



Research article

Innovations in small businesses: do public procurement contracts and intellectual property rights matter?

Samuel Amponsah Odei^{*}, Eva Hamplová

Department of Economics, University of Hradec Králové, Rokytanského 62, 50003, Hradec Králové, Czech Republic

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ABSTRACT

Small and Medium Scale Enterprises (SMEs) are known to drive innovations, economic growth, and job creation. Numerous studies have analysed small businesses' innovations using new products and processes, with indicators such as funding, innovation activities, and collaborations. However, other vital determinants such as public procurement contracts and intellectual property rights protections capable of influencing innovations have not received enough scholarly attention, especially in the context of Central European countries. This paper aims to examine whether public procurement contracts, market orientations, public subsidies, intellectual property rights, and other firm characteristics shape small businesses' innovation outcomes in the Czech Republic. The results based on a cross-sectional sample of 4,193 small businesses from the Community Innovation survey 2014 prove that European utility models positively influence major and minor forms of innovation but not general innovations. Our findings also show that foreign procurement contracts matter for small businesses' major and minor forms of innovation but not general innovations. Our results further demonstrate that exporting, collaborations with universities and other public research organizations, and external research and development positively influence major and minor forms of innovation but not general innovations. The results on the average treatment effects confirm that firms' collaborations with universities and public research organizations have the highest additional effects on major and minor forms of innovations. Finally, we find evidence that firm size and belonging to the enterprise group positively impact small businesses' general innovations. We conclude with practical implications for policymakers and firm managers in Visegrad economies on measures that could be adopted to develop and improve upon existing and new policy initiatives to increase the effect of major and minor innovation outcomes.

1. Introduction

Small and medium-sized enterprises (SMEs) play essential roles in economic development and contribute extensively to ensuring sustainability, economic growth, and wealth. Small businesses constitute a pulsing part of all European countries, and they are the predominant type of business, accounting for about 99 percent of companies (Tian et al., 2020). In transition and developing economies, SMEs represent about 90% of total businesses (Manzoor et al., 2021). Small businesses are the most active and vibrant enterprise sector for new job creation and start-ups. SMEs also play significant roles when it comes to innovations; they undertake numerous innovative activities which significantly help to scale-up their businesses in terms of new product development or service deliveries. In general, the vital contributions of SMEs to innovations have been widely proven. They are seen as valuable innovation

drivers and mediums for knowledge spill overs. They engage in in-house development and commercialization of research and innovations. Besides in-house innovations, SMEs' innovation activities are also built around and carried out in collaboration with large firms, research institutions, and higher education institutions (Apa et al., 2021).

Despite these essential contributions SMEs make to economic development and growth, they often face several obstacles that hinder their innovation performance. Most of these obstacles to SMEs' innovation activities emanate from the external environment, which in transition and developing countries are characterized as weak. Weak business ecosystems can significantly increase the cost of introducing new products, and services, making the returns on investments in new services, technologies, and products more indeterminate. Besides the weaker business ecosystem, other factors also undermine SMEs' incentives and aptitude to innovate, especially for those in developing and transitional

^{*} Corresponding author.

E-mail address: ppodei@yahoo.co.uk (S.A. Odei).

economies. Among these factors are inadequate specialized financing as working or venture capital (Eggers, 2020; Civelek et al., 2021), skilled labour shortages (Serumaga-Zake and van der Poll, 2021), elevated barriers to entry for new firms (Paul et al., 2017), and ineffective protection of intellectual property rights (Jee and Sohn, 2021). For instance, weak and ineffective protection of intellectual property rights can prevent SMEs from accessing and absorbing new knowledge from research institutions to support innovation activities and expand their knowledge base (Goduscheit and Knudsen, 2015).

The current debates in the innovation literature in transition countries exhibit numerous weaknesses that limit the extent to which firm-level innovation drivers can be meaningfully understood and analysed. They downplay innovations in small businesses, as they often focus on large firms and are usually biased towards firms in the manufacturing sector (Bockova and Zizlavsky, 2016). Most innovation research conducted in the Czech Republic has measured firm-level innovations from the technological perspective (new products and processes) and non-technological perspectives comprising marketing and organizational innovations (Zygmunt, 2020). We argue that although numerous studies have been devoted to analysing innovations in the Czech Republic, they have not focused on measuring innovations using degrees of the novelty of inventions. The degrees of the novelty of inventions help to distinguish between inventions new to the firm and those that are new to the firm's market (Storz et al., 2021). From the extensive literature reviewed, we found that most of the studies on innovations in the Czech Republic and other Visegrad countries have neglected using key determinants such as public procurement contracts and Intellectual Property Rights (IPR) protection. The neglect of these vital determinants makes our understanding of the innovation ecosystem in the Czech Republic and other Visegrad economies incomplete, hence calling for a different approach or research incorporating all these to provide a better understanding of the innovation landscape. This study fills this gap by showing that public procurement contracts and IPR protections matter for small businesses' innovation performance. In sum, the main aim of this paper is to analyse the determinants that drive innovations in small businesses in the Czech Republic.

For the empirical approach, we used a dataset from 4,193 small businesses in the Czech Republic to analyse whether public procurement contracts, intellectual property rights, market orientations, and innovation activities influence small businesses' innovation outcomes. This study is novel as it analyses foreign procurement contracts and European utility models' influence on small businesses' innovativeness. To the best of our knowledge, no studies have used these determinants to analyse firm-level innovations in the Czech Republic and other Eastern European countries. However, we did find a study by Stojčić et al. (2020) on domestic public procurement contracts, but this did not include foreign procurements.

Another novelty of the paper that makes it different from existing studies is the measures of innovation adopted. Previous studies on innovations in the Czech Republic and other Eastern European countries have analysed innovations from the technological and non-technological perspectives (see, for instance, Odei and Stejskal, 2018; Grabowski and Staszewska-Bystrova, 2020). However, this paper adopts two measures of innovation that differ from existing studies. Firstly, we measured innovation by the degree of novelty, which allowed us to distinguish between innovations that are new to the company that introduced them and those that are first to market (Antonionioli and Montresor, 2021). We measured innovations as either major or minor based on the degrees of novelties. Secondly, we measured general innovations with the total turnover value from the sale of new to firm or new-to-market innovative products. Adopting innovations can improve firms' general sales and profitability (Gherghina et al., 2020).

The empirical results from the econometric analyses have pointed out the significant and positive influence of marketing orientations, firms' collaboration, European utility models, and foreign procurement contracts on small businesses' innovativeness. These findings indicate that

foreign exposure through exporting and participating in international tender bidding can positively influence small businesses' innovation. The paper's findings contribute to the literature on firms' innovations from the resources and knowledge-based point of view. These results extend and build on innovations from the resource-based perspective as studies on how the foreign procurement contracts impact firm-level innovations have not been widely explored. The second theoretical implication is its contribution to intellectual property rights and innovation literature. Studies on IPRs' impacts on innovations have excessively focused on using patents while ignoring other types of intellectual property rights protection. We have demonstrated that other IPRs tools such as the European utility models could positively influence small enterprises' innovation performances. This result contributes to expanding the existing knowledge on the European utility models as a suitable alternative to small businesses' innovations. The main limitation of the paper is that it was conducted on innovative small businesses in the Czech Republic that introduced innovations between 2012 and 2014. This reduces the generalization of our results to non-innovative small businesses and larger firms.

Our results, especially on public procurement contracts, market orientations, innovation collaborations, and intellectual property rights, have practical implications for businesses and firm managers. Small business managers in the Czech Republic and other transition countries are urged to consider internationalizing by exporting to other countries as this can be an avenue for acquiring foreign knowledge and new technologies. The second practical implication for small business managers is that foreign procurement contracts matter for small businesses' innovations, as shown by the empirical results. Small businesses are encouraged to actively participate in international tender calls as serving foreign clients can induce them to adopt innovative approaches for new products and processes. Finally, small businesses in the Visegrad and other transition countries should also consider applying for European utility models as they have proven to affect the production and diffusion of major innovations. Their low-cost nature and ease of acquiring means they can be more accessible and a viable alternative for technical invention protection for small businesses.

The article is structured as follows: Section one introduces the paper; section two reviews and discusses the literature on the concepts of the extent of novelties of innovations which are new-to-market and new-to-firm innovations, general innovations, and the various factors promoting them. Section three presents the methodology, sources of data, and measures; section four is devoted to the results and discussions in relation to the existing literature. Section five concludes the paper with suggestions for future research, policy recommendations, and research limitations.

2. Conceptual background and hypotheses

To meet the objective of the paper, which focuses on understanding the factors driving innovations in small businesses in the Czech Republic, we carefully selected and reviewed extant literature on previous related studies. The main theoretical underpinning of this article is the resource-based view or theory (RBV). The RBV emphasizes that possessing strategic resources provide organizations with golden opportunities to develop and maintain competitive advantages over market rivals (Barney et al., 2011). Firms can capitalize on these strategic resources to innovate and stay competitive (Gaur et al., 2014). RBV incorporates the concept of firm heterogeneity which focuses on ownership of resources and the ability to manage and utilize these resources productively to benefit from them (Safari and Saleh, 2020). Strategic resources comprise physical and capital assets such as the conventional production factors, knowledge, human capital, organizational processes, firm characteristics, abilities, social capital (relationships), and coordinating structure (David-West et al., 2018). Knowledge is acknowledged as one of the most important strategic resources capable of driving sustainable firm performance and competitiveness (Pereira and Bamel, 2021). Due to the intense market

competition, firms are constantly looking for new knowledge to gain a competitive advantage.

Innovation is considered an important factor driving and enhancing improvements in socio-economic development and competitiveness both at the firm and macro levels. There is no consensus on the acceptable definition of innovations as numerous authors have defined it from different perspectives (Geldes et al., 2017). Nevertheless, there is some form of concurrence among scholars on the definition proposed by the Oslo Manual, which describes innovations as “the introduction of a new or significantly improved product (good or service), process, a marketing method, or a new organizational method in the internal practices of the business workplace organization or external relations” (OECD, 2005, p. 46). Per this definition, the minimum prerequisite for any innovation is that the process, products, marketing techniques, and organizational procedures must be novel and substantially new to the firm that introduced them. Several authors have coined different terminologies to cover various aspects of this definition. Geldes et al. (2017) and Khan et al. (2019), among other researchers, classified innovations into two categories thus technological innovation (products and processes) and non-technological innovation also consists of (marketing and organizational). Others have also defined innovations as radical (Tellis et al., 2009; Tiberius et al., 2021) and incremental innovation (Bourreau et al., 2012; Norman and Verganti, 2014; Lennerts et al., 2020), major and minor innovations (Tambo and Wünscher, 2017; Storz et al., 2021). The classification of innovations as major and minor helps to differentiate the extent to which these inventions are novel to the firm or the market. Minor innovations are those inventions (products) that are significantly novel to the firm that produced them (Coviello and Joseph, 2012). It might have been developed based on research and development, making them substantially different from all other firms' products. The introduction of major innovations encompasses radically new technologies or a combination of existing and new technologies. On the other hand, major innovations can be explained as product innovations undertaken by firms that are new to the markets in which they operate, making them the first to offer these new products for sale compared to their market competitors (Storz et al., 2021).

Firm-level innovations are influenced by numerous factors that can be internal or based on some of the firms' characteristics. These determinants can also be external for which the firms do not have absolute control, such as their business environment and government regulations among others. Firm characteristics such as size and age have been demonstrated in the innovation literature to play significant roles in firms' ability to innovate (Kijkasiwat and Phuensane, 2020). Embarking on innovation is associated with exorbitant costs; the enormous sums involved position large firms better to be innovative than small and medium-scale enterprises. Large firms can easily raise money from financial institutions better in comparison to SMEs. Hence, they are more likely to invest in innovations and related activities. Furthermore, firms that belong to the same enterprise group bound by legal and financial connections undertake vital decisions, including that of innovations collectively (D'Attoma and Ieva, 2020). Such decisions become binding, meaning that once a firm is part of this group, it must work on fulfilling its collective obligations to be innovative.

Access to finance for research and development plays a crucial role in innovation. It is a vital resource that allows businesses to carry out research and adopt new technologies essential for inventions and commercialization (Odei and Novak, 2020). Firms' internal and external financing structures can affect their innovation outcomes and prospects. The availability of funding enables firms to begin and sustain their innovation activities. Without requisite R&D financing, firms may possibly abandon new product development. Firms can access funding for innovation activities from either internal or external sources or a combination. Firms can access funding for their innovation activities using different funding instruments provided by different types of financial institutions, governments, private sources, and investors. For small businesses, access to external finance is usually challenging as they

face numerous barriers that hinder them from accessing finance. Across the European Union, firms have access to external financing from central governmental sources and regional governments for their innovation and R&D activities (public support). The EU funding support research, development, and innovation across member countries (Mazzucato, 2018). EU funding support also aims at promoting firms and institutional innovation collaboration with higher educational institutions, along with other public research organizations and consultants (Radice et al., 2020). Public support for innovations is intended to create new knowledge using universities, national, and private labs (Jugend et al., 2020), and it is also intended to mobilize resources for knowledge and innovation diffusion across all sectors of the economy (Brix, 2017). Research by Grabowski and Staszewska-Bystrova (2020) concluded that EU funding significantly contributes to research and development and innovations in older EU member countries than in new members. Anderson and Stejskal (2019) also found that public funding from national and European Union sources is statistically significant in enhancing innovation output in Estonia.

Firms' interactions and competitions in markets are known to be a significant driver of innovations, making various decisions on their choice of markets for their final products, and influencing their market orientations. This choice of markets can be the domestic market, or they can export to other foreign markets. The choice of either of these markets can be the bait to induce firm-level innovations. Access to markets plays a significant role in firms' innovation outcomes since prevailing markets have the potential to determine whether they will successfully innovate or not. Market competitions can promote innovations by serving as a strong, compelling incentive to innovate and survive. Better access to domestic and overseas markets can accelerate the acquisition of foreign knowledge and technologies with their indirect spill over effects (Bloom et al., 2019). In countries with bigger domestic market sizes, firms might find it unchallenging to innovate because there are always higher levels of local demand for new products and services. For firms in emerging markets, foreign markets allow them to gain access to foreign technologies, which will be limited in their domestic countries of operations. A study by Cai et al. (2020) found that exports to foreign markets positively enhance innovations in terms of research & development and new product sales (turnover). In agreement with the study by Cai et al. (2020), we summarize the understanding that foreign markets are avenues for firms' innovations. Exporting firms interact and compete with other firms and customers in foreign markets who can contribute to improving their innovations. These intense competitions and collaborations in these markets can provide new knowledge and technologies that can help small businesses stimulate their general innovation outcomes. However, several bodies of literature also confirm that the causality goes from innovations to exporting (see Dohse and Niebuhr, 2018). Firms' search for innovations could be influential in the decision to export where successful exporting can stimulate innovation. Therefore, the causation between exporting and innovation potentially goes on both ways.

Intellectual property rights protection (IPRs) and licensing matters for firms' innovation. The nexus between the potential costs and benefits of stronger and more effective IPRs and firm-level innovation has been well established in the literature (see Branstetter, 2017; Heikkilä and Verba, 2018; Grimaldi et al., 2021). IPRs are essential for firms to transmute their innovation outcomes and creativity into economic worth and competitiveness. IPRs protection allows innovators to safeguard their discoveries. Without this protection, the market system will fail to provide innovators with sufficient incentives to embark on the expensive and risky investments that produce novel ideas, knowledge, and technologies. Stronger IPR protection is essential because of knowledge's public good and non-excludability characteristics. These attributes make it difficult and impossible to prevent other individuals from utilizing new knowledge without the approval of its originator. IPR protection serves as enticements to finance innovation and R&D and can incentivize technology alliances with universities, firms, and public research

organizations. Stronger IPRs protections can enable firms and other economic agents to access new ideas and knowledge from markets and innovation networks. The lack of these rights and protection will lead to pilfering and imitating valuable ideas, knowledge, and inventions, hence denying the original producers the prospects of reaping the economic benefit associated with their discoveries (Branstetter, 2017). The absence of these IPRs is a disincentive to innovations as they reduce the potential benefits, making inventors reluctant to engage in innovative activities (Adu-Danso and Abbey, 2020). IPRs are protected using patents, trademarks and service marks, industrial design rights, and utility models. Among all these tools, patents have received more scholarly attention, and it's generally viewed as the most applied and valuable instrument that grants inventors short-term exclusionary rights allowing them to recapture the benefits of their inventions.

Utility models (UMs) as an intellectual property rights protection tool though essential have received less scholarly attention. Suthersanen (2019) describes UM as a “second-tier patent system” which provides cheaper insulation to inventions. Its properties fall between patent and design laws. UMs are like patents in that the invention being sought for protection should be new and demonstrated to measure the accomplishment of an invention. UMs are usually given without previous examinations to verify the novelty of the invention. UMs grant the holder the exclusive right to use and benefit from their technical invention. This temporary right is granted in exchange for open disclosure of finished or ongoing inventions. Unlike patents, utility models give swift and low-cost protection with no substantive examinations. These reasons make them more accessible to innovators and small businesses than patents. Limited empirical research has focused on utility models and their potential influences on firms' innovations (Torres-Barreto et al., 2016; Heikkilä and Lorenz, 2018; Suthersanen, 2019). A study by Suthersanen (2019) concluded that utility models should be promoted as a more predominant form of intellectual property right in countries as they enhance innovations. Based on the findings of the above-mentioned studies, we expect that small businesses in the Czech Republic will be more likely to acquire European utility models due to their cheap nature and ease of acquiring. When they do acquire European utility models as alternatives to patents, it can contribute to improving innovations. We, therefore, propose the hypothesis that.

Hypothesis 1a: European utility models can positively contribute to small businesses' new-to-market innovation.

Hypothesis 1b: European utility models are positively related to small businesses' general innovations.

Innovation networks have become an essential component of firms' innovation. The open innovation model outlines a new paradigm for business innovation (Gassmann et al., 2010; Chesbrough, 2012). The open innovation model demands firms build alliances with external partners to complement their internal activities intended to promote innovations. Businesses need cooperative learning abilities to produce, disseminate, understand, and incorporate new knowledge from potential partners to enable networks and firm-level innovation development. Though firms have lots of partners to choose from for their innovation development, the alliances between public research organizations (PROs) have received prominent attention. These public research institutions (universities and public or private research centres) are hubs of knowledge that firms need to complement their internal knowledge shortfalls. Research activities undertaken by universities and other PROs further innovation in several ways. The conventional view postulates that such research activities lead to codified knowledge, which manifests in publications. This knowledge is exemplified in technological innovations and inventions that innovative firms can utilize. Firms' direct collaboration with firms in the form of R&D can enable this knowledge to be transferred and used. Firms can also develop and verify new technologies in partnerships with these institutions through synergies and use their laboratories and premises as a suitable testing environment (Bayuo et al.,

2020). Recent research by Barra et al. (2021) in seven European countries found that academic research directly influences firms' tendency to develop innovation. Similarly, Caloghirou et al. (2021) also found that firms' R&D collaborations are essential in shaping firm innovation. In a study of Spanish firms' collaboration, Vega-Jurado et al. (2021) also concluded that small businesses demonstrated to highly benefit and improve their product innovations when they cooperate with PROs. Based on these previous studies, we summarise the understanding that university and PROs research is vital for small businesses' innovation. This external knowledge can complement internal knowledge leading to sustainable innovations. When firms collaborate with these knowledge repositories, they assimilate this new knowledge, an essential catalyst needed to sustain innovations. We expect that small businesses' collaboration with these institutions is likely to enable them to access new knowledge which can contribute to product innovations. We hypothesize that:

Hypothesis 2: SMEs' collaboration with universities and public research organizations will likely induce new-to-market and new-to-firm innovations.

In recent times, the attention given to demand-side policies such as public procurement contracts and their ability to stimulate innovations has increased among policymakers and researchers (Divella and Sterlacchini, 2020; Czarnitzki et al., 2020). Therefore, in simple terms, public procurement can be explained as the purchase of goods and services by public sector organizations mainly governments. The main rationale behind public innovation procurement as an EU and national policy instrument can be inspired by the total amount of governmental demands. Public procurement constitutes a substantial proportion of total demand for goods and services and is progressively seen as a feasible and appealing instrument for promoting innovation policies (Edquist and Zabala-Iturriagoitia, 2020). A fundamental tenet of research on the linkages between innovation, demand, and market structures is built on the Schumpeterian line of reasoning of the positive effect of market power on innovation outcomes. Innovation in the procurement processes may be an essential precursor for the active use of public procurement to stimulate innovations in suppliers and the broader economy. According to Melander and Arvidsson (2020), innovation has become a vital part of the contract bidding and tender process. To win public procurement contracts, it is imperative to be innovative. Firms are required as part of the process to incorporate new technologies and apply sustainable solutions to improve new and existing product development. Public procurement potentially influences innovation because it shapes the demand that exposes firms to competition and subsequently induces them to innovate. For firms, the assurance of a constant demand for their goods and services can significantly rouse innovation as it encourages them to significantly scale up production (Edler and Georghiou, 2007). The assurance of ready demand reduces the uncertainty that allows firms to profit from technological investment and economies of scale to reap huge profits (Storz et al., 2021). The EU's Innovation Union Flagship Program has been constituted to help improve the smooth and effective public procurement markets for innovation within Europe (Blind et al., 2020). The EU initiative aims to overcome the disintegration of EU procurement activities by standardizing support conditions that permit cross-border tenders. This new mandate is strongly encouraged and has become an integral part of calls for tender. The attention to functional specifications helps to reduce the potential risk of too limited tenders. It allows more flexibility for bidders and contractors to find innovative methods of meeting public demands (Blind et al., 2020). A study by Divella and Sterlacchini (2020) conducted on Norwegian and Italian firms found that SMEs, in comparison to larger companies, have a reduced capability to bid in the procurement market. Nevertheless, once they enter and are successful, they become capable of providing innovative solutions to buyers. Similarly, Czarnitzki et al. (2020) study of German firms also found a strong and statistically significant relationship between innovation-focused public procurement and turnover from innovative

products and services. However, studies investigating the relationship between foreign procurement contracts and innovations are scarce to date. We believe that bidding for foreign procurement contracts will mean that innovative companies will be more preferred over non-innovative ones and that foreign procurement contracts are usually competitive and place more emphasis on innovation as one of the selection criteria. Therefore, we expect foreign procurement contracts to be more competitive than local ones. Winning these foreign procurement contracts will likely compel small businesses to adopt innovative approaches to improve product innovation performances. Based on the argument mentioned above, we summarize and hypothesize that:

Hypothesis 3: Acquiring foreign procurement contracts are more likely to influence small businesses' new-to-market and new-to-firm innovations.

The hypothesized relationships established based on the innovation literature above are summarized in [Figure 1](#) below. We test these hypotheses using regression models to confirm or refute if these relationships will exist in our sample of 4,193 small businesses spanning all sectors in the Czech Republic. We classify SMEs as firms that employ less than 250 employees using the community innovation survey measurement.

3. Data source and description of measurements

Data used in this paper was sourced from the Eurostat Community Innovation Survey (CIS) conducted between 2012 to 2014. As of the time of writing this paper, the 2014 dataset is the latest released by the Eurostat safe centre. The CIS is a harmonized survey that collects data and information on firms' innovativeness and innovation activities across various European regions and sectors. CIS data is collected using questionnaires administered through the postal survey. The CIS uses a blend of sample surveys and census of enterprises to get the final population. Enterprises are selected using the stratified random sampling technique with two levels of groupings. Stratification by firm size splits the population of enterprises into three groups of sizes using the total number of employees where small businesses have between (10–49 employees), medium enterprises (50–249 employees), and large firms (more than 250 employees). Firms are also stratified based on economic activities by sectors, which broadly consist of manufacturing and service sector firms. The CIS surveys have become the most important data source for analysing firm-level and regional innovation across Europe. The datasets report on the basic information on firm characteristics (sector, belonging to the enterprise group, and firm's size), innovations (product, process, organizational, and marketing), innovation activities and expenses, impacts of innovation, innovation collaborations, public funding for innovation, public procurement contracts and data on intellectual property rights and licensing. Many researchers have used this data for similar analysis (see [Horbach and Rammer, 2020](#); [Stojčić, 2021](#)). Ethical consideration is not a major issue in secondary data analysis. Despite this, the researchers have carefully evaluated the institution that collected the data (Eurostat), its data collection methodologies, accuracies, time of data collection, reasons for data collection, and the contents of the data to make sure they are reliable, consistent, and credible.

In this study, we focused on small and medium enterprises in the Czech Republic because, according to the Innovation Union Scoreboard classification, the Czech Republic is classified into the moderate innovator group that has performed relatively lower in terms of innovations and lagging the European Union average (European Commission, 2021). The population under study comprises small and medium-scale enterprises with less than 250 employees. The final sample consisted of 4,193 firms (2,832 small firms with below 50 employees classified as micro-enterprises) and (1361 medium enterprises with between 50 and 249 employees). The total number of firms that completed the 2014 CIS survey in the Czech Republic totalled 5,198. [Table 1](#) elaborates on the main characteristics of firms in our sample regarding sectors. The sample's sectoral composition shows that small businesses in the Czech Republic are overrepresented by firms in the manufacturing industry

representing about 61.5%, while firms in the services sector constitute about 38.5%. The most prominent firms in the manufacturing industry are those that manufacture basic and fabricated metal products, followed by those that manufacture furniture, repairs and installation of machinery and wood, paper, printing, and reproduction. The sample's least represented firms were firms in the insurance and pension sector.

3.1. Dependent variables

We used three dependent variables proven to capture the different measures of innovations such as general, major, and minor innovations. The definitions of these variables are adapted from the Eurostat Community Innovation Survey. We measure firms' **general innovation performance** using the total share of annual turnover made from selling new products and services (see [Nylund et al., 2020](#); [Storz et al., 2021](#)). General innovation is a measure defined as the total market sales of goods and services by innovative firms within the years of the survey i.e., 2012 and 2014. When firms effectively adopt innovative ideas, we believe this will significantly impact the ability to introduce new or significantly improved products that meet customers' expectations and subsequently contribute to total turnover in innovative enterprises.

We also introduced two dependent variables that help us to distinguish between product innovations. This helped us to distinguish if the innovations are new-to-market or new-to-firm, a method that has been well used in previous studies (see [Storz et al., 2021](#)). In the CIS 2014 questionnaire, firms were asked if their new product innovations including goods and services are their own products or if these were products manufactured by other enterprises. Product innovations that were just new to the same enterprise are classified as minor innovations whilst product innovations introduced to the market before firms' competitors could be classified as major innovations. These are all binary variables that take the value of 1 if these firms introduced new or significantly improved products onto the market before competitors and 0 if otherwise (**major innovations**). It also takes the value of 1 if firms introduced new or significantly improved products that were previously available from market competitors and 0 if otherwise (**minor innovations**).

3.2. Independent variables

For our covariates, we selected determinants that have been widely used in innovation studies. We used a variable to measure company market orientations ([Nuruzzaman et al., 2019](#)). We distinguished exporting firms as those with international market orientation (exporters). This variable takes values of 1 if these firms' markets export to other EU markets and 0 if they are not exporters.

Innovation activities: We used five variables that capture the activities undertaken by firms to improve their innovation performance following previous studies ([Giannopoulou et al., 2019](#)). The first consist of *external R&D* with the value of 1 implying these firms contracted-out R&D to other businesses or public or private knowledge institutions and 0 meaning otherwise. The second independent variable included in the empirical model focused on *acquiring machinery, software, and other equipment*, taking the value of 1 if the firms procured any of these and 0 meaning they didn't. The third independent variable is *external knowledge*, a measure taking the value of 1 if firms acquired existing know-how, copyrighted works, patented and non-patented inventions from other firms or specialized knowledge organizations to help develop new or significantly enhanced products and processes with 0 meaning they didn't acquire these. Finally, *training for innovative activities* also took the value of 1 if these firms performed training for employees, particularly for the development and introduction of significantly improved and new products and processes, and 0 if otherwise.

Firms' innovation cooperation: We use two sets of dummy variables to capture firms' collaboration. We included partnerships with just knowledge institutions (universities and other public research organizations) that specialized in knowledge production through research. We included

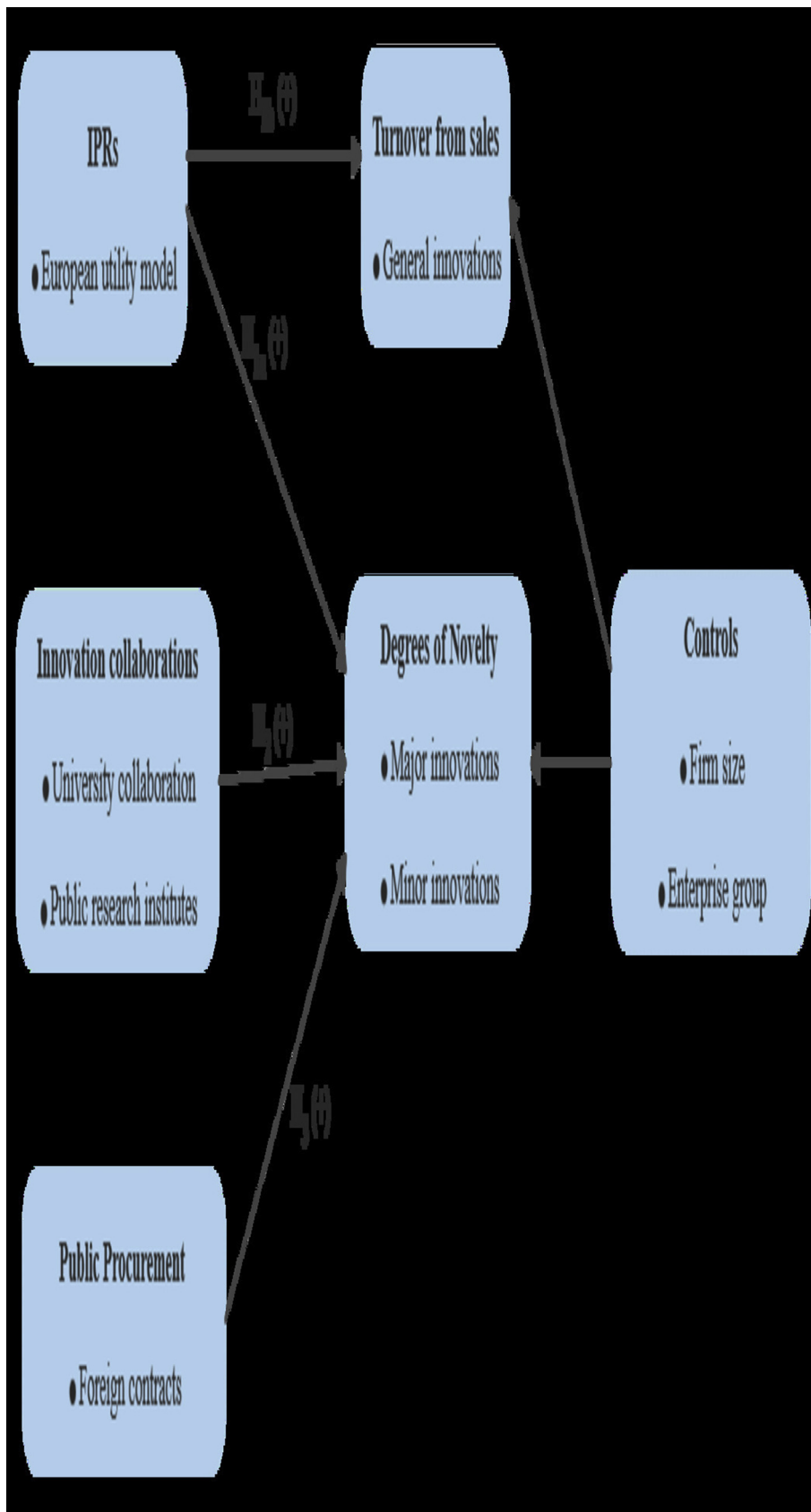


Figure 1. Theoretical model and hypotheses. Source: Authors' elaboration

Table 1. Distribution of sample.

Sectors	N	%
Mining of coal and lignite	67	1.60
Manufacture of food products, beverages, and tobacco	202	4.82
Manufacture of textiles, wearing apparel, leather	290	6.92
Manufacture of wood, paper, printing, and reproduction	352	8.38
Manufacture of petroleum, chemical, pharmaceutical	278	6.63
Manufacture of other non-metallic mineral products	115	2.74
Manufacture of basic and fabricated metal products	768	18.31
Manufacture of furniture, repair and installation of machinery	364	8.68
Electricity, gas, steam, and air conditioning supply	142	3.39
Sewerage, waste management, remediation activities	143	3.41
Wholesale trade, except of motor vehicles and motorcycles	218	5.22
Transportation (land, water, and air)	160	3.82
Warehousing support activities for transportation and courier	136	3.25
Publishing activities	75	1.79
Telecommunications	61	1.45
Financial service activities	53	1.26
Insurance, reinsurance, and pension funding	27	0.64
Activities auxiliary to financial services and insurance	78	1.86
Theatrical and non-theatrical motion pictures, broadcasting	29	0.69
Computer programming, consultancy, information service	294	7.01
Scientific research and development	341	8.13
Total	4,193	100.00

Note: N= Number of companies.

Source: Authors' calculations.

a variable equal to 1 if firms collaborated with universities and other public research organizations and 0 if they didn't have any form of engagement with these institutions.

Public innovation support: we added two dummy variables that focus on innovation funding sources for these firms (Czarnitzki and Lopes-Bento, 2014). They both take the values of 1 if these firms received financial support from the central government and the European Union sources. And 0 meaning they didn't get this support from these two sources.

Intellectual property rights and licensing: The nexus between innovations and intellectual property rights protection has well been established in the innovation literature. In agreement with previous studies (Neves et al., 2021) we used a proxy dummy variable for protecting intellectual property rights, with 1 signifying a firm applied for European utility models and 0 if these firms didn't apply.

Public sector contracts: We used public sector contracts as proxies for public procurement. Following previous studies (see Storz et al., 2021) we set up a dummy variable for public procurement contracts. We included foreign procurement contracts, with values equal to 1 if firms bid for or delivered contracts to foreign public sector clients in 2014 and 0 if they didn't bid for such contracts.

3.3. Control variables

We controlled for other firm-level characteristics which are internal in firms and known to impact their innovation performances along with the *firm size* using the total number of employees a firm has. Firm size helped us distinguish between micro and medium enterprises. *Belonging to the enterprise group* also plays a key role in impacting firms' innovation outcomes (Stojčić, 2021). We added a dummy variable to measure if the firm was part of an enterprise group, with this taking the value of 1 and when the firm was not part of any business group having the value of 0.

3.4. Methods

We developed three separate models to test our hypotheses and estimate firms' innovation outcomes and the various factors capable of

influencing them. We used the Poisson Pseudo Maximum Likelihood (PPML) regression in the first model because our first dependent variable is count data with non-negative values. The PPML regression is a well-known and appropriate model that offers a natural approach to handling count data with zero values as dependent variable. The PPML regression was preferred to other log-linear regressions because, in the existence of heteroskedasticity, the estimations of log-linearized models fitted by, for instance, the Ordinary Least Square (OLS) will be inconsistent (Silva and Tenreyro, 2006; Correia et al., 2020). We used the PPML model applied to the share of sales of new products, which allowed us to account for zero values. We believe that not all firms can make profits from the sale of new products as there will be firms that can break even. So, the PPML regression can be the solution to the zero turnover problems in our data helping us avoid dropping such observations. This regression model also helped us to overcome selection bias, which will not be in the case of the OLS model. We provide the model to capture firms' general innovations using the abovementioned determinants.

Secondly, we used two separate probit regression models to analyse major and minor innovations. The choice of this model is due to the dependent variables for these innovation measures, which are all dichotomous. The probit model was used to estimate the probability that firms' innovation outcomes will fall into specific categories of whether they introduced major or minor innovations. We also calculated the marginal effects after probits to help determine the magnitude of the directions of the relationships. The marginal effects provide good estimates of the amount of change in the outcome variable that a unit change in the covariates will produce. The probit model specification for the innovation outcomes is provided as:

$$Probit(Z_i) = \beta_0 + \beta_1 \text{ parameters}_i + \text{firm characteristics} \lambda + \varepsilon_i \quad [1]$$

Where Z_i takes the values of 1 if the firm introduced major or minor innovations and 0 meaning they didn't introduce any of these. β_0 is the constant, β_1 are the parameters, firm characteristics λ is the vector, and ε_i is the random error term.

In the second stage of our analysis of the binary data using the probit models, we employed the regression adjustment doubly robust treatment effect estimation technique. The treatment effects analyse the causal effects of treatments on outcomes of interest. Though we believe the probit model is an efficient and coherent estimator, it can be contaminated with principal econometric problems of confounding and selection biases. Using the treatment effect analysis can help correct these key econometric problems. Regression adjustment is a popular technique for estimating more unbiased, robust average treatment effects (Liu and Yang, 2020; Negi and Wooldridge, 2021). Using the regression adjustment method also helped us manage and eliminate all potential problems related to endogeneity leading to robust results (Negi and Wooldridge, 2021). We modelled the outcome variables with major and minor innovations and the treatment dependent variables as the various variables which focus on firms' market orientations, R&D activities, R&D collaboration, intellectual property rights, and public procurement contracts. The regression adjustment also helped determine the additional effects these treatment variables have on major and minor innovation outcomes. For the outcome model estimation, we used the probit model.

4. Analyses and results

Table 2 presents the results of the descriptive statistics of variables used in our study and the Pearson chi-squared test analysis. The results show that the average turnover of these firms is about 97762.01 Czech Crowns. Regarding market orientation, about 59% of these firms are exporters to other markets in the European Union. We used two other variables to measure innovations, and the results point out that a little over half of these firms are major innovators (52%), while 77% can be classified as minor innovators. Across the sampled firms, about 73% of the firms acquired new machinery during the period 2012 and 2014. Few firms, about 14% reported having acquired knowledge from external

Table 2. Descriptive statistics and Pearson chi-squared analysis results.

Variables	Mean	Major innovations		Minor innovations	
		χ^2	P-value	χ^2	P-value
Turnover (million Czech Crowns)	9776201				
Major Innovations	0.52	-	-	-	-
Minor innovations	0.77	-	-	-	-
Exporting	0.59	94.377***	0.000	79.259***	0.000
External R&D	0.45	5.950**	0.015	4.843*	0.028
Acquisition of machinery	0.73	0.194	0.660	0.421	0.516
External knowledge	0.14	27.195***	0.000	3.552*	0.059
Innovative trainings	0.45	25.080***	0.000	26.456***	0.000
National funding	0.27	20.258***	0.000	8.154**	0.004
EU funding	0.21	94.377***	0.000	3.270	0.071
University cooperation	0.06	281.902***	0.000	175.624***	0.000
Public research cooperation	0.03	139.844***	0.000	65.393***	0.000
EU utility model	0.04	156.747***	0.000	35.483***	0.000
Foreign procurement contract	0.02	41.530***	0.000	52.127***	0.000
Part of business group	0.27	32.865***	0.000	59.190***	0.000
Firm size	1.32	58.872***	0.000	71.028***	0.000

Source: Authors' calculations.

Note: Sector dummies not included in descriptive statistics. Pearson χ^2 not calculated for General innovations due to its count nature. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

sources. Approximately 45% of these firms reported having carried out innovation training for their employees. The mean value for external research and development is about 0.45, meaning that 45% of small businesses reported having engaged in R&D externally. The results on innovation funding show that domestic funding from the central government was dominant. About 27% of firms reported having received this funding, while 21% reported having received funding from the European Union.

The results show that small business cooperation in the Czech Republic is low in terms of innovation cooperation. Just 6% of these firms reported having formal cooperation with universities for new product and process innovations. On the other hand, just 3% of these firms stated to have cooperated with other public research organizations. The results on collaborations demonstrate that firms perceive less importance to networking with other entities for innovations. This result of weak firm synergies in the Czech Republic and other Visegrad countries is supported by other empirical studies (see Odei and Stejskal, 2020; Zygumt, 2020). The results also show the comparative significance and utilization rates of the various intellectual property rights instruments. About 4% of firms in the sample reported applying for and using EU utility models. About 2% of firms reported having bid for or delivered foreign procurement contracts. About 27% of these small businesses are part of the enterprise group. Finally, most of the firms in the sample are classified as micro-enterprises with less than 50 employees.

Table 2 also shows the results of the Pearson chi-squared (χ^2) goodness of fit test to determine the associations between exporting, innovation activities, collaboration, public procurement contracts, utility models, firm characteristics, and small businesses' product innovations (major and minor). The Pearson chi-squared (χ^2) results revealed that all the selected variables have significant associations with major innovations except for the machinery acquisitions. On the other hand, there are also significant associations between minor innovations and all selected variables except for the machinery acquisitions and EU funding variables. All the regression coefficients, marginal, and average

treatment effects of the model specifications in Tables 3, 4, 5, and 6 include carefully selected control variables and the various independent variables. Table 3 presents the results of the estimation of SMEs' general innovations using sensitivity analysis by introducing each group of independent variables separately (specifications 1–6, while model 7 is the combined model using all variables). Model 1 explains the relationship between SMEs' general innovations and marketing orientations (Table 3). We find insufficient evidence that exporting to other EU market induce general innovations by ($\beta = -0.689$, $p < 0.05$). In Table 3 (model 3), we find that subsidies from central governments and European Union sources are statistically significant but negatively correlated with SMEs' general innovations ($\beta = -0.571$, $P < 0.01$; $\beta = -0.437$, $P < 0.001$). However, we find compelling evidence that central government funding positively correlates with major and minor forms of innovation ($\beta = 0.288$, $P < 0.001$; $\beta = 0.191$, $P < 0.01$).

Our hypothesis 1a sought to examine whether European utility models positively influence major forms of innovation. We find that applying for European Union utility models has a positive and statistically significant relationship with the ability of small businesses to introduce major forms of innovation ($\beta = 1.121$, $P < 0.001$). This result means that our hypothesis 1a is fully supported. However, regarding hypothesis 1b, we find no evidence in support of it. We find a negative but statistically significant correlation between EU utility models and general innovations ($\beta = -0.531$, $P < 0.001$). We, therefore, reject our hypothesis 1b.

We also find that small businesses' cooperation with universities and other public research organizations had no positive and statistically significant influence on general innovations. The collaborations with universities had negative but statistically significant relations ($\beta = -0.571$, $P < 0.01$). On the other hand, cooperation with public research institutions was not statistically significant in inducing general innovation ($\beta = 0.404$, $P > 0.05$). However, in the models for major innovations in Tables 4 and 5, the results of collaborations fully confirm our hypothesis 2, suggesting that SMEs' collaboration with these knowledge institutions is likely to positively impact major and minor forms of innovations. We find evidence in our sample that both collaborations are likely to have positive influences on major forms of innovation ($\beta = 1.002$, $P < 0.001$; $\beta = 0.566$, $P < 0.001$) and minor forms of innovation ($\beta = 0.862$, $P < 0.001$; $\beta = 0.308$, $P < 0.05$).

Our hypothesis 3 proposing that small businesses' major and minor forms of innovation are likely to be positively influenced when they apply for foreign procurement contracts is also fully supported. Our results show that when these firms apply for foreign procurement contracts, it rather exerts a negative effect on general innovations ($\beta = -0.591$, $P < 0.001$). Contrary, the results were however positively supported for major forms of innovation as shown in Table 4 ($\beta = 0.739$, $P < 0.001$) and minor forms of innovation in Table 5 ($\beta = 0.864$, $P < 0.001$).

Surprisingly, we find that innovation activities undertaken by SMEs in the Czech Republic were not statistically significant in influencing general innovations. However, our results in Table 4 (model specification 2) show that the only innovation activity that showed to positively influence major innovation was external research and development ($\beta = 0.175$, $P < 0.05$) and external knowledge ($\beta = 0.229$, $P < 0.05$). Also, for minor forms of innovation, we found that innovative training was the only statistically significant factor ($\beta = 0.330$, $P < 0.001$). The results on the marginal and treatment effects in Table 6 show that European utility models ($\beta = 0.321$, $P < 0.001$) had a marginal influence on major forms of innovation. Foreign procurement contracts ($\beta = 0.147$, $P < 0.05$) have a marginal influence on minor forms of innovation. An additional increase in foreign procurement contracts leads to a marginal rise in minor forms of innovation to about 16 percentage points. Innovation training demonstrated to have marginal effects on both major and minor forms of innovations ($\beta = 0.077$, $P < 0.05$; $\beta = 0.115$, $P < 0.001$). Any additional increases in these innovation training correspondingly increase major forms of innovation marginally by 8 percentage points and minor innovations by 12 percentage points respectively. The results of the

Table 3. Regression analysis of factors driving general innovations.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Exporting	-0.689* (0.299)						-0.177 (0.174)
External R&D		-0.236 (0.135)					-0.208 (0.136)
machinery Acquisition		-0.218 (0.134)					-0.185 (0.140)
External knowledge		0.154 (0.164)					0.167 (0.167)
Innovative trainings		0.064 (0.125)					0.057 (0.128)
National funding			-0.571** (0.192)				-0.096 (0.153)
EU funding			-0.437*** (0.126)				-0.069 (0.113)
University cooperation				-0.552** (0.187)			-0.256 (0.240)
Public research cooperation				0.404 (0.307)			0.511 (0.476)
EU utility model					-0.531*** (0.160)		-0.105 (0.146)
Foreign procurement contract						-0.591*** (0.171)	-0.132 (0.128)
Constant	14.041*** (0.511)	12.911*** (0.261)	12.868*** (0.308)	13.897*** (0.512)	13.901*** (0.513)	13.915*** (0.512)	12.961*** (0.292)
Control variables							
business group	1.743*** (0.276)	0.628*** (0.119)	1.028*** (0.195)	1.666*** (0.262)	1.652*** (0.260)	1.663*** (0.261)	0.622*** (0.113)
Firm size	1.049** (0.372)	1.744*** (0.139)	1.844*** (0.207)	0.920** (0.360)	0.921** (0.362)	0.905** (0.361)	1.821*** (0.153)
Pseudo R ²	0.277	0.400	0.318	0.256	0.255	0.254	0.419
N	4193	892	1,642	4192	4,193	4193	892
Prob > chi ²	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

Source: Authors' calculations.

Note: dependent variable: turnover from sales of new products, *p < 0.05, **p < 0.01, ***p < 0.001.

Heteroskedasticity robust standard errors in parentheses. Industry dummies not included in the regression.

Model estimated using the Poisson pseudo maximum likelihood (PPML) regression.

Table 4. Regression analysis of factors driving major innovations.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Exporting	0.289*** (0.085)						0.094 (0.111)
External R&D		0.175* (0.089)					0.073 (0.092)
Machinery acquisition		0.158 (0.101)					0.101 (0.103)
External knowledge		0.229* (0.119)					0.182 (0.123)
Innovative trainings		0.176 (0.095)					0.203* (0.097)
National funding			0.288*** (0.078)				0.008 (0.107)
EU funding			0.081 (0.085)				0.198 (0.116)
University cooperation				1.002*** (0.098)			0.095 (0.122)
Public research cooperation				0.566*** (0.140)			0.232 (0.167)
EU utility model					1.121*** (0.114)		0.611*** (0.165)
Foreign procurement contract						0.739*** (0.139)	0.145 (0.191)
Constant	-0.293** (0.120)	-0.242 (0.152)	-0.416*** (0.101)	-1.405*** (0.079)	-1.367*** (0.078)	-1.428*** (0.077)	-0.247 (1.164)
Control variables							
business group	-0.040 (0.080)	-0.055 (0.095)	0.049 (0.072)	0.136* (0.060)	0.212*** (0.059)	0.171*** (0.058)	-0.039 (0.098)
Firm size	0.100 (0.080)	0.018 (0.092)	0.037 (0.071)	0.237*** (0.057)	0.239*** (0.056)	0.317*** (0.055)	-0.088 (0.097)
Pseudo R ²	0.010	0.019	0.011	0.082	0.051	0.029	0.048
N	1196	849	1541	3433	3433	3433	849
Prob > chi ²	0.001***	0.001***	0.000***	0.000***	0.000***	0.000***	0.000***

Source: Authors' calculations.

Note: Heteroskedasticity robust standard errors in parentheses. Industry dummies not included in the regression.

Model estimated using the probit model, *p < 0.05, **p < 0.01, ***p < 0.001.

Average Treatment Effects (ATE) of the population are also presented in Table 6. For the model with major forms of innovation, the regression adjustment results show that only machinery acquisitions do not produce additional effects. Regarding minor forms of innovation, we also found that machinery acquisitions and EU funding do not have additional influence.

The results of the control variables show that firm size (micro-enterprises versus medium enterprises) exerted a statistically significant and positive effect on general innovations (see Table 3, specifications

1–6). These results mean that medium enterprises are more likely to be innovative than micro-enterprises. Therefore, size positively influences general innovations (Gherghina et al., 2020). Similar results were also found for the second control variable belonging to the enterprise group. Our results show that being part of the enterprise group could positively impact small businesses' general innovations. However, size and belonging to the enterprise group produced mixed results on major and minor innovations as seen with the insignificant and negative results in Tables 4 and 5.

Table 5. Regression analysis of factors driving minor innovations.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Exporting	0.347*** (0.051)						0.152 (0.114)
External R&D		0.158 (0.092)					0.107 (0.094)
machinery Acquisition		0.020 (0.105)					0.017 (0.106)
External knowledge		-0.103 (0.122)					-0.128 (0.124)
Innovative trainings		0.330*** (0.099)					0.330*** (0.100)
National funding			0.191** (0.079)				0.139 (0.099)
EU funding			0.091 (0.086)				-
University cooperation				0.862*** (0.097)			-
Public research cooperation				0.308* (0.140)			-
EU utility model					0.524*** (0.112)		-
Foreign procurement contract						0.864*** (0.138)	0.422* (0.212)
Constant	-1.240*** (0.073)	0.145 (0.155)	0.198* (0.101)	-1.102*** (0.071)	-1.096*** (0.071)	-1.128*** (0.071)	0.070 (0.168)
Control variables							
business group	0.232*** (0.054)	0.152 (0.100)	0.132 (0.073)	0.233*** (0.055)	0.275*** (0.054)	0.254*** (0.054)	0.148 (0.100)
Firm size	0.240*** (0.052)	0.012 (0.096)	-0.046 (0.071)	0.243*** (0.052)	0.272*** (0.052)	0.299*** (0.051)	-0.045 (0.100)
Pseudo R ²	0.035	0.021	0.006	0.055	0.029	0.033	0.029
N	3429	849	1540	3429	3429	3429	849
Prob > chi ²	0.000***	0.001***	0.014**	0.001***	0.001***	0.001***	0.001***

Source: Authors' calculations.

Note: Heteroskedasticity robust standard errors in parentheses. Industry dummies not included in the regression.

Model estimated using the probit model, *p < 0.05, **p < 0.01, ***p < 0.001.

Finally, the results in Table 7 focused on sectoral dummies. The results demonstrate that some sectors are more likely to be innovative than others. Regarding general innovations, measured the share of sales from new products (turnover) between 2012 and 2014. These results show that firms that manufacture basic metals, motor vehicles, trailers, and semi-trailers, electricity, gas, steam, and air conditioning supply, wholesale trade, air transport, financial service activities, insurance, reinsurance, and pension funding, the manufacture of petrochemicals, pharmaceutical, rubber, and plastic products were all likely to be innovative with higher turnovers. As expected, firms in the manufacture of textiles, wearing apparel and leather, manufacture of wood, paper, printing, and reproduction are not likely to be innovators. However, we have found that firms that manufacture other non-metallic mineral products ($\beta = 1.006$, $P < 0.05$), architectural and engineering activities

($\beta = 1.085$, $P < 0.05$), and scientific research and development ($\beta = 1.280$, $P < 0.05$) were likely to be major innovators.

5. Discussion

Previous research on firm-level innovations in the Czech Republic has mainly focused on using determinants such as innovation activities, innovation subsidies, and firms' cooperation to measure innovation outcomes. The numerous previous studies ignored two vital factors that could positively influence firm-level innovations i.e., issues of public procurement and intellectual property rights. The omission of these variables means that innovation outcomes are underestimated. This paper has dealt with these important issues using a harmonized survey applied to a sample of innovative small businesses from the Czech

Table 6. Results of marginal effects and average treatment effects estimations.

Variables	Marginal effects		Treatment effect	
	Major innovations	Minor innovation	Major innovations	Minor innovations
Exporting	0.036 (0.042)	0.053 (0.040)	0.131*** (0.012)	0.138*** (0.015)
External R&D	0.028 (0.035)	0.037 (0.033)	0.084** (0.034)	0.071* (0.032)
machinery Acquisition	0.038 (0.039)	0.006 (0.037)	-0.012 (0.028)	-0.018 (0.028)
External knowledge	0.069 (0.046)	-0.045 (0.043)	0.183*** (0.035)	0.066* (0.034)
Innovative trainings	0.077* (0.036)	0.115*** (0.034)	0.126*** (0.025)	0.129*** (0.025)
National funding	0.003 (0.040)	0.048 (0.035)	0.126*** (0.028)	0.080** (0.027)
EU funding	0.075 (0.044)	-	0.075** (0.031)	0.055 (0.030)
University cooperation	0.036 (0.046)	-	0.435*** (0.033)	0.396*** (0.032)
Public research cooperation	0.087 (0.063)	-	0.427*** (0.046)	0.336*** (0.046)
EU utility model	0.321*** (0.061)	-	0.425*** (0.043)	0.233*** (0.044)
Foreign procurement contract	0.055 (0.072)	0.147* (0.074)	0.273*** (0.054)	0.352*** (0.053)
Control variables				
business group	-0.015 (0.037)	0.052 (0.035)	0.084*** (0.016)	0.130*** (0.018)
Firm size	-0.033 (0.036)	-0.016 (0.035)	0.105*** (0.015)	0.134*** (0.016)
N	849	849	3433	3429

Source: Authors' calculations.

Note: Robust standard errors in parentheses, treatment effects estimated using the regression adjustments estimator.

Outcome model of the treatment effects estimated using the probit model, *p < 0.05, **p < 0.01, ***p < 0.001.

Table 7. Regression models with sectoral dummies.

Sectors	General innovations	Major innovations
Manufacture of textiles, wearing apparel and leather	-1.496***(0.285)	
Manufacture of wood, paper, printing, and reproduction	-0.917***(0.237)	
Manufacture of basic metals and fabricated metal products	0.794**(0.298)	
Manufacture of transport equipment	0.629**(0.235)	
Manufacture of other non-metallic mineral products	-	1.006*(0.565)
Manufacture of basic metals	0.794**(0.298)	
Manufacture of motor vehicles, trailers, and semi-trailers	0.629**(0.235)	
Manufacture of furniture	-0.736**(0.238)	
Other manufacturing	-0.634**(0.253)	
Electricity, gas, steam, and air conditioning supply	3.084***(0.418)	
Wholesale trade, except of motor vehicles and motorcycles	1.076***(0.256)	
Land transport and transport via pipelines	-0.715**(0.229)	
Water transport	-1.293**(0.533)	
Air transport	1.672*(0.794)	
Telecommunications	-0.807**(0.260)	
Financial service activities	1.365***(0.265)	
Insurance, reinsurance, and pension funding	2.130***(0.410)	
Architectural and engineering activities	-0.626**(0.228)	1.085*(0.572)
Manufacture of refined petroleum, chemicals and products	0.909***(0.277)	
Publishing, audiovisual and broadcasting activities	0.832*(0.375)	
IT and other information services	-0.689***(0.210)	
Scientific research and development	-	1.290*(0.575)
Constant	15.639***(0.187)	-0.431 (529)
N	4193	1187
Pseudo R ²	0.345	0.048
Prob > chi ²	0.000***	0.000***

Source: Authors' calculations.

Note: Heteroskedasticity robust standard errors in parentheses. Only sectors that are statistically significant reported. Model for minor innovations not included because none of the sectors were found to be statistically significant. General innovations model estimated using ppml estimator, major innovations model estimated using the probit model. *p < 0.05, **p < 0.01, ***p < 0.001.

Republic. We combined these new variables that focused on intellectual property rights and public procurement contracts with some other variables widely used and have been proven to influence innovation outcomes positively. Our results have shown the importance of international markets as avenues capable of inducing major and minor forms of innovations. These results are as expected because the descriptive statistics show that more than half of these small businesses are reported to be exporters to other European markets. These markets in other EU countries where these small businesses export are avenues for interactions, collaborations, and competitions with other firms and end-users of their outputs for feedback. The feedback and the intense competition that characterize these markets could be vital for these small businesses' innovations. The results of the ATE confirm the importance of international markets to small businesses' innovations. Exporters are shown to be 13 percentage points capable of improving both major and minor innovations, and all firms that internationalize aim to be market leaders to command the largest market share in terms of profits and customers. This development compels them to adopt innovative ideas and production processes. These markets can also serve as learning platforms for these firms to “copy and imitate” new ideas and knowledge that their

competitors have used. Competition among firms in the market can spur the development of new or improved products and efficient processes. Through this market competition, businesses can recognize consumers' needs and expectations and develop innovative products or services to satisfy these needs. Exporting and moving into new markets can help firms to increase their knowledge of production processes existing in these markets. Our result is supported by similar research conducted in China by Wu et al. (2015), who also found that expanding into foreign markets with well-established institutions helps exporting firms enhance their innovation performance. Bodlaj, Kadic-Maglajlic and Vida (2020) also found similar results in their study of SMEs in Central and Eastern Europe (CEE). They found that exporting SMEs benefit more from innovations when they expand geographically.

Our results show that small business innovation cooperation significantly enhances major and minor innovations, albeit the descriptive statistics show that these collaborations are low. However, this was not the case for general innovations, where small business collaboration with knowledge centres was found to be negatively correlated. These vital collaborations have increased effects on major than minor innovations. As proven by the ATE results, small businesses that reported collaborating with universities can improve their major forms of innovation on average by 44 percentage points in comparison to firms that do not collaborate. The same applies to collaborations with other public research organizations, which can stimulate major forms of innovation by 43 percentage points better than non-cooperating firms. On the other hand, when it comes to minor forms of innovation, the ATE results show that firms that collaborate with universities are likely to improve their minor forms of innovation by 40 percentage points better than firms that do not collaborate. The same trend was witnessed for collaboration with public research organisations which proved to likely improve minor forms of innovation by 34 percentage points. These results show that collaborations with universities have the highest effect on major innovations in comparison to minor forms of innovations and the results are all as expected because innovations require new research, ideas, and knowledge that these knowledge institutions produce to be successful and sustainable. These knowledge institutions play an important role in creating and disseminating new knowledge that firms can adopt in their innovation activities (Odei and Stejskal, 2020). These interactions with knowledge institutes can also grant firms access to specialized knowledge paving the way for high-quality research capable of generating new opportunities for innovation development. Our result is identical to other previous findings that all concluded that these knowledge institutions promote innovations in firms (Radacic et al., 2020; Hernández-Trasobares and Murillo-Luna, 2020). However, our results need to be understood and interpreted as knowledge from these institutions can help complement firms' innovation activities rather than being absolute substitutes (Tether and Tajar, 2008).

The results also confirm the significance of central government innovation funding as a significant determinant of small businesses' major and minor forms of innovations. This result is not surprising because the descriptive statistics confirmed this is the dominant form of innovation funding. As shown by the results of the ATE, innovation funds from central government sources have added effects on these innovation types. Small businesses that received innovation funding from the Czech government are likely to improve their major innovations by 13 percentage points vis-a-vis those that didn't get this support. On the other hand, firms that reported receiving central government funding were also probable to improve their minor innovations by 8 percentage points. Surprisingly, the analysis did not confirm the significance of EU funding on all small businesses' innovations in the Czech Republic. For general innovation outcomes, receiving funding from the European Union and central government sources did not likely influence general innovations. Regarding major and minor forms of innovations, our results suggest that public innovation support instruments from European Union sources are not an effective determinant. Nevertheless, the ATE provides a different result on the ineffectiveness of EU funding. The ATE result found that

small businesses that received EU funding are likely to increase their major innovations by 8 percentage points. This result means the EU funding did not have any additionality effects on minor innovations. The descriptive statistics result established that few small businesses reported having received this funding; hence the results are not surprising. The results show that public support, especially those from EU sources, is ineffective and does not achieve its desired results of inducing innovations. These results are contrary to our expectations as these instruments aim to enhance innovations, and R&D, which improve firms' innovations and competitiveness. These results could be attributed to the allocation inefficiencies that characterize this funding support. Financial allocations for innovation follow the centralized top-down approach characterized by tight bureaucracies and reduced interactions between funding recipients, technocrats, and experts. This inefficiency of EU funding requires further research to unravel the reasons behind the ineffectiveness of EU funding support for innovations across new EU member countries. The results on EU funding contradict other previous studies conducted in Slovakia, the Czech Republic, Hungary (Odei et al., 2021), and Dvouletý et al. (2021) in the Czech Republic, which found that innovation funding significantly influenced firm-level innovations.

Though the descriptive statistics show that fewer firms from the sample reported having applied for EU utility models, the regression results show that applying intellectual property rights protection enhances innovations. We find that EU utility models are positively associated with major and minor forms of innovations. We observe that EU utility models have additionality impacts on major and minor forms of innovations, as shown by the ATE results. Small businesses that apply and possessed EU utility models can improve their major forms of innovations by 43 percentage points in comparison to those without EU utility models. Similarly, EU utility models are likely to improve minor innovations by 23 percentage points compared to firms without. These results highlight the role that the EU utility models play in facilitating major and minor forms of innovations in small businesses in the Czech Republic. These results mean that EU utility models as a form of intellectual protection are likely to impact minor and major forms of innovations positively. This is because an EU utility model relieves small businesses of the concerns about disclosing information concerning new products and processes. With their knowledge and inventions protected, they become more open to innovating or sharing their inventions with others (Heikkilä and Lorenz, 2018). This IPR tool contributes to innovations because it allows access to new technologies and knowledge. Since this tool guarantees exclusive ownership to innovators, it can provide adequate incentives for small businesses to invest in research and development, which is a catalyst for innovations. This result is not surprising because the descriptive statistics show that firms prefer the EU utility models to patents, probably due to its low acquisition cost and swift granting times. This protection allows firms to innovate without fear, thus increasing and strengthening the public knowledge base, which can further technological innovations (Suthersanen, 2019). This result contradicts the traditional view that utility models are intended to cover minor forms of innovations (see Heikkilä and Verba, 2018).

The positive influences that innovation training, external R&D and external knowledge have on small businesses' major and minor forms of innovation outcomes can be observed in the sampled firms. Firms that reported undertaking these innovation activities demonstrated to gain from them in terms of improved innovations positively. Our ATE results show that small businesses that engage in external R&D are more likely to improve their major innovations by 8 percentage points compared to firms that did not carry out external R&D. Similarly, conducting external R&D increases the likelihood of contributing to minor forms of innovations by 7 percentage points. This result may be explained by the fact that engaging in external R&D can help firms increase their capabilities to absorb new knowledge and technologies. This can make firms more likely to successfully introduce novel products and processes. Our result on the importance of external R&D on innovation outcomes in the Czech Republic has been confirmed by related studies (Odei and Stejskal,

2018; Zygmunt, 2020). Though in the individual models, most of the small businesses' innovation activities demonstrated not to influence all measures of innovations, the ATE results proved otherwise. External knowledge is also likely to result in additionality effects on major and minor forms of innovations. Small businesses that acquire external knowledge can improve their major forms of innovations by 18 and minor forms of innovations by 7 percentage points respectively. These are as expected because external knowledge from diverse sources can complement in-house knowledge that can infuse new ideas needed to spur innovations. However, for external knowledge to be beneficial to firms, they need to improve their absorptive capacities to assimilate and utilize this knowledge. This result on the impact of external knowledge on firm-level innovations is supported by similar research in the manufacturing firms in the Czech Republic (Odei and Stejskal, 2018). Innovation training undertaken by small businesses has also shown to have positive spillovers that are likely to contribute to both major and minor innovations. Small businesses engaged in innovation training are about 13 percentage points likely to improve both major and minor innovations compared to those not engaging in this training. Innovation training is a source of new knowledge required to sustain the innovation process. The result of the positive impact innovation training exerts on firms' innovation outcomes is also supported by a related study in the Czech Republic (Odei et al., 2021).

We contribute to the discussion on public procurement and its potential to enhance firm-level innovations in Visegrad countries. Though research on public procurement continues to receive scholarly interest from researchers (Czarnitzki et al., 2018; Georghiou et al., 2014; Storz et al., 2021), there is little evidence found for research of this kind in the Czech Republic and other Visegrad countries. We found the study by Stojčić et al. (2020) as the only research on public procurement and its potential impact on innovations in eight Central and Eastern European countries. Their results showed that national procurement contracts was a significant factor influencing general innovations within the sampled firms. However, we find that foreign procurement contract was statistically significant and exerted a positive influence on major and minor forms of innovations in the Czech sampled firms. Foreign procurement contracts have both marginal and additionality effects on major and minor forms of innovations. Foreign procurement contracts, however, proved to influence general innovations negatively. As shown by the ATE results, firms that won foreign procurement contracts were more likely to improve their major forms of innovations by 27 percentage points and minor forms of innovations by 35 percentage points. These results show that foreign procurement contracts have greater additionality effects on minor innovations than major innovations. These results can be attributed to the fact that serving foreign firms and customers compels these firms to adopt innovative solutions to meet customers' demands and expectations. Serving foreign customers may necessitate improved production, logistical solutions and delivery methods, as swift and prompt delivery is indispensable for an efficient supply chain. Our results differ from recent studies on procurement and general innovations (Rocha, 2018; Fernández-Sastre and Montalvo-Quizhpi, 2019). However, Storz et al. (2021) studies on Chinese small businesses found that domestic public procurement influences major innovations. Based on these results, we argue that firm managers and policymakers seeking to boost their innovation capabilities should place a stronger emphasis on securing foreign procurement contracts. It has been shown to influence small businesses' major and minor forms of innovations positively.

6. Summary and limitations

This study proposes a model to study small and medium-scale enterprises' innovation from the perspective of general, major, and minor innovations. We argue that there are numerous studies conducted in the Czech Republic on firm-level innovations. But these studies have not focused on small businesses which play vital roles in economic health. This study aimed at assessing the factors driving small businesses'

innovation performance, specifically using new sets of determinants new to research in Visegrad countries. We find that the successful innovation of small businesses depends on the combination of several factors. The results of the empirical model specifications showed that small businesses' general innovations measured with the share of sales of new products (turnover) was not influenced by exporting, innovation subsidies from central and EU governments, collaborations with knowledge institutions, and foreign procurement contracts. We find that innovation activities carried out by small businesses do not significantly influence their general innovations. Strikingly, we also find that intellectual property rights do not influence general innovations.

Additionally, we distinguished between minor and major forms of innovations. Our results show that small businesses' major forms of innovation are significantly and positively influenced by exporting to other European Union countries. In the econometric assessment, the trend we expected for SMEs is validated. We found that the only innovation activities undertaken by small businesses likely to influence major forms of innovations positively and significantly are external research and development and innovative training. We found no evidence of EU subsidies influencing all measures of innovations in the Czech Republic, though central government funding positively influenced small businesses' major and minor innovations. Regarding intellectual property rights, our results show that acquiring utility models from the EU is likely to influence major and minor forms of innovations positively. Finally, the results show that the factors that significantly influence minor innovations within these small businesses are exporting, innovative training, national funding, and foreign procurement contracts. We again find that innovation collaboration with knowledge repositories significantly influences minor forms of innovation, and the results show that subsidies from EU sources do not stimulate minor forms of innovation.

Our key findings have implications for the burgeoning literature on intellectual property rights, internationalization, university-industry cooperation, and public procurement. These call for the design of policies and strategies to strengthen the innovation of small businesses in transition economies. We contribute to the literature on intellectual property rights and their ability to enhance SMEs innovations. The scholarly attention given to this vital determinant of innovation is meagre, we found limited studies in this regard in both developing and transition economies. In the case of Visegrad countries, we found few studies that used EU utility models as a determinant of firms' innovation. We argue that ignoring this will mean that we will underestimate firm-level innovations and be unable to get a detailed understanding of firms' innovations and their levels of novelties. We have shown that the EU utility model is an essential factor that can significantly enhance major and minor forms of innovations. We contribute to the literature on intellectual property rights by showing that small businesses benefit when they acquire EU utility models. This result calls for policymakers to strengthen intellectual property rights policies to harmonize with other innovation policy instruments that support firms' innovation performance. Consistency among these policy initiatives will be critical to safeguarding the efficiencies of existing IPR policies and their governance mechanisms.

Our paper theoretically contributes to the literature on innovations and a resource-based view in transition countries, particularly the literature on public procurement's role in influencing innovations. We find that very little research has paid attention to public procurement as a key driver of innovations in Eastern European countries. The only study on this topic was that done by [Stojčić et al., in 2020](#). Our work extends this previous study by incorporating foreign procurement contracts into small businesses' innovation. We found compelling evidence that small businesses benefit from foreign procurement contracts, and this was vital in stimulating major and minor forms of innovations. Our result pointed out that bidding for and delivering goods and services to foreign clients spearhead major and minor forms of innovation. Bidding for foreign contracts is vital as it compels small businesses to adopt innovative ideas and methods in the production and logistic deliveries to meet foreign

clients' and customers' needs. These results call for policies to make the bidding and public procurement process transparent and competitive, using sustainable innovations as a selection criterion. Public procurement policies should be bottom-up and aim at providing the necessary incentives, skills, and abilities to allow public buyers to develop their own strategic decisions that will accelerate innovations. Besides, these policies should also make provisions to facilitate coordination and collaboration within and across the various tiers of government, purchasing units, and government departments ([Lember et al., 2015](#)).

Our paper's second theoretical implication is its contribution to the literature on intellectual property rights and innovation. Most studies on IPRs' influence on innovations have focused on using patents as technical invention protection while ignoring other types of protection. We have demonstrated that European utility model as an IPRs tool positively correlates with small businesses' innovation performances. European utility models proved to have a positive influence on major and minor forms of innovations in the sampled small businesses. This result contributes to expanding the existing research and knowledge on the potential influence European utility models have in enhancing small businesses' innovations. We have shown that small businesses that use European utility models will likely introduce major and minor innovations.

Our results also have managerial and policy implications, they significantly contribute to a better understanding of the benefits small businesses gain from their collaborations with knowledge institutions. We have shown that small businesses in the Czech Republic benefit from their cooperation with universities and other public research organizations. These interactions were demonstrated to enhance major and minor innovations positively. One main implication that emerges from the results is that firms do not still value the benefits of cooperating with knowledge institutions (universities and other public research organizations). According to [Vega-Jurado et al. \(2021\)](#), this trend is widespread in countries with low absorptive capacities. This calls for policymakers and firm managers to devise strategies to make these alliances more profitable to allow firms to improve their innovative capabilities and access useful knowledge from these institutions. Innovation policies designing should assist in solving institutional conflicts of interests that undermine successful university-industry synergies. Therefore, universities, public research institutions, and firms must be involved in the innovation policy designs and implementation. The second managerial implication is that small business managers in the Czech Republic need to focus on acquiring European utility models for the protection of intellectual property rights. This is demonstrated to provide a cheaper alternative to patents but serves the same purpose and can influence innovativeness within these firms. Our empirical estimations results have also shown the important contributions of international markets to small businesses' minor and major innovations. Firm managers need to encourage internationalization through direct exporting to other European markets because these markets are avenues to acquire new knowledge and technologies that can spur innovations. Policies should focus on tariff and non-tariff entry obstacles and other legal restrictions that limit small businesses' participation in international trade. These entry obstacles must be reviewed to ensure they are favourable for small businesses. Finally, the results have pointed to the importance of public procurement as a demand-side policy that can stimulate small businesses' innovations. Small businesses are encouraged to actively participate in foreign procurement bidding as it can help to improve their innovation performance.

The paper has few limitations that need to be acknowledged. First, we used data spanning 2012 and 2014, the current anonymised data released by Eurostat at the time of writing this research. This means that the results will not truly reflect the status quo of small businesses' innovations in the Czech Republic due to response lags. Secondly, the data was cross-sectional, meaning that the issues related to potential endogeneity and selection bias cannot be rejected. We acknowledge that some of the variables are clear choice and endogenous. As shown by the

model for minor innovations in Table 5, EU funding, university, and public research cooperation, and EU utility model were potentially endogenous and affected the directions of the coefficients in the overall model specification. However, their potential negative influences were reduced with our use of the doubly robust treatment effect analysis using the regression adjustment estimator. The study was also conducted on innovative firms that introduced innovations between 2012 and 2014. This, therefore, reduces the generalization of our results to non-innovative firms. Finally, this study concentrated on a sample of Czech innovative small businesses. We encourage future studies to focus on different countries with different innovation ecosystems to replicate our results and discover if these same carefully selected determinants will stimulate innovations.

Declarations

Author contribution statement

Samuel Amponsah Odei: Conceived and designed the analysis; Analysed and interpreted the data; Wrote the paper.

Eva Hamplová: Analysed and interpreted the data; Wrote the paper.

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Data availability statement

The authors do not have permission to share data.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

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