to find a sustainable solution to the endogeneity issue.

The contingency theory – Government funding perspective

The contingency theory is based on the tenet that firms' activities are influenced by external forces (Adomako et al., 2021). Given that the government plays a significant role in firms' innovation activities, we linked the contingency theory to the moderating role of government funding. Firms possess open systems. This makes them vulnerable to environmental conditions (Victer, 2020). External activities have the potential to influence firms' operations. Consequently, the effectiveness of a firm's knowledge activities depends on its environmental context. Contingency theory provides a better explanation for this scenario. The impact of the determinants of the knowledge production function on innovation is contingent on environmental context. Internal and external environmental factors affect the determinants of the knowledge production function on innovation. We argue that the influence of firm collaboration and patent and trade publications on firm innovation performance is contingent on funding support from the government. This is essential because current studies (Hegde et al., 2023) ignored the contingency issues in assessing the influence of knowledge-based determinants and innovation. These studies that acknowledged the moderating roles in the impact of knowledge-based determinants and firm innovation performance did not consider the role of government (Safari & Saleh, 2020). The extent to which the determinants of knowledge production function (firm collaboration, patent and trade publications influence micro and medium firm innovations depend on factors such as tax credits, R&D investment, and favourable innovation policies.

Connecting trade publication, patent publication and innovation

Innovation depends on acquiring knowledge (Stejskal et al., 2018). The availability of new knowledge to firms enhances their ability to innovate. The driving force behind increased knowledge acquisition efforts by firms and other transnational institutions is innovation, maintaining relevance to customers and stakeholders (Prokop & Stejskal, 2019). In this situation, sources of knowledge are crucial for firms. The quality and authenticity of information depends on its source. Firms rely on publications as a source of information about their innovation performance. For this study, we examined how trade and patent publications could be viable knowledge sources for firm innovation performance. Trade publications are articles published in a specific industry. They typically inform members of the latest practices, methods, technologies, and other relevant information. Trade publications contain some of the most reliable and verified information (Nemethova et al., 2022) for firms seeking to innovate. Therefore, they can be considered trusted sources when seeking new information about innovation. Examples of trade publications in Europe include digital innovation magazines and trade journals. Trade publications have been identified as one of the primary sources of product innovation in the Chinese hospitality and tourism industry (Cao et al., 2022) or the US healthcare industry (McKelvey & Rake, 2016). According to Kraft and Rammer (2023), trade publications do not have a powerful, significant effect on higher innovation output. However, they add that trade publications lead to the dissemination and implementation of scientific knowledge in different organisations, thus indirectly increasing their innovation output. We then consider a patent publication to be the published use of patent applications by institutions such as the European Patent Office (EPO) and the United States Patent and Trademark Office (USPTO). Although a patent application is not equivalent to a granted patent, its information, such as drawings and written specifications, is valuable for innovation performance. The time between filing a patent application and the publication of a patent has long been shorter than the time between filing a patent application and the grant of a patent. This finding has led to the claim that patent publication is a knowledge source in the stock market (Kabulova & Stankeviciene, 2020). In addition, patent publications have promoted innovation in different sectors and forms over the years (Blind et al., 2022). Argente et al. (2018) state that this support is most noticeable for small firms. Considering the above arguments, we hypothesise the following:

H1a: Knowledge from patent and trade publications positively influences product innovation.

H2a: Knowledge from patent and trade publications positively influences process innovation.

Firm collaboration and innovation performance.

Existing research on knowledge networks supports the assertion that collaboration for innovation benefits firms in gaining a competitive advantage (Rybnicek & Königsgruber, 2019; Prokop & Hajek, 2023). Firm collaborations include meetings, consultancy services, and acquiring licenses and intellectual property rights (IPRs) from research institutions and universities (Leckel et al., 2020). The triple-helix model effectively captures the value and nature of firm collaborations. Universities continue to provide valuable knowledge sources to local firms (Atta-Owusu et al., 2021). They do this by training graduates employed by firms, commercialising intellectual property, and offering expert advice (via collaboration and consultations). Establishing knowledge linkages with the universities improves micro and medium firms' creativity and R&D capabilities (Leten et al., 2014). This suggests that selecting collaboration partners, methods, and timing for innovation purposes leads to variations in firms' innovation performance. Micro- and medium-sized firms typically lag in innovation performance compared to large and multinational organisations. Consequently, it is advantageous for these firms to collaborate with institutions with superior knowledge and expertise (Brown & Qua, 2017). Our study examined firm collaborations from three perspectives: firm general collaboration on IPR (Eppinger et al., 2021), firm collaboration with universities on IPR and firm collaboration with universities on consultancy services. Firm collaboration with universities on consultancy services is where firms seek expert advice from the universities on innovation and non-innovation matters (Rementilla, 2023), while collaboration on IPR means purchasing intellectual property from the university. In addition to acquiring patents, licenses, and other IPRs from institutions, micro and medium-sized firms should supplement these acquisitions with ongoing consultations to achieve sustainable innovation performance.

Considering the arguments above, we hypothesised that the following:

H1b: Knowledge from firm collaborations positively influences product innovation.

H2b: Knowledge from firm collaborations positively influences process innovation.

The moderating role of government funding

The extant literature has established the value of firm collaboration through IPR acquisition in innovation performance. However, the cost of IPR acquisition presents a significant obstacle to firms' procurement, particularly micro and medium-sized enterprises. The network theory of small and young firms posits that SMEs' smallness (in market size, technical abilities, and funding capacity) impedes raising internal resources (Park et al., 2020). Government financial support serves to rectify existing funding biases against micro and medium-sized firms by improving their performance for survival and growth. A study on small and medium enterprises in North America shows that government financial support positively and significantly affects SMEs' innovation and growth performance (Brown & Quas, 2017). Manual (2018) cites firms' funding sources for innovation activities as equity

finance, debt finance, local and regional government finance, EU horizon finance, and central government finance. Government funding exerts both direct and interacting effects on the innovation performance of micro and medium-sized firms. The moderating role of government funding in the form of grants, subsidies, and loans has been significant in SMEs' R&D and innovation activities (Ma & Li, 2021). Thus, a firm's success in acquiring intellectual property and effectively collaborating for innovation is contingent on government support. Based on the assertions mentioned earlier, we propose the following:

H3: Government funding significantly moderates the relationship between firm collaboration and innovations.

Based on an extensive literature review, we propose a conceptual framework (see Figure 1) that incorporates the above hypotheses to explore the relationships described above.

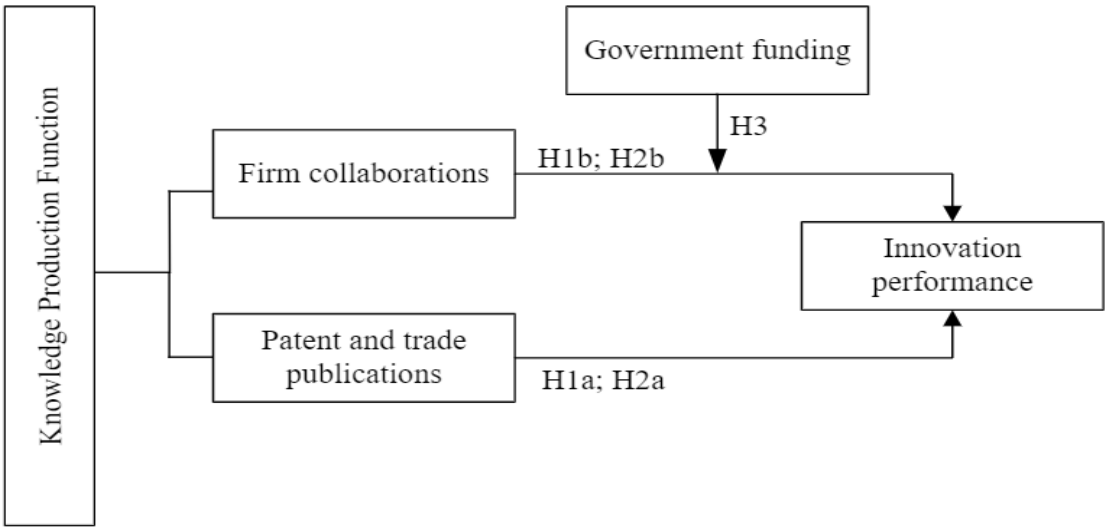

Fig. 1. Conceptual framework.

Methods

This study utilised data from 14 European countries (Table 1) from the Community Innovation Survey (CIS) 2018, accessed via the Eurostat site. The selected period was chosen because it is one of the most recent CIS datasets released by the Eurostat Safe Centre. It also provides more stable patterns and historical trends in the relationships of the interested variables compared to CIS 2020 and 2022 data (Rammer et al., 2022) which were affected by downtimes and disruptions in firm innovation activities. It contains all variables of interest with minimal missing data. CIS employs a harmonised survey methodology to collect data on various themes, including innovation and innovation activities of firms across sectors in the European region. Stratified sampling techniques were employed to select firms to participate in the study. Firms were categorised into four strata based on size: micro firms (10-49 employees), medium firms (50-249 employees), macro firms (250-499 employees), and large firms (500 or more employees). Sectorial grouping is primarily based on the economic activities of a sector, typically encompassing the manufacturing and service sectors.

The CIS is a significant database for scientific research because of its rigorous processes in ensuring that the data collection and processes are ethical, valid, reliable, accurate, and of sufficient quality for scientific inquiry. CIS data provide information on enterprise or firm characteristics (size, year of registration, enterprise group, and enterprise marketplace), firm innovation activities (R&D, new or improved products or processes, factors hampering innovation activities, turnover from new or improved products or processes, public funding for innovation, sources and types of innovation funding, and enterprise expenditure on innovation), and strategies for knowledge flow towards innovation (patent registration and publication, channels of information, intellectual property rights issues-IPR, and innovation cooperation and co-creation).

This study focuses on micro- and medium-sized firms in the manufacturing sector in 14 European countries (Belgium, Czech Republic, Greece, Croatia, Hungary, Lithuania, Romania, Slovakia, Germany, Malta, Estonia, Spain, Latvia, and Portugal). These countries were selected based on data availability and the classification of countries by Onuferová et al. (2020). Also, these countries fall within the categories of economically averaged and economically limited countries (Onuferová et al., 2020), as they are either at or below the EU average regarding the indicators used for the classification. Compared to economic leaders and economically advanced countries, economic development in economically averaged and limited countries renders micro- and medium-sized firms more susceptible to government support for innovation performance. The study concentrated on micro- and medium-sized firms due to their lag in innovation performance and exposure to funding biases (Park et al., 2020), with fewer than 250 employees (Manual, 2018). Micro-firms constituted 71.19% (66654) of the sample, while medium firms represented 28.81% (25152). Micro and medium-sized firms contribute significantly to economic

development, accounting for approximately 25% of exports in OECD countries. However, they face challenges such as funding, labour, technology, and R&D investments in their innovation pursuit (Hervas-Oliver et al., 2021). Micro and medium firms are known to be more innovative in manufacturing than in service sectors (Baierle et al., 2020).

Onuferová et al. (2020) classified EU countries into economic leaders, economically advanced countries, economically averaged countries, and economically limited countries. The classification was based on five indices: the Global Competitive Index (GCI), Economic Freedom Index (EFI), Global Innovation Index (GII), Human Development Index (HDI), and Corruption Perception Index (CPI). The average countries comprised Germany, Estonia, Spain, Latvia, Malta, and Portugal, while the limited countries included Bulgaria, the Czech Republic, Greece, Croatia, Hungary, Lithuania, Romania, and Slovakia. Economically averaged countries have indices with values equivalent to or approximating the European region average. In contrast, economically limited countries lag in the European region's average based on the analysis of individual indices in the cluster.

Table 1. Sample of firm distribution by country.

Country	Freq.	Percent	Cum.
Belgium	14967	16.70	16.70
Czech Republic	4524	5.05	21.75
Greece	3758	4.19	25.95
Croatia	2421	2.70	28.65
Hungary	6680	7.45	36.10
Lithuania	2086	2.33	38.43
Romania	6442	7.19	45.62
Slovakia	2802	3.13	48.75
Germany	4769	5.32	54.07
Malta	1047	1.17	55.24
Estonia	2756	3.08	58.32
Spain	27417	30.60	88.92
Latvia	2302	2.57	91.49
Portugal	7634	8.51	100.00
Total	89605	100.00	

Source: Own estimations

Dependent variables

This study employed innovation performance as the dependent variable and proxied it with product and process innovations. The definition and measurement of dependent variables were based on the 2018 Edition of the Oslo Manual. Other scientific studies have used product and process innovations to measure innovation performance (Rammer et al., 2022). Product innovation is a new or improved product that differs significantly from a firm's previous product and primarily encompasses physical goods, services, or digital products. Process innovation (PI) is distinct from product innovation. A firm is a process innovator if it has introduced a new process or improved an existing process in areas such as logistics, communication, marketing, organisation, and administration in the preceding three-year period, significantly different from the existing process. Examining how elements, such as firm collaboration, influence these innovations is essential. These variables are dichotomous. They assume a value of 1 if the firm has introduced a new or improved product or process in the preceding three-year period and 0 otherwise.

Independent variables

Proxies for firm collaboration comprised collaboration in general for IPR, firm collaboration with public universities for intellectual property (IPR) and consultancy services (CON). Firms were assigned a value of 1 if they collaborated with public institutions for intellectual property acquisition and consultancy and 0 if they did not collaborate. Similarly, a value of 1 was assigned if firms collaborated with private institutions to acquire machinery and software and 0 if they did not engage in such activities. We also adopted Trade publications (TP) and patent publications (PP) as additional independent variables. A value of 1 was assigned to firms that utilised trade and patent publications to acquire knowledge from 2016 to 2018, and a value of 0 was assigned if they did not engage in such an activity. These measures were selected based on extant literature (Giannopoulou et al., 2022) on innovation.

Control and moderation variables

We controlled for firm age (Chatterjee et al., 2022). Firm age is a recognised firm-level characteristic internal to firms that positively correlates with firm size (Pellegrino & Piva, 2020) and may influence firm innovation performance. Firm age (AGE) was categorised into four groups based on the year of establishment. The value 1 was assigned to firms established in 2016 or later, 2 for those established from 2014 to 2015, 3 for those established from 2010 to 2013, and 4 for those established in 2009 or before. Firm size can influence innovation activity. Large firms and corporations are known to possess more significant resources and more stable financial capacity to engage in R&D for new knowledge and innovation (Bachmann et al., 2021). We measured firm size by the number of employees. This study includes medium (50-249) and micro (10-49) firms. Variations in size can influence a firm's innovation performance. Consequently, firm size was controlled, with one for micro and two for medium firms.

Our moderating variable was public financial support (Saberi & Hamdan, 2019). Public financial support is significant in the innovation activities of micro and medium-sized firms, as such firms encounter numerous challenges in accessing funds from financial institutions. We measured government funding with central government funds (CGF) received and utilised for R&D and innovation activities. The value 1 was assigned to firms that received government funding for R&D and innovation activities. The value 0 was assigned to firms that received public financial support but did not utilise any portion for R&D and innovation activities.

Methods

Table 2 presents the descriptive statistics used in the study. The statistics included the number of observations, mean, standard deviations, and minimum and maximum values. General collaboration on IPR exhibits the highest number of observations at 89,605, followed by government funding with 89,603 observations. Trade and patent publications demonstrate the lowest observations, at 51,507 and 51,477, respectively. Except for firm age, which ranges from 0 to 4, all other variables employed in the study assume a value of 1 if the firm utilised or acquired the variable and 0 if the firm did not utilise or acquire the variable. The mean values indicate that 17.9% of the firms involved in the study were product innovators between 2016 and 2018, compared with 14.3% of marketing method innovators. Approximately 44.9% and 18.6% of firms reported benefiting from obtaining information from trade and patent publications, respectively, for their innovation activities. A small proportion (3.6%) of the firms reported general collaboration on IPR. In collaboration with universities on IPR, 16.8% of the firms purchased IPR from public universities, 0.5% consulted with public universities, and 18.2% obtained machinery and software from private institutions. With a mean of 0.271, 27.1% of firms reported obtaining government funding and utilising a portion for innovation activities. Most of the firms involved in this study were established in or before 2009.

Table 2. Summary statistics.

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Product innovation	89291	0.179	0.383	0	1
Process innovation	83461	0.143	0.351	0	1
Trade publication	51507	0.449	0.497	0	1
Patent Publication	51477	0.188	0.390	0	1
Firm general collaboration on IPR	88729	0.036	0.186	0	1
Firm collaboration with universities on IPR	89605	0.168	0.058	0	1
Firm collaboration with universities on consultancy services	88180	0.005	0.071	0	1
Government funding	89603	0.271	0.185	0	1
Firm age	89594	3.665	0.745	0	4
Firm size	87303	1.288	0.452	1	2

Source: Own estimations

Due to the variables' dummy nature, we used logistic regression for the baseline analysis (Rodríguez-López & Souto, 2020). First, to test hypotheses H1a and H2a, the baseline logistic regression analysis was conducted on product innovation for overall, economically averaged, and economically limited countries. Second, we tested hypotheses H1b and H2b by running the baseline logistic regression analysis on process innovation for overall, economically averaged, and economically limited countries. Third, hypothesis H3 was tested by conducting the interaction effect of government funding with firm general collaboration for IPR on product and process innovation for overall, economically averaged, and economically limited countries. Finally, we tested for the robustness of the results by introducing an instrumental variable for a 2-stage analysis.

Our references to model 1 are the overall country analysis (14 countries in the study), model 2 are economically

averaged countries (Germany, Estonia, Spain, Latvia, Malta, and Portugal), and model 3 are economically limited countries (Bulgaria, the Czech Republic, Greece, Croatia, Hungary, Lithuania, Romania, and Slovakia).

This is represented in the logistic regression econometric model as follows:

$$\text{Ln } (P/\ 1\text{-}P) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_k X_k \quad (3)$$

where

Ln (P/ 1-P)	log ratio indicating the likelihood of innovation occurrence within the firm,
β_0	constant,
$\beta_1 \ldots \beta_k$	parameters.

The moderating effect model is represented as:

$$\text{Ln } (P/\ 1\text{-}P) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 \quad (4)$$

where

Ln (P/ 1-P)	log ratio indicating the likelihood of innovation occurrence within the firm,
β_0	constant,
β_1 and β_2	parameters,
$\beta_3 X_1 X_2$	interaction effect.

In the final stage, we tested the robustness of the baseline analysis with the two-stage least square (2SLS) method. We also analysed the probit to verify whether the 2SLS model is needed (Dunyo & Odei, 2023). The Wald test of homogeneity in the probit results was significant. Thus, further analysis is needed to check and resolve endogeneity issues in our baseline results. The two-stage least squares method was used to resolve the endogeneity issues. This is represented as:

$$Yi = \beta_0 + \beta_1 X_{1\,i} + \beta 2\ \hat{X}_{2i} + u_i \quad (5)$$

Results

The results in Table 3 demonstrate the impact of firms' general collaborations, firms' sourcing knowledge from patent and trade publications, and firms' collaboration with public universities for IPR and consultancy services on product innovation. The findings indicate that publications positively and significantly affect product innovation across all models (1,2,3). Specifically, trade publications improve firm innovation performance as shown in Model 1(β=0.754, P < 0.05), Model 2(β=0.747, P < 0.05) and Model 3(β=0.790, P < 0.05). The results in model 1(β=0.532, P < 0.05), model 2:(β=0.103, P < 0.05) and model 3(β=0.692, P < 0.05) show the impact of patent publications. The analysis reveals that the impact of trade publications on product innovation is more significant than that of patent publications across the three models.

Table 3. Results of the logit regression for product innovation.

DV: Product innovation			
Variables	Model1 Overall	Model 2 Averaged countries	Model 3 Limited countries
Trade publications	0.754***	0.747***	0.790***
	(0.291)	(0.043)	(0.033)
Patent publications	0.532***	0.103***	0.692***
	(0.030)	(0.069)	(0.051)
Firm general collaboration on IPR	0.417***	0.517***	0.297***
	(0.052)	(0.105)	(0.062)
Firm collaboration with universities on IPR	0.014	-0.233	0.540**
	(0.173)	(0.268)	(0.268)
Firm collaboration with universities on consultancy services	0.922***	0.118*	0.620***
	(0.121)	(0.61)	(0.141)
Firm size	0.351***	0.036*	0.011***

	(0.022)	(0.141)	(0.040)
Firm age			
1	-0.419***	-0.342***	0.173
	(0.076)	(0.143)	(0.113)
2	-0221***	-0.090	-0.345***
	(0.061)	(0.110)	(0.099)
3	-0.058*	0.092	0.492***
	(0.040)	(0.071)	(0.090)
Constant	-3.282***	-1.976***	-3.021***
	(0.100)	(0.041)	(0.089))
Pseudo R2	0.157	0.104	0.156
N	50499	14378	36353
Prob>Chi2	0.000	0.000	0.000
LR Chi2	7662.92	1700.72	5024.35

Notes: * Significant at 10%, **significant at 5% and ***significant at 1%; robust standard errors are in parenthesis.

Source: Authors' own calculations

Further results in Table 3 indicate that firm general collaboration positively improves product innovation. Except for firm collaboration with universities on IPR in Model 1 (β=0.417, P > 0.05) and Model 2 (β= -0.233, P > 0.05), all other proxies for firm collaborations demonstrate a positive and significant impact on product innovation. Thus, micro and medium firms from economically limited countries that acquired IPR from public universities improved product innovation but not firms from overall and economically averaged countries.

The control variable (firm age) exhibited significance in Models 1 and 2 but not in Model 3. The Pseudo R2 results accounted for 15.7% (Model 1), 10.4% (Model 2), and 15.6% (Model 3) of variations in the outcome variable.

In terms of the impact of patent and trade publications on process innovations, firms in model 2 show the strongest impact (Table 4). Except for firm collaboration with universities on IPR, all proxies for firm collaborations positively and significantly impact micro and medium firms' process innovations in Models 1, 2, and 3. Model 2 exhibits the highest significant impact (β= -0.620, P < 0.05) on process innovations. The control variable (firm age) significantly impacted the outcome variable. Our model explains 17.1% (Model 1), 9.7% (Model 2), and 13.8% (Model 3) of the variation in the outcome variable.

Table 4. Results of the logit regression for process innovation.

DV: Process innovation (Process innovation)			
Variables	Model1 Overall	Model 2 Averaged countries	Model 3 Limited countries
Trade publications	0.714***	0.873***	0.852***
	(0.358)	(0.048)	(0.041)
Patent publications	0.559***	0.691***	0.674***
	(0.036)	(0.070)	(0.058)
Firm general collaboration on IPR	0.330***	0.62***	0.261***
	(0.130)	(0.106)	(0.068)
Firm collaboration with universities on IPR	0.086	-0.068	0.245
	(0.576)	(0.269)	(0.189)
Firm collaboration with universities on consultancy services	0.569***	0.063*	0.406*
	(0.033)	(0.052)	(0.149)
Firm size	0.697**	0.559***	0.102***
	(0.021)	(0.151)	(0.040)
Firm age			
1	0.149**	0.278**	-0.121*
	(0.078)	(0.137)	(0.120)
2	-0.056	-0.098	-0.075*
	(0.069)	(0.117)	(0.105)

3	0.063*	0.147**	-0.019
	(0.047)	(0.077)	(0.093)
Constant	-3.045***	-2.254***	-2.924***
	(0.031)	(0.047)	(0.093)
Pseudo R2	0.171	0.097	0.138
N	41354	14508	30400
Prob>Chi2	0.000	0.000	0.000
LR Chi2	6047.20	1371.09	3122.80

Notes: * Significant at 10%, **significant at 5% and ***significant at 1%; robust standard errors are in parenthesis.
Source: Authors' own calculations

The results presented in Table 5 demonstrate the interaction effect of government funding on the relationship between firm general collaboration on IPR and product innovation across the three models.

Table 5. Results of the interaction effect of public funding on product innovation.

DV: Product innovation			
Variables	Model1 Overall	Model 2 Averaged countries	Model 3 Limited countries
Trade publications	0.624***	0.665***	0.422***
	(0.321)	(0.049)	(0.083)
Patent publications	0.344***	0.844***	0.732***
	(0.035)	(0.081)	(0.122)
Firm general collaboration on IPR	0.157***	0.673***	0.076***
	(0.059)	(0.090)	(0.160)
Firm collaboration with universities on IPR	0.511***	0.441**	0.316
	(0.131)	(0.208)	(0.208)
Firm collaboration with universities on consultancy services	0.499***	0.473***	0.687***
	(0.042)	(0.191)	(0.251)
Firm general collaboration on IPR #government funding	0.347*	0.786***	0.441*
	(0.271)	(0.271)	(0.242)
Firm size	0.493**	0.132*	0.088**
	(0.049)	(0.31)	(0.017)
Firm age			
1	-0.474***	-0.270***	-0.021
	(0.084)	(0.082)	(0.304)
2	-0.213***	-0.137**	0.397*
	(0.066)	(0.065)	(0.265)
3	-0.084**	-0.076*	0.465**
	(0.044)	(0.044)	(0.245)
Constant	-2.718***	-2.425***	-2.262***
	(0.027)	(0.034)	(0.247)
Pseudo R2	0.175	0.115	0.141
N	43515	42254	38097
Prob>Chi2	0.000	0.000	0.000
LR Chi2	7203.40	4637.34	4729.09

Notes: * Significant at 10%, **significant at 5% and ***significant at 1%; robust standard errors are in parenthesis.
Source: Authors' own calculations

On the other hand, Table 6 illustrates the interaction effect of government funding on the relationship between firm general collaboration on IPR and process innovation among the three models. The findings in Tables 5 and 6 show that government funding significantly moderates the relationship between firm's general collaboration on IPR and product innovation. The moderating influence of government funding is more pronounced in economically averaged

countries than in economically limited countries.

Table 6. Results of the interaction effect of public funding on process innovation.

DV: Process innovation (Process innovation)			
Variables	Model1 Overall	Model 2 Averaged countries	Model 3 Limited countries
Trade publications	0.869*** (0.033)	0.808*** (0.056)	0.535*** (0.095)
Patent publications	0.755*** (0.032)	0.663*** (0.083)	0.470*** (0.123)
Firm general collaboration on IPR	0.373*** (0.055)	0.728*** (0.092)	0.210 (0.183)
Firm collaboration with universities on IPR	-0.689*** (0.187)	0.289 (0.228)	0.522 (0.370)
Firm collaboration with universities on consultancy services	0.442*** (0.127)	0.806*** (0.192)	0.209 (0.251)
Firm general collaboration on IPR #government funding	0.293** (0.123)	0.723*** (0.207)	0.370* (0.256)
Firm size	0.070* (0.194)	0.013* (0.651)	0.076*** (0.183)
Firm age			
1	-0.138** (0.073)	-0.159 (0.091)	-0.199 (0.300)
2	-0.094* (0.067)	0.023 (0.073)	-0.241 (0.263)
3	0.029 (0.045)	0.135* (0.049)	-0.211* (0.239)
Constant	-2.661*** (0.041)	-3.031*** (0.093)	-2.121*** (0.241)
Pseudo R2	0.146	0.120	0.099
N	44231	42353	39018
Prob>Chi2	0.000	0.000	0.000
LR Chi2	5811.77	3840.83	3419.50

Notes: * Significant at 10%, **significant at 5% and ***significant at 1%; robust standard errors are in parenthesis.
Source: Authors' calculations

The instrumental variable probit (ivprobit) was employed to examine endogeneity issues and the robustness of the baseline results. Oudgou (2021) posits that the null hypothesis is rejected if the p-value of the Wald test of exogeneity is less than 0.05. This indicates an endogeneity issue, necessitating the introduction of an instrumental variable in the model for further robustness checks. Conversely, the null hypothesis was accepted if the p-value of the Wald test of exogeneity exceeded 0.05. This suggests the absence of endogeneity issues, rendering two-stage least squares analysis unnecessary. The Wald test of exogeneity results in Table 7 for product innovation (Ch2 =152.06; p-value =0.000) and process innovation (Ch2 = 42.92; p-value =0.000) indicates a rejection of the null hypothesis for both product and process innovations due to endogeneity issues and biases in the baseline results. Consequently, findings regarding the impact of publications and firm collaboration on innovation performance may be misleading. Despite the scientific selection of explanatory variables, endogeneity issues could render the results unreliable, necessitating resolution. To address these endogeneity issues, instrumental and exogenous variables were incorporated into a two-stage least squares model for further robustness analysis (Dunyo & Odei, 2023). Valid instrumental variables should correlate with endogenous regressors but not the error term. It means the instrumental variables should affect firm collaborations, patents and trade publications but should not affect innovation performance except through firm collaborations, patents, and trade publications. This facilitates a comprehensive explanation of the impact of the endogenous regressors on the dependent variable.

Table 7. Results ivprobit and two-stage least squares (2SLS).

Variables	Product innovation		Process innovation	
	ivprobit	2SLS	ivprobit	2SLS
Trade publications	0.194***	0.537***	0.303**	0.995***
	(0.45)	(0.392)	(0.133)	(2.129)
Patent publications	-.0.371**	-0.110***	-0.284***	-0.783**
	(.061)	(0.204)	(0.035)	(0.263)
Firm general collaboration on IPR	-0.168***	-0.146**	-0.100*	-0.075**
	(.0716)	(0.052)	(0.058)	(0.049)
Firm collaboration with universities on IPR	.0427**	0.365***	0.241***	0.165**
	(0.091)	(0.085)	(0.094)	(0.073)
Firm collaboration with universities on consultancy services	0.120***	0.096***	0.195***	0.113**
	(0.008)	(0.016)	(0.009)	(0.026)
Trade fairs and conferences	-0.286***	-0.226***	-0.281***	-0.178**
	(0.113)	(0.041)	(0.034)	(0.062)
Firm size	-0.021	-0.030*	-0.058**	-0.054
	(0.014)	(.088)	(0.028)	(0.027)
Firm age	0.020	0.696***	0.110***	0.641***
1	(0.029)	(0.055)	(0.031)	(0.070)
2	0.045**	0.707***	0.088**	0.628***
	(0.022)	(0.053)	(0.026)	(0.066)
3	0.079***	0.665***	0.141***	0.656)
	(0.015)	(0.054)	(0.20)	(0.071)
Constant	-1.419***	-1.294***	-1.807***	-1.069***
	(0.015)	(0.142)	(0.130)	(.231)
Wald test of exogeneity	Ch2 =152.06		Ch2 = 42.92	
	Prob =0.000		Prob =0.000	
F statistics		441.83		327.66
Kleibergen-Paap rk LM statistic		17.308***		16.177***
Cragg-Donald Wald F statistic		31.444		29.257
Hansen test statistic		0.000***		0.000***
Centered R2		-3.6013		-2.401
Uncentered R2		-2.7695		-1.946
Prob > ch2	0.000***	0.000***	.000***	.000***
Observations	57108	57109	51155	51156

Notes: * Significant at 10%, **significant at 5% and ***significant at 1%; robust standard errors are in parenthesis.
Source: Authors' calculations

The exogenous variables should correlate with the dependent variable but not the instrument. Thus, it should impact firm innovation performance but not R&D tax credit. Therefore, the R&D tax credit was introduced as the instrumental variable, and firms' participation in conferences and trade fairs was considered an exogenous variable. When firms receive tax subsidies for engaging in R&D activities, they promote R&D endeavours, leading to discoveries and inventions for more patent publications. The inventions and innovations from R&D activities enable firms to participate in and showcase their innovations at conferences and trade fairs. Additionally, participation in trade fairs and conferences enhances firms' networking capacity for collaboration.

Two-stage least squares (2SLS) analysis was employed to determine the robustness of the instrumental variables because weak instruments could potentially lead to econometric issues. This is shown in the Kleibergen-Paap rk

LM statistic values and the Cragg-Donald Wald F statistic derived from the 2SLS method. The Kleibergen-Paap rk LM statistic for product innovation is 17.308 with a p-value of 0.000, indicating that sufficient and valid instruments are present in the model to identify the endogenous variables. Regarding process innovation, the value of 16.177 and p-value of 0.000 demonstrate that the R&D tax credit utilised as an instrument in the model is valid and adequate for identifying endogenous variables. The results of the Cragg-Donald Wald F statistic further corroborate this. The Cragg-Donald Wald F statistic values for product (31.444) and process (29.257) innovation exceeded 10, further validating the instrument's robustness in explaining the endogenous variables (Windmeijer, 2021). Based on the results presented in Table 7, it can be concluded that there were no potential endogeneity issues in the variables used in this study. The Sagan-Hansen test is not applicable because the number of instruments used is equal to that of exogenous variables (Windmeijer, 2021). Therefore, it can be assumed that the baseline results from the logit model are consistent and not biased by potential endogeneity issues.

Discussion

The primary purpose of our study is to conduct a quantitative analysis on how selected determinants of knowledge production function (firm collaborations, patent, and trade publications) serve as a knowledge source hub to influence firm innovation performance moderated by government funding. All hypothesis decisions, including their justifications, are shown in Table 8.

Table 8. Summary decisions of hypotheses.

Hypotheses	Decision(s)	Justification
Hypothesis 1a	Supported	Trade and patent publications positively and significantly affect product innovations across all models.
Hypothesis 2a	Supported	Trade and patent publications positively and significantly affect process innovations across all models.
Hypothesis 1b	Partially supported	Firm general collaboration on IPR and firm collaboration with universities on consultancy services have positive and significant effects on product innovations for all models. However, the impact of firm collaboration with universities on IPR was positive and insignificant on product innovation for model 1, negative and insignificant on product innovation for model 2 and positive and significant on product innovation for model 3.
Hypothesis 2b	Partially supported	Firm general collaboration on IPR and firm collaboration with universities on consultancy services had a positive and significant effect on process innovations for all models. However, the impact of firm collaboration with universities on IPR on process innovations was not statistically significant for all models.
Hypothesis 3	Supported	The moderating role of government funding in the relationship between firm general collaboration on IPR and innovation performance was positive and significant for product and process innovations in all three models.

Across all economies, we consistently find a positive and significant impact of patent and trade publications on product and process innovation. These findings support hypotheses H1a and H2a (see Table 8). Our results align with Cao et al. (2022) and Ndubuisi (2020) studies on patent and trade publication and firm innovation. Thus, publications, particularly in the trade and patent literature, remain crucial in enhancing product innovation among micro and medium-sized firms in the EU. It is recommended that micro- and medium-sized enterprises in Europe utilise trade and patent publications as sources of information for product innovation.

Firms' general IPR cooperation and firms' cooperation with universities on consulting services positively and significantly affect product innovation for all models. However, the effect of firms' cooperation with universities on IPR was positive and insignificant on product innovation for Model 1, negative and insignificant on product innovation for Model 2, and positive and significant on product innovation for Model 3. Therefore, hypothesis H1b (see Table 8) is only partially supported. Based on these results, it is thus evident that firm collaboration with universities on IPR showed a negative, non-significant impact on innovation performance in economically average countries. The reason for this result could be the need for staff with the right expertise to implement intellectual property acquired from universities. Intellectual property is technical and requires special knowledge to implement it effectively. Firms should ensure that, when seeking new knowledge from universities, they have the requisite expertise to implement it. Other issues could be cultural and commination processes between the firms and the university. The academic environment and cultural practice could be different. While universities value scientific

orientation, firms focus on practical and profit-orientated innovation. Before firm-university collaboration, mutual interests, goals, and policy alignment should be discussed. However, firm general collaboration on intellectual property was positive and significant in all countries, partially supporting hypothesis H2b (see Table 8). This explains that in firm collaboration, the type, location, actors involved, and timing of collaboration can determine the impact and variations in innovation performance (Odei & Hamplová, 2022).

The main findings show that government funding positively mitigates the impact of general firm collaboration on intellectual property for micro and medium-sized European firms, supporting hypothesis H3 (see Table 8). This supports the assertions by Ma & Li (2021) that government roles in funding, taxation and subsidies moderate firms' activities and innovation. Large corporations and multinational firms can access funding more readily than smaller firms. These challenges result in funding bias, leaving micro and medium-sized firms needing help to pursue innovation. This finding explains that micro and medium firms are constrained in R&D funding, hiring innovation experts and entering new markets (Park et al., 2020). Government support is needed to boost their performance in the innovation ecosystem. Again, we found that the level of influence of government funding on the firm general collaboration and innovation nexus varies according to the firms' economies. The impact of government intervention in micro and micro firm innovation activities was more substantial for firms in economically averaged economies than economically limited economies. Thus, economic development creates favourable systems to spur innovation activities of European micro and medium firms. We recommend that the government funding earmarked for R&D and innovation activities be sustained and enhanced. The boards of directors and managers of firms seeking improvement in innovation performance should make a concerted effort to allocate at least a portion of the government funding received for R&D and innovation activities.

Based on our findings, we can, therefore, argue that a firm's openness to external knowledge can improve innovation performance in the context of government support and the level of economic development. Micro and medium firms receptive to external knowledge through patent and trade publications are valuable sources of new knowledge to enhance their innovation performance. Prior studies on open innovation have focused on management-related factors, such as top management relationships with buyers and suppliers (Prokop & Hajek, 2023). This study confirms the active role of firm collaborations and patent and trade publications in promoting innovation in European micro and medium firms through the principles of open innovation theory.

Conclusion

Internal and external factors influence innovation performance in the firm (Prokop & Hajek, 2023). Prior studies have focused on knowledge sources for innovation, but factors such as trade and patent publications and firm collaboration from the perspective of knowledge production function are under-researched. Hence, this study focused on the influence of firm collaboration, patent, and trade publications on firm innovation performance in the context of knowledge production function with government support as the moderator. Our findings confirm that trade and patent publications positively and significantly impact product and process innovations (Hegde et al., 2023), but the effect is more substantial on process innovation compared to product innovation; that intellectual property acquisition from universities negatively impacts product and process innovations in the average countries, but the effect was positive for economically limited countries and government funding positively and significantly moderates the impact firm general collaboration in intellectual; property rights and innovation performance.

Our study contributes to the literature on knowledge production function, contingency theory, and open innovation theory by showing that inputs such as trade and patent publications, general firm collaboration on IPR, and firm collaboration with universities on consultancy services positively influence firm innovation performance. Thus, the input-output nexus in the knowledge production function is important in knowledge sourcing and micro and medium firm innovation performance (Link & Scott, 2019) in economically averaged and economically limited countries. This study demonstrates that various forms of knowledge dissemination and diverse knowledge sources promote positive firm innovation outcomes (Haus-Reve et al., 2019). On open innovation theory, our study reinforces the tenets of open innovation that firms are open systems. When firms are open to external knowledge, it improves their innovation capacity (Bartello et al., 2024). We demonstrate that firms open to collaborating with institutions such as universities and firms that rely on trade and patent publications obtain new knowledge to enhance innovation performance. We extended the literature on contingency theory by establishing that micro and medium firms' innovation performance is contingent on government funding. Due to the difficulty in accessing funds and the intense market competition faced by small and micro firms, government funding is necessary to sustain their innovation performance.

Implications of the study

Furthermore, our study presents practical implications for micro and medium firms in economically averaged and limited countries. We recommend that firm collaborations be preceded by a common interest, policy alignment, and clear communication strategies to enable firms to benefit from university-industry collaborations (Rybnicek & Königsgruber, 2019). There are no differences in the positive impact of trade publications on firm innovation performance between economically averaged countries and limited countries. However, the impact of patent

publications on firm innovation performance in economically limited countries is higher than firms in economically averaged countries. This indicates that micro and medium firms in economically limited countries benefit more from sourcing knowledge through patent publications for innovation performance than firms in economically averaged countries (Odei & Hamplová, 2022). On firm collaboration, micro and medium firms in economically averaged countries did not benefit from improving product and process innovations in collaboration with universities on IPR. On the other hand, economically limited firms benefited from improving product innovation in collaboration with universities on IPR but not from improving process innovation. We suggest that micro and medium firms in economically limited countries collaborate with public universities (Atta-Owusu et al., 2021) to improve product innovation. Micro and medium firms should focus on general collaboration on IPR and collaboration with universities on consultancy services (Audretsch et al., 2023) to improve process and product innovations. The study underscores the importance of the form of collaboration firms should engage in. It also implies that general policies on firm innovation performance cannot benefit micro and medium firms in economically averaged and limited countries. Innovation policies should, therefore, be tailored to the specific needs of firms in economically averaged and economically limited countries (Atta-Owusu et al., 2021).

Limitations and future research

Notwithstanding the significant contributions of our study to practice and theory, it is not without limitations. We used the 2018 CIS data for our analysis (Audretsch & Belitski, 2020). However, CIS 2022 data is the most current. Micro- and medium-sized enterprises experienced substantial setbacks during this period, suffering from reduced turnover, workforce reduction, and operational closures. Therefore, we recommend further research utilising CIS 2022 data to ascertain whether the results differ. We focus on micro- and medium-sized manufacturing firms in Europe that engaged in innovative activities from 2016 to 2018. This constrains our generalisation of geographical and sector-specific contexts. We recommend that our findings be verified in future studies outside Europe (Odei & Hamplová, 2022) and include the service sector (Haus-Reve et al., 2019). The selection of our variables was predominantly related to knowledge networks and firm-level innovation. We suggest that future research examine the role of digital platforms (Díaz-Arancibia et al., 2024) and open publications within the knowledge production function perspective in firm innovation performance. The selection of firm collaboration and patent and trade publications potentially have endogeneity issues and could produce biased results. However, introducing a two-stage least squares estimation provides a robust analysis, mitigating the biased effects of the selected variables.

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Appendix A

Table A-1: Pearson correlation matrix.

	1	2	3	4	5	6	7	8	9	10
PI	1.0000									
PCI	0.3922	1.0000								
TP	0.2664	0.2568	1.0000							
PP	0.2143	0.2469	0.4114	1.0000						
FGC	0.1068	0.0951	0.1276	0.0630	1.0000					
CON	0.0646	0.0535	0.0511	0.0440	0.1659	1.0000				
IPR	0.0316	-0.0030	-0.0014	-0.0577	0.2468	0.0840	1.0000			
GF	-0.0136	-0.0063	-0.0204	-0.0030	-0.0024	0.0038	-0.0075	-0.0050		
AGE	0.0630	0.0313	0.1099	0.0827	0.0060	-0.0105	-0.0214	0.0504	1.0000	
SIZE	0.0420	0.0931	0.1331	0.2710	0.05910	-0.0112	-0.1600	0.6114	0.0213	1.0000