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Contact to corresponding author: Jan Stejskal, jan.stejskal@upce.cz

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Viktor Prokop
University of Pardubice, Czech Republic
orcid.org/0000-0001-6313-395X

Michaela Kotkova Striteska
University of Pardubice, Czech Republic
orcid.org/0000-0002-6730-3335

Jan Stejskal
University of Pardubice, Czech Republic
orcid.org/0000-0003-3015-8274

Fostering Czech firms' innovation performance through efficient cooperation

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Abstract

Research background: The business climate development and the stage of innovation systems' transformation are very similar in many Central and Eastern European countries, making it necessary to study these specific economies. These economies are at a different level of transformation, and their governments are trying to support the development of a knowledge-based economy, the creation of innovation systems, and collaboration among different types of entities. These governments need feedback in the form of research into the impacts of public funding on innovation activities through the influence of basic research and cooperation-based resources in individual countries.

Purpose of the article: This paper focuses on the examination of (i) the influence of national and European subsidies on innovation performance in manufacturing firms in the Czech Republic and (ii) impacts of knowledge- and cooperation-based resources on innovation activities in Czech manufacturing.
Methods: The latest available data from the Community Innovation Survey was used for analyses realized by different regression models. The proposed research models were gradually created to verify the influence of pro-innovation factors (expenditures on in-house and external R&D and on the acquisition of external tangible and intangible sources, cooperation with different partners and innovation) and public (national and/or European) funding of firms' innovation performance within the Czech manufacturing industry.
Findings and value added: The results have showed that there is a need to focus on direct and indirect effects of selected innovation determinants; we have also identified the crucial role of cooperation (specifically with government, public, or private research institutes) as a mediating variable within innovation processes. The results have also evidenced that public funding affects the efficiency of knowledge- and cooperation-based resources and amplifies the impact on firms' innovation performance differently. Whereas subsidies from national budgets do not significantly influence the innovation performance of Czech manufacturing firms, European subsidies, on the other hand, significantly increase firms' innovation performance. A long-term contribution of this paper is the significant completion of the theory of policy implications that may be applicable in a broad international context beyond the borders of the Czech Republic. This study significantly contributes to the ongoing discussion about (i) the significance of public financial subsidies from both national and European funds and (ii) the effects of cooperation and R&D on firms' innovation performance within "catching-up" in Central and Eastern Europe.

Introduction

If economic entities begin to use knowledge and technology to obtain their performance and the individual processes are knowledge-based, it is possible to state the emergence of a knowledge-based or knowledge economy. According to Chen *et al.* (2009), a knowledge economy is an environment in which knowledge is (i) acquired, (ii) created, (iii) disseminated, and (iv) used effectively to enhance economic development. Supporting this form of creation and the diffusion of new knowledge should be part of public policy. State interventions are an integral part of the current knowledge economy. Here, we again follow the link between knowledge economy and increased competitiveness. Although the terms *knowledge economy* and *knowledge-based economy* are often used synonymously, they are not the same. As Cooke and Leydesdorff argue: "[the] knowledge economy is the older of the two concepts (with its origins in the 1950s) and it is focused mainly on the composition of the labour force. On the other hand, the term knowledge-based economy has added the structural aspects of technological trajectories and regimes from a systems perspective, which leads e.g. to discussions about intellectual property rights as another form of capital" (Cooke & Leydesdorff, 2006). Skills and knowhow are applied in the knowledge-based or knowledge economy (Asheim *et al*., 2011; Nemec,

2015; Rim *et al*., 2019). Many scholars (for example, Kafouros & Forsans, 2012; Berchicci, 2013; Odei *et al*., 2020) point out that high technologies, new knowledge acquisition, and transfer allow the firms to increase their innovation capacity and, thus, they can achieve their business goals and develop the local economy, the region, or the whole country.

However, the situation varies in differently developed economic systems. Weaker economies (typically countries from Central and Eastern Europe [CEE], also called "catching-up" countries), which started their technological development only in the 1990s, have a different level of development than Western European countries (Radosevic, 1999; 2002; Sum & Jessop, 2013; Stejskal *et al*., 2018). As part of the restructuring and transformation processes, innovative systems have gradually emerged (separate scientific and technological systems are disappearing). Business ecosystems, regional innovation systems, and ways of cooperating and disseminating knowledge are specific in these countries due to the complex interactions among actors, low levels of trust, and the different culture and education system (Kotkova Striteska & Prokop, 2020). These countries had to undergo a transformation and apply a new paradigm of innovation systems in practice. The development of the business climate and the stage of innovation systems' transformation are very similar in many CEE countries; they also experience similar cultural habits and levels of trust. Some scholars have analyzed these specific types of economies based on the same principles and found them to be very similar due to the level of economic transformation. The public sectors of these countries vary in size due to the different orientations of government, but all are constantly striving to support the emergence of a knowledge and knowledge-based economy, the creation of an innovation milieu, and the promotion of innovation cooperation. However, in all of these economies, the effectiveness of this effort is relatively low because of these same factors.

As evidenced by prior research, the governments need feedback in the form of research into the impacts of public funding on firms' innovation performance through the influence of basic research and cooperation-based resources in the individual countries of Central and Eastern Europe (Prokop & Stejskal, 2014; Klímová *et al*., 2019). There is still a discrepancy in the researchers' and practitioners' conclusions regarding the efficiency of the use of public national and European funds in these "catching-up" countries. Moreover, it is still unclear whether innovators from CEE countries rely on internal or external R&D sources and the role played by cooperation with different partners in the innovation processes (Prokop *et al*., 2021). This situation creates a long-term research gap within the "catching-up litera-

ture" dealing with the issues of innovation, cooperation, and public financial support in Central and Eastern European countries.

Therefore, this paper focuses on the examination of (i) the influence of national and European subsidies and (ii) the impacts of knowledge- and cooperation-based resources on the innovation performance of manufacturing firms in the Czech Republic. The research results will help define the situation of enterprises in selected branches of the manufacturing industry in the Czech Republic and find the main knowledge resources that affect their innovative activities. This is an initial analysis of selected branches, which follows similar analyses carried out by the author in other industries and CEE countries.

The remainder of this paper has been structured as follows. The paper first gives an overview of the literature. The next section presents the data and research model. The subsequent part provides experimental results. Next, discussion and practical implications are shown. The conclusions that have been achieved by the models, limitations of our study, and proposals for future research are described in the last part.

Literature review

A number of studies have concluded that the open innovation approach creates the necessary basis for achieving economies of scale in companies (Dyer & Singh, 1998; Appleyard & Chesbrough, 2017). They stated that, if firms shared knowledge flows and carry out knowledge transfer, it would help them increase production efficiency and increase effectiveness. The reason for increased efficiency is the emphasis on the use of new technologies as well as the accumulation and transfer of knowledge. In this sense, a very dynamic, technologically demanding, advanced, and knowledge-based milieu is not negligible (Stejskal & Hajek, 2015). Innovation systems have been supplemented by a new element — namely, outsourcing — that has begun to be used in science and research. The point is that firms can help each other, share technological knowledge, and increase their ability to innovate. According to this, several types of outsourcing are distinguished, including technological and knowledge outsourcing. Some scholars have concluded that the relationship between business and technology outsourcing allows developing and focusing on the use of technology and knowledge in manufacturing (Becker & Dietz, 2004).

Another essential element of cooperation that determines higher performance (the highest efficiency has been recorded in dynamic business networks or regional innovation systems) is trust. These technologically de-

manding functions are used mainly by innovative firms. These fundamentally positively oriented functions affect their ability to increase innovation absorption, their overall productivity, and the profitability of similar investments. However, knowledge and their knowledge resources have an important influence in this area. Some studies deal with knowledge transfer and its impact on the pro-export orientation of small and medium-sized enterprises (Booltink & Saka-Helmhout, 2018), some answer questions about how to control the human capital and employ it for innovation creation and how to effectively use the external knowledge acquisition (Pucci *et al*., 2020); their goal is to accumulate knowledge, create the principles of internal knowledge acquisition, and achieve moderate effects (Yang & Grabe, 2011). The studies agree that knowledge has a positive influence on corporate performance (Prochazka & Hajek, 2015; Abubakar *et al*., 2019). Only some of them analyze the influence of knowledge-acquisition sources on performance; for example, Cruz-González *et al.* (2014) analyze the impact on the performance in high-technology industries, Rašula *et al.* (2012) deal with the impact on organizational innovations, Garcia Martinez *et al.* (2014) focus on the impact of the open innovation strategy on performance, and Roper *et al.* (2017) analyze the influence of a firm's openness on its innovative performance. Their results emphasize that the openness of the firm brings positive externalities (due to knowledge spillover effects).

From the discussion thus far, it is clear that innovations are not an exclusive (primarily in the private sector) domain separated from others, such as the public sector (Lavčák *et al*., 2019); moreover, they are not created within an isolated firm, but interact with the environment. The company's pro-innovation behavior, strategies, and culture are associated with organizational ambidexterity and include various activities (e.g., creativity, courage, flexibility, openness or closure, focus on learning, information sharing). These activities subsequently influence the company's approach to creating innovations through its openness to adopt new ideas and processes (Hurley & Hult, 1998; Lee *et al*., 2017; Kraśnicka *et al*., 2018). We can state that firms' cooperation-based activity — any cooperation — between at least two different entities directed toward a common goal (especially on innovation) should lead to the growth of their performance (Prokop & Stejskal, 2019).

On the other hand, the reality is that, from time to time, different firms' cooperation leads to a decrease in their performance, specifically within Central and Eastern Europe "catching-up" countries, including the Czech Republic, which had to overcome several problems (e.g., small volume of investments from public budgets, high indebtedness limiting investments in the future, non-functional cooperation incentives necessary to build capaci-

ty in order to be able to utilize the flow of knowledge and technology; Gyamfi & Stejskal, 2019). Moreover, compared to Western European countries, they fail due to a reluctance to share information and create strategic plans and business strategies to support competitiveness, less developed social capital, or mental lock-in (Kotkova Striteska & Prokop, 2020; Dvouletý & Blažková, 2020). However, a few studies have analyzed the case of the Czech Republic. For example, Knell and Srholec (2005) showed that international cooperative agreements are important for the Czech economy, but that foreign ownership does not facilitate knowledge spillovers to the local economy. Blažek and Uhlíř (2007) provided an overview of the development of a Czech innovation policy, specifically in the case of the capital city Prague. Ehrenberger *et al.* (2015) focused on determinants (own research, development, investment in technology, product innovation, attractiveness of foreign markets) and their impact on the competitiveness of Czech SMEs.

Therefore, based on the literature review, we selected a combination of internal and external innovation determinants (pro-innovation factors), including firms' research and development, cooperation with various actors, and internal activities leading to introducing goods innovation, and analyzed their influence on firms' innovation performance in the Czech Republic, specifically in manufacturing industries.

Klímová (2018) concluded that the Czech Republic has a long tradition of implementing quality science and research. Therefore, it can be assumed that public finances have the potential to increase the efficiency of the core sources of firms' pro-innovative activities. We support the claim of studies confirming the number of firms that received financial aid from national and European public funds (specifically to promote innovation activities). In recent years, a number of these financial incentives were ineffectively used; therefore, most of the studies analyzed the impacts of R&D European subsidies on firms (e.g., Bronzini & Piselli, 2016; Chapman *et al*., 2018; Szücs, 2020). However, studies focusing on catching-up economies are missing. More precisely, there is a need for more empirical studies on the role and effects of R&D, public financial subsidies, and collaboration with various partners on firms' innovation performance within transition and catching-up CEE countries. For the further creation and direction of the common European regional policy, it is necessary to know whether public support for R&D, innovation, and cooperation brings positive effects in this specific group of countries in the long period. Here, a high degree of dependence can be expected between the R&D activities of SMEs and the volume of subsidies provided. The importance of research into the relation-

ship among R&D, cooperation, and motivating European funding is also recognized.

Therefore, to fill the identified gaps calling for additional comprehensive research within "catching-up" CEE countries, we build on the previous studies of (i) Prokop *et al.* (2018), who showed that public subsidies could have stimulus effects on firms' willingness to cooperate in the Czech Republic and Slovakia, but did not distinguish between the effects of national and/or European subsidies separately, and (ii) Pisár *et al.* (2020), who conducted a study examining the impact of government spending on research and development (exclusively to support SME entrepreneurship) on increasing private investment in science and research in the EU countries (including the Czech Republic) but did not consider the effects of cooperation with various partners that demonstrably influence the innovative performance of firms and whose role cannot be neglected. For our purposes, we proposed our own research models (see Research methodology section) analyzing not only the influence of pro-innovation activities (including various forms of cooperation) on firms' innovation performance, but also the effects of national and European public funding on firms' innovation performance in the Czech Republic.

Research methodology

Data source

As a data source, we are using the harmonized questionnaire Community Innovation Survey (CIS) provided by Eurostat. This is a widely accepted and used (see, e.g., Audretsch & Belitski, 2020; Barbieri *et al*., 2020) questionnaire, which has been providing the largest database for broad analysis across Europe for more than 15 years. For the purpose of this study, we use the dataset of micro (un-aggregated) data from 2012–2014 (released by Eurostat with a 3-year lag during 2017). From one perspective, the authors are aware that they are working with relatively old data, which is a limitation of this study. Consistent with Stojčić (2021), at the time of writing this article, the last accessible version of the dataset was the one released during 2017. In contrast, the CIS provides access to a unique data set that provides the necessary information for this study. By analyzing these data, it is possible to define conclusions that can be applied in the next EU programming period; moreover, our analysis could serve as a preliminary study for further research. In addition, it is a unique and broad European survey that can

provide results for macroeconomic comparisons of the effectiveness of the use of public support.

This research used random sampling and exhaustive surveys, generating a 60% response rate. The survey respondents were firms that employ more than ten workers. In total, data on 5,198 Czech firms were analyzed. Because the aim of the research was to analyze data only about innovative manufacturing firms, the data were filtered and the research sample was reduced to 832 firms belonging to 26–30 NACE categories. These industry sectors make the most of new knowledge and are the most frequent part of cooperative networks; in addition, they represent the firms with the largest volume of production. Descriptive characteristics for selected branches of the manufacturing industry are presented in Table 1.

Research model, research questions, and methods

Based on the previously described literature research, we propose our own research models (see Figure 1) to reveal the influence of pro-innovation activities and public funding (national and European) on firm innovation performance.

More specifically, we create the two following models (input and output variables are described in detail below):

- Model 1 (M1) is aimed at demonstrating the direct impact of firms' pro-innovation activities (R&D expenditures, cooperation, and introducing innovation) on firms' innovation performance.
- Model 2 (M2) examines how external public funding affects the efficiency of the identified pro-innovation activities and multiplies its impact on firms' innovation performance.

Consistent with Sofka and Grimpe (2010), who pointed out a difference in the influence of national and European public funding on firms' innovation, we define our first research question:

RQ_1: *Are there different effects of national and European financial support on firms' innovation in the Czech Republic?*

We also aim to reveal whether a combination of both national and European public funding leads to more significant results than support from only one source. Therefore, we define the second research question as follows:

RQ_2: *Does the combination of national and European financial support lead to more significant results than using only one public funding source in the Czech Republic?*

In order to be able to answer the defined questions, Model 2 is divided into 3 sub-models, as follows:

- Model 2a (M2a) – combination of national and European public financial support.
- Model 2b (M2b) – the influence of European public financial support.
- Model 2c (M2c) – the influence of national public financial support.

As a *dependent variable*, in accordance with De Tienne and Mallette (2012), who confirmed the existence of the links between firms' innovation-oriented behavior (activity) and performance (measured subjectively; e.g., by product innovations, growth, and a return on investment), we are using (as a proxy for firm innovation performance):

- *percentage of turnover in new or improved products (innovations) introduced during the analyzed period.*

This variable clearly documents the causal relationship between the input and output variables (the input used clearly served to create an innovation that was commercialized). This variable was used in all proposed models (M1-M2a, b, c).

As *independent variables* (as proxies for pro-innovation activities), we used a number of categorical (binary) and continuous variables that were empirically proved as significant, yet in different ways within countries and industries. All variables are listed in Table 2.

In order to analyze the relationship between one continuous dependent variable Y, whose value depends on the covariates x•j (Gustafsson & Wogenius, 2014), we used multiple linear regression. Many scholars have employed the multiple linear regression models (logistic or multiple regression models) in similarly oriented studies (e.g., Keizer *et al*., 2002); therefore, we consider this method to be sufficient to prove the relationship between variables, quantify it, and determine the nature of such a relationship. The theoretical basis can be found, for example, in Vlachogianni *et al.* (2011) and Wu *et al*. (2013), whereas the general form of the multiple linear regression could be expressed as follows (Chatterjee & Hadi, 2013):

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + \varepsilon \quad (1)$$

where Y is a dependent variable; x_1, x_2 … x_n are independent variables; ε is an error term that accounts for the variability in Y that cannot be explained by the linear effect of the n independent variables; and β_1, β_2 … β_n, called the regression parameters or coefficients, are unknown constants to be determined (estimated) from the data.

Results

In the first stage, we verified that the input data are not correlated with each other by the Spearman test. In addition, collinearity among the independent variables in the regression models was measured using the variance inflation factor (VIF). Multicollinearity was not observed as the values of VIF were in all models <5. To avoid selection bias, in agreement with Frenz and Ietto-Gillies (2009), the treatment effects of innovative/non-innovative firms (with or without product/process innovation) were examined. Treatment-effects estimation was performed using nearest-neighbor matching with Mahalanobis distance. Significant treatment effects were not detected as the p-value was >0.1.

We employed the above-mentioned method and present the results of our models in Table 3.

The results in Table 3 confirm the scientific assumptions of the model — namely, the significance of public funds for manufacturing enterprises in the Czech Republic. Models M1, M2a, and M2c show no significant results (see p-value of individual models). Only model M2b, where the effect of only European public support is investigated, is highly significant (0.008***). We can see that provision of European funds seems to be crucial even though it does not directly and significantly affect firms' innovation output. Other results show that R&D expenditures and product innovations do not directly affect innovation performance in the case of Czech manufacturing firms. On the contrary, cooperation with government, public, and/or private research institutes has a significant positive impact on the firms' innovative performance. Cooperation on technical innovation also has a significant, but negative, influence. In the next section, we discuss the obtained results.

Based on the results in Table 3, primarily the results obtained from Model M2b, we modified the proposed model (Fig. 1) and performed additional analyses to examine whether the cooperation, which proved to be a significant variable in the process of creating innovations, functions as a mediating variable enabling the emergence of indirect effects of pro-innovation activities on firms' innovation performance within Czech manufacturing industries. As variables providing information about firms' cooperation are binary (see Table 2), to reveal the influence of pro-innovation activities and public funding on different types of cooperation, we used binary logistic regression that is generally expressed as follows (Retherford & Choe, 2011):

$$ln[P_i / (1 - P_i)] = \beta_0 + \beta_1 \times X_{1i} + \beta_2 \times X_{2i} + \ldots + \beta_n \times X_{ni}, \quad (2)$$

where subscript *i* denotes the *i*-th observation in the sample, P is the probability of the outcome, β_0 is the intercept term, and β_1, β_2, … β_n are the coefficients associated with each explanatory variable X_1, X_2, …, X_k.

The proposed model including direct and indirect effects is shown in Fig. 2. Note that, as the results showed that public financial support from national funds is insignificant, we focused only on providing public financial support from European funds.

Results in Table 4 show the influence of pro-innovation activities (R&D and innovation) on firms' cooperation with various external partners within manufacturing industries in the Czech Republic. We can see, compared with the results in Table 3, the growing significance of selected factors — specifically, firms' internal (in-house) and external R&D expenditures. Moreover, European public financial support seems to be highly significant although it is primarily focused on the exact type of cooperation, specifically cooperation with universities, the government, and public or private research institutes as well as cooperation on technical innovation activities. On the other hand, cooperation with market subjects (suppliers, clients, or customers) seems to be more independent of the provision of financial support, and firms prefer to use their own financial resources or the resources of their partners. In addition, the significance of firms' participation in the group of enterprises and market orientation increased.

The results presented thus far allow us to reveal indirect effects of pro-innovation activities on firms' innovation performance through cooperation as a mediating variable in this process (see Fig. 3).

Fig. 3 compares the results of our research models shown in Tables 3 and 4; full lines show the direct effects of innovation activities and public funding on the firm's innovation performance (Table 3–M2b), and dashed lines show the indirect effects of pro-innovation activities and public financial support on the innovation performance of the Czech manufacturing firms, where the cooperation is a fundamental mediating variable in this process. Fig. 3 shows that cooperation with government, public, or private research institutes in all cases produced the most significant results and, thus, appear to be a key variable.

Discussion

Considering the first research question of this study (i.e., *Are there different effects of national and European financial support on firms' innovation in*

the Czech Republic?), the results have showed that only European public financial support is significant and influences the innovation performance of the selected Czech manufacturing firms. Therefore, we can only partially confirm our assumption that public funding affects the efficiency of firm pro-innovation activities and multiplies their impact on innovation performance. As evidenced above, the significance of national and European financial resources is different.

The causes can be seen in the very generous support of innovative activities from the European budget that have been provided in the last ten years. Czech firms are strongly motivated to implement innovation-inducing activities through financial incentives. Unfortunately, research has not been realized as a qualitative one, so the implications and effectiveness of this support cannot be discussed. Its so-called low-hanging fruit can be seen as a negative phenomenon as firms can easily obtain European subsidies and, therefore, they innovate. Without these subsidies, not all innovation activities are finished. There is a high degree of dependence, which threatens their competitiveness in the long run. State aid may be granted if the marginal benefits from its provision are higher than the marginal costs. Therefore, the impact of European funding on other important assumptions of innovation performance should be further explored. We do not assume the endogeneity between cooperation in R&D and European funding.

Regarding the second research question (i.e., *Does the combination of national and European financial support lead to more significant results than using only one public funding source in the Czech Republic?*), the results have showed that the combination of public funding from national and European funds leads to mutual crowding out rather than to the strengthening of the impact of public financial support on firms' innovation performance. A certain degree of "crowding-out effect" is understandable due to the mandatory co-financing. However, the results have clearly shown that firms, as well as the government, save their own resources if European funds can be obtained. However, it is possible to discuss the effectiveness of such decisions, as the use of European funds involves a high degree of bureaucracy. It is also necessary to consider the compatibility of business strategic objectives and the objectives of European financial incentives. Very often, they are not the same, and firms (in order to obtain public funds) adjust their goals and intentions on an ad hoc basis. In addition, this behavior often leads in practice to the effects associated with so-called "low-hanging fruit." This is one example of the limited ability to control all innovative entities that receive public financial support.

What is interesting is the fact that our results also revealed the importance of cooperation with government, public, or private research insti-

tutes in the process of innovation. As evidenced by prior research (see Prokop *et al*., 2017), Czech manufacturing firms are able to create innovations as a result of mutual interaction between different cooperating partners. Consistent with Prokop *et al*. (2017), we also showed that the use of public funds is in many cases inefficient and that the combination of these resources (national and European) does not have a significant effect on the innovation activities of Czech manufacturing firms. However, in this study, we extended previous findings and examined in more detail the mediating role of cooperation in these innovation processes, while revealing how to use public financial support effectively, primarily from European funds. Therefore, as a contribution of this research, our results clearly show the significant impact of European financial support on different kinds of innovation cooperation (except cooperation with market subjects — namely, suppliers, clients, or customers) while allowing the creation of spillover effects and having a significant impact on the innovation performance of Czech manufacturing firms. It can also be confirmed that European funds positively stimulate cooperation on technical innovations as well.

We empirically evidenced that cooperation with government, public, or private research institutes is a key mediator between inputs to the innovation process and its outputs. These cooperation partners can act as a catalyst and a leading creator of new knowledge. These results are consistent with the findings reached by Bigliardi *et al*. (2006) in the case of Italy. The authors confirmed that policy-driven cooperation promotes technology and knowledge transfer (especially between businesses and public sector knowledge organizations). We confirm these findings in the case of countries in Central Europe, whereas cooperating partners from this geographical area are often perceived as such partners who enter into mutual interactions with distrust and are more closed to the surrounding environment (Prokop *et al*., 2021). In addition, we show that cooperation as a mediating variable is crucial for firms' market orientation and participation in the groups of companies. This finding is in accordance with, for example, Myšková and Kuběnka (2019), who state that firms (primarily SMEs) seek to eliminate shortcomings through various forms of cooperation and pooling into larger entities. Using Myšková and Kuběnka's (2019) study, we have developed their findings on a larger research sample, which includes all size categories of companies, various forms of cooperation, and information on public financial support from national and European funds.

What is surprising and calls for further research is the finding that Czech manufacturing firms' cooperation with market subjects financed from the EU decreased their innovation performance. This kind of innovation cooperation is often problematic because firms always choose between

knowledge and internal know-how they will share and keep secret and what benefits cooperation with these subjects will bring. This is especially important in the case of countries in Central Europe, where firms face the challenge of absorbing knowledge and technology from external partners, whereas wrong firms' external acquisition strategy could lead to the creation of negative effects on innovation outputs (Prokop *et al*., 2021). Moreover, public subsidies could crowd out private R&D inputs (crowding-out effect) and decrease firms' outputs (Guo *et al*., 2016). Market subjects also have to face a number of barriers, such as bureaucracy, geographical distance, uncertainty, and insufficient financial sources, that decrease firms' innovation performance (Vásquez-Urriago *et al*., 2016). Subsequently, innovative outputs from such cooperation are not applicable and profitable in the markets.

Following these arguments, another contribution of this research is that we have showed that the appropriate selection of cooperative partners increases significance of internal and external R&D expenditures within Czech manufacturing firms. In contrast, these firms are not able to successfully absorb external R&D sources — namely, equipment and external knowledge. Hussinger and Wastyn (2016) state that the successful adoption and implementation of acquired technologies relies on the openness of the individual employees toward externally developed technologies. Employees' inability and unwillingness to absorb external equipment, technologies, and knowledge likely stem from two factors. The first is the psychological phenomenon widely known as the Not-Invented-Here Syndrome (Hannen *et al*., 2019), which is associated with the individual's (employee's) negative attitude toward external knowledge (from a different field of expertise, from another enterprise or geography). It is considered to be outside the firm and, therefore, internal R&D employees reject this external knowledge. The second factor is the absence of absorption capacity that is associated with employees' low skills and inability to translate externally generated knowledge into own commercial benefits (Stulova & Rungi, 2017).

Summing up the statements made thus far, it should be stressed that our findings also have international value, with obvious direct implications for other Central European economies, but also economies within different institutional contexts, but at similar development stages. Our results contribute to and help expand the current state of knowledge about the issues related to the innovation processes of firms from "catching-up" countries, specifically the Czech manufacturing firms, and allow us to propose several practical implications, which are listed below. These recommendations can be considered applicable in other European countries, primarily in the

countries of Central and Eastern Europe, because these countries have a number of elements in common, such as a lower economic performance compared to Western European countries or the transformation of centrally planned to market economies in the early 1990s (Prokop *et al*., 2021). As these countries are also called "catching-up" countries, the findings of our study significantly contribute to the "catching-up literature" dealing with the issues of innovation, cooperation, and public financial support in Central and Eastern Europe.

Practical Implications

For the above-mentioned reasons, we propose some practical implications for firms and policymakers. These implications could be applicable not only in the Czech Republic, but also in other European countries, especially in countries in transition from production toward innovation-driven growth such as "catching-up" CEE countries (Stojčić, 2021). Moreover, it is also possible to find the special aspects of these implications in other European countries; typically, it is possible to direct these implications for countries belonging to the same innovation group according to their innovation performance, expressed in the Innovation Performance Scoreboard developed by the European Commission (2020). These are moderate EU innovators.

While cooperation seems to be a crucial mediator among pro-innovation activities, public funding, and firms' innovation performance, policymakers should focus on the creation of sufficient innovation environment (ecosystem), which would facilitate cooperation between market subjects, specifically clients and customers (users). These subjects provide information about their preferences, ideas, and wishes, which is an important resource for business innovation creators (see, e.g., open innovation and lead-user concepts). Rayna *et al*. (2015) came to the same conclusions. They emphasize that manufacturing companies can also use these partners to test finished products (whether the innovation meets customer expectations). In this case, it is more than necessary for innovators in CEE countries to overcome the initial barrier to successful cooperation, which can be, for example, mistrust and the fear of "something new" — typically radical innovations. These innovations can make employees afraid that the new goods or procedures will replace the old ones and the employees will no longer be needed. For example, Shaikh and O'Connor (2020) warn of cases where there are strong incentives at the managerial (and organizational) level to under-invest in radical innovation due to the risk of cannibalizing existing products, creating fear among lower-level employees. Therefore, it is nec-

essary to build mutual trust, values, and internal environment. Building internal (firm) social capital (Westlund & Nilsson, 2005), including corporate spirit, climate for cooperation, methods of codification of knowledge, product development, and conflict resolution could also be fruitful for the firm.

Another important aspect with which European innovators struggle, not only in Central and Eastern Europe, is the low absorption capacity (Prokop *et al*., 2021), which is formed by internal and external factors and depends on internal R&D or collaboration with external actors. In our study, we have showed that Czech manufacturing firms were not able to absorb external knowledge and equipment. According to Stulova and Rungi (2017), there are four interrelated dimensions of the firm's absorptive capacity, which need consideration. These are continuing development (e.g., employees' learning support, following industry trends for strategy development), trust-based internal development (e.g., exchange of information, cooperation effort), bottom-up innovation (e.g., measures of the employees' ability to recognize the value of new trends), and deferred knowledge use (e.g., willingness to maintain valuable knowledge over extended time periods). In this case, from the one perspective, the public sector can help firms, for example by supporting the education and training of employees. This should be, for example, in the form of support for R&D trainings or internships for firms' employees. It is crucial to support foreign internships as well, which can lead to an influx of foreign knowledge and experience into firms in CEE countries. However, these trainees must be able to transpose newly acquired experience and knowledge into a very specific (often rigid, less ambitious, and not open) environment of CEE firms, whose main markets are mainly located in CEE countries. It is also necessary to assume that the firm management is open to new knowledge, a willingness to change firm processes, and the investing of one's own funds in development. From another perspective, firms must encourage employees' desire and efforts to learn and educate themselves, whether they receive public financial support or not.

We also propose deepening innovative collaboration among firms in the manufacturing industry in the Czech Republic, mostly with government, public, or private research institutes. This can be done through appropriately targeted subsidy government expenditure programs supporting innovation or cooperation within the manufacturing industry (or, more specifically, in areas with higher added value or industrial sectors that are a major engine for the Czech economy). We recommend that public policies for industry support have clear (measurable) conditions, including not only the creation of innovative outputs, but also cooperation on a knowledge base.

We highlight the proper choice of partners for innovative cooperation (on product innovation).

Next, following the ideas of the concept of an open innovation (Appleyard & Chesbrough, 2017), we propose that European firms pursue innovative collaboration in open (international) business networks because it has the potential to influence the firms' turnover positively. Even the public sector can contribute to this recommendation, especially by initiating cooperative chains (for example, industrial clusters, regional innovation systems, and innovation ecosystems), entering into them, and maybe subsidizing their activities. It is obvious that collaboration-based networks create a sufficient environment that allows the creation and sharing of new knowledge and the creation of knowledge spillover effects. Moreover, the participation of firms, especially those from "catching-up" CEE countries, in such international networks enables these firms to better overcome the identified barriers and can thus help more successfully apply innovative models that are successful in Western European countries, but often unsuccessful in CEE countries. In addition, weaker innovators can benefit from the reputation of the entire network and have easier access to foreign experts. This implication also has support in foreign literature, where Stojčić (2021) claims that there is a high attractiveness for collaboration with partners from other parts of the world for firms from CEE countries, especially with those partners that wish to participate in large integrated markets. In this case, the important implication is growing for strong innovators, who should be willing to cooperate and help weaker innovators, even though they may not profit.

Finding common interests of individual cooperating actors is also crucial. For example, in the current practice of the Czech Republic, it is common that universities pursue different goals (e.g., publications) than firms (e.g., profit). As a result, this type of cooperation is often inefficient, in terms of both time and costs. Firms then choose a contract research option (as we have shown, for example, with private research institutions), which will allow them to play a leading role in the whole innovation process. Public funds are then spent on less profitable projects that are high risk and whose outcome is uncertain. Therefore, we see it as necessary that the goals of individual cooperating partners be at least partially aligned.

Conclusions

In this paper, we gradually developed several research models to verify the influence of pro-innovation factors (expenditures on in-house and external

R&D and on the acquisition of external tangible and intangible sources, cooperation with different partners and innovation) and public (national and/or European) funding on firms' innovation performance within the Czech manufacturing industry. Our results have showed that there is a need to focus on direct and indirect effects of selected innovation determinants, while we pointed out the crucial role of cooperation (specifically with government, public, or private research institutes) as a mediating variable within innovation processes. We show that finding suitable cooperation partners could increase the efficiency of internal and external R&D expenditures and European public funds. The results of our research also show that there is a significant difference between national and European financial resources and its influence on firms' innovation performance. Although subsidies from national budgets do not significantly influence innovation production of Czech manufacturing firms, European subsidies, on the other hand, significantly increase firms' innovation performance, albeit only through a mediating variable (cooperation). This is an important research result with high uniqueness and significant input for other theoretical and practical implications. Based on these findings, it is possible to expect new insights into this field in future studies and research.

In our research, limitations must be also mentioned. These are based on primary data, which were the input data used for analysis. The data come from a 2014 EU survey, which means we are describing reality more than 6 years ago. However, we believe that in the current economy it is possible to count on several years of delay as well as with continuity in the provision of public subsidies in the continuing programming periods of the EU. Therefore, we believe that our results and implications have significance. Moreover, we consider our study to be a preliminary one, which has proved the significance of firms' cooperation as a mediating variable within innovation processes and showed the direction on which further follow-up research on firms' innovation and the innovation environment in the Czech Republic should focus. Another limitation is the quantitative aspect of the research, which lacks the possibility of qualitative evaluation.

In the context of further research, it is appropriate to examine how the impact of public funds in the individual EU countries (primarily CEE countries) differs and whether their importance is gradually diminishing. There is also a need to focus on several interesting and important topics designed primarily for the innovation environment not only in the Czech Republic, but also within other "catching-up" CEE countries. These topics include (i) setting appropriate conditions for inter-firm as well as inter-industry, cooperation; (ii) addressing the different interests of various cooperating partners, including public institutions; (iii) strengthening the absorption capaci-

ty of firms and building their internal social capital; and (iv) designing suitable innovation ecosystems. From an empirical point of view, it would be interesting to examine the moderation effects of some groups of variables, such as by using the structural equation modeling approach in future research. In this case, however, it would be necessary to increase the number of variables and thus create larger constructs (including selected groups of variables in the models). As the regression models are linear in their nature, it would also be interesting to analyze whether nonlinear effects occur, such as the nonlinear effects of R&D expenditures on innovation performance (see, e.g., Dong *et al*., 2021).

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Annex

Table 1. Descriptive characteristics for selected branches of the manufacturing industry (CZK/year)

Innovative	**YES**	**NO**
Implementation of innovation (goods)	49 %	51 %
Total turnover	43,533,055,130	13,713,812,323
Participation in the group of enterprises	65.7 %	38.4 %
In-house R&D	79.2 %	10.6 %
External R&D expenditure	49.5 %	3.1 %
Acquisition of equipment	75.5 %	21.2 %
Acquisition of external knowledge	20.8 %	2.4 %
Regional and/or national public financial support of innovation	45.3 %	5.7 %
Public financial support from the EU of innovation	26.9 %	5.9 %
Cooperation on technical innovation activities	57.4 %	7.5 %

Source: primary data from CIS 12-14.

Table 2. Description of input variables in the models

Variable	**Description**	**Category**	**Reference**
Innovation performance (dependent)	The percentage of turnover in new or improved products (innovations) introduced during the analyzed period.	Continuous	De Tienne and Mallette (2012)
R&D expenditures			
In-house R&D (RRDIN)	How much did your enterprise spend on internal R&D?	Continuous	Gardiner and Hajek (2016); Sharma *et al.* (2016)
External R&D (RRDEX)	How much did your enterprise spend on external R&D?	Continuous	
Acquisition of equipment (RMAC)	How much did your enterprise spend on the acquisition of equipment?	Continuous	
Acquisition of external knowledge (ROEK)	How much did your enterprise spend on the acquisition of external knowledge?	Continuous	
Cooperation			
University (COUNI)	Did your enterprise co-operate on any of your innovation activities with universities or other higher education institutions?	Binary (1 = firm cooperated; 0 = otherwise)	Meričková *et al.* (2016); Prokop *et al.* (2017)

Table 2. Continued

Variable	Description	Category	Reference
Government (COGOV)	Did your enterprise co-operate on any of your innovation activities with government, public, or private research institutes?	Binary (1 = firm cooperated; 0 = otherwise)	
Market subjects (COMAR)	Did your enterprise co-operate on any of your innovation activities with suppliers, clients, or customers?	Binary (1 = firm cooperated; 0 = otherwise)	
Technical (COTECH)	Did your enterprise co-operate on technical innovation activities?	Binary (1 = firm cooperated; 0 = otherwise)	
Introducing innovation			
Innovation of goods (INNG)	Introduction of goods innovation.	Binary (1 = firm introduced into the market a new or significantly improved good; 0 = otherwise)	Santi & Santoleri (2016); McKelvie *et al.* (2017)
Funding			
National (FUNGOV)	Did your enterprise receive any public financial support for innovation activities from the central government (including central government agencies or ministries)?	Binary (1 = firm received public financial support; 0 = otherwise)	Bronzini and Piselli (2016); Caiazza and Stanton (2016)
European (FUNEU)	Did your enterprise receive any public financial support for innovation activities from the EU?	Binary (1 = firm received public financial support; 0 = otherwise)	
Control variables			
Enterprise group (GP)	Was your enterprise part of an enterprise group?	Binary (1 = firm was part of firm group; 0 = otherwise)	Dachs and Peters (2014)
Market orientation (MAR)	In which geographic markets did your enterprise sell goods and/or services?	Binary (1 = national markets; 0 = foreign markets)	Patel *et al.* (2014); Chlebovský *et al.* (2018)

Table 3. Proposed multiple linear regression models – Significance of public funds for manufacturing enterprises

	Model 1 R= 0.326; R2= 0.106; *p*= 0.362		**Model 2a** R= 0.513; R2= 0.263; *p*= 0.143		**Model 2b** R= 0.472; R2= 0.223; *p*= 0.008***		**Model 2c** R= 0.369; R2= 0.136; *p*= 0.772	
Indep. var.	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
R&D exp.								
RRDIN	0.055	0.329	0.023	0.702	0.030	0.598	0.046	0.446
RRDEX	0.007	0.881	0.038	0.468	0.019	0.699	0.017	0.738
RMAC	-0.005	0.920	0.008	0.883	-0.003	0.950	-0.004	0.937
ROEK	0.000	0.999	0.044	0.454	0.018	0.735	0.014	0.793
Cooperation								
COUNI	0.280	0.516	-0.509	0.454	-0.470	0.492	0.408	0.494
COGOV	0.369	0.003 ***	1.403	0.000 ***	1.208	0.000 ***	0.477	0.001 ***
COMAR	-0.273	0.555	0.309	0.653	0.446	0.396	-0.204	0.704
COTECH	-0.774	0.105	-2.012	0.035 **	-2.062	0.001 ***	-0.941	0.112
Innovation								
INNG	-0.072	0.524	-0.037	0.817	-0.065	0.738	-0.048	0.762
Funding								
FUNEU			0.662	0.154	0.461	0.182		
FUNGMT			-0.960	0.162			-0.675	0.198
Control var.								
GP	-0.699	0.026***	-1.685	0.005***	-1.296	0.002***	-0.782	0.079*
MAR	-0.159	0.532	-0.604	0.197	-0.409	0.188	-0.137	0.703

Legend: RRDIN – in-house R&D expenditure; RRDEX – external R&D expenditure; RMAC – acquisition of equipment; ROEK – acquisition of external knowledge; COUNI – coop. with universities or other higher education institutions; COGOV – coop. with government, public or private research institutes; COMAR – coop. with market subjects (suppliers, clients or customers); COTECH – cooperation on technical innovation activities; INNG – goods innovations; FUNEU – public financial support from the EU; FUNGMT – regional or national public financial support; GP – part of the group of enterprises; MAR – market orientation;

*** significant at p<0.01; ** significant at p<0.05; * significant at p<0.10

Table 4. Cooperative binary logistic regression models – influence of pro-innovation activities on firms´ cooperation with various external partners

	COUNI		**COGOV**		**COMAR**		**COTECH**	
Cox & Snell R	0.345		0.342		0.136		0.254	
Nagelkerke R	0.477		0.567		0.201		0.339	
Indep. var.	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
R&D exp.								
RRDIN	1.679	0.000 ***	3.113	0.005 ***	0.596	0.046 **	0.774	0.002 ***
RRDEX	1.846	0.000 ***	2.579	0.000 ***	1.411	0.000 ***	1.235	0.000 ***
RMAC	0.028	0.933	0.217	0.679	0.225	0.419	-0.056	0.819
ROEK	-0.243	0.505	-0.555	0.310	0.246	0.362	-0.130	0.642
Innovation								
INNG	0.555	0.167	0.891	0.236	-0.081	0.805	0.467	0.084 *
Funding								
FUNEU	1.358	0.000 ***	1.645	0.001 ***	0.042	0.870	0.837	0.001 ***
Control var.								
GP	1.203	0.000 ***	1.367	0.001 ***	0.560	0.022 **	1.526	0.000 ***
MAR	0.914	0.036 **	1.709	0.017 **	0.175	0.590	0.395	0.167

*** significant at p<0.01; ** significant at p<0.05; * significant at p<0.10. Legend is the same as in table 2.

Figure 1. Proposed research model for the Czech manufacturing firms

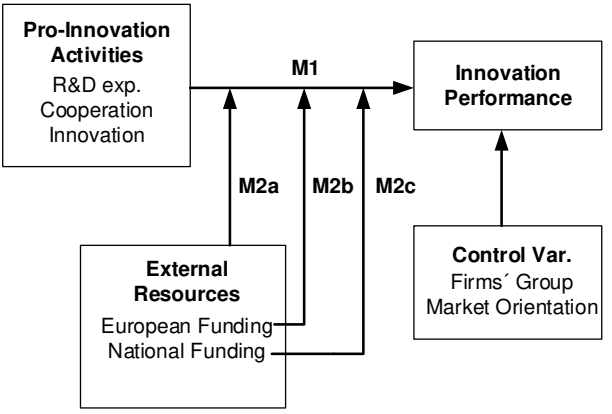

Figure 2. Advanced research model for the Czech manufacturing firms based on the results of M2b

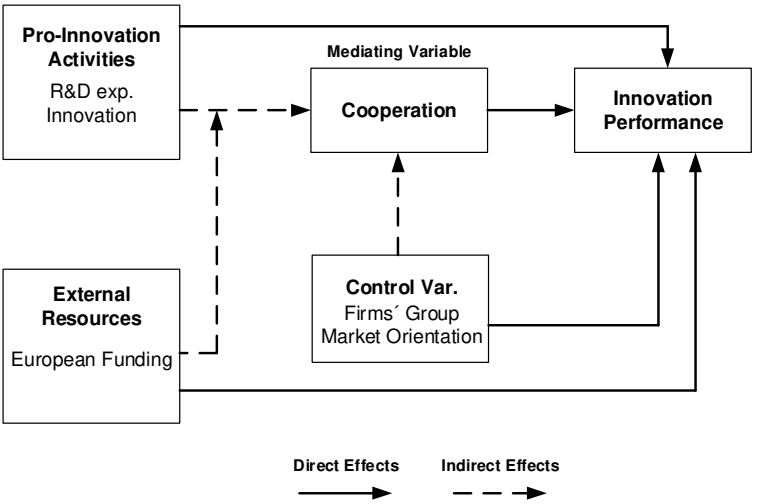

Figure 3. Comparison of direct and indirect effects of pro-innovation activities and public support on Czech manufacturing firms´ innovation performance