The Effects of Demand-Side Policy on Firm Innovation: The Mediating Role of R&D Activities

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Abstract: Today, innovation is seen as the engine of economic growth. As a result, governments foster innovation activities in both the public and private sectors by using policy tools such as measures, regulations, and incentives. There are two main approaches in government innovation policy: supply-side policy and demand-side policy. Supply-side policy instruments primarily stimulate technological development and diffuse innovation capabilities. On the other hand, demand-side policy supports specific demand and minimizes technological and trade uncertainty at all stages of production. Moreover, a demand-driven procurement policy is one of the main drivers of high-tech industries. At the same time, in line with the growing importance of the knowledge economy and societal concepts, knowledge or technology has become the major determinant of innovation. In this way, companies are encouraged to undertake research and development activities in order to create innovation and advance their technologies. Moreover, the government's support for investing in research and development (R&D) activities has become an effective solution for the firm's innovation outputs. These R&D activities are of particular importance in transition and catch-up economies such as the Czech Republic. Therefore, this article aims to analyze the impact of demand-driven policy on business innovation through R&D activities in the Czech Republic. Data from the Community Innovation Survey and partial least squares structural equation modelling are used to achieve the purpose of this article. Our findings show that demand-driven policy (procurement for innovation) significantly and positively affects firm product and process innovation through R&D activities. The findings of our research also have practical implications for firms and policymakers in the Czech Republic. These results could also apply to Central and Eastern Europe, where we can observe similar characteristics of firms, for instance, because of their innovation performance.

Keywords*:* Supply and demand-side policy, Product and process innovation, R&D activities, Czech Republic

1. Introduction

Innovation policy refers to government policies and initiatives which promote innovation for regional development. In government innovation policy, there are two major approaches to the measures used, supply-side and demand-side policy (Borrás & Edquist, 2013). Supply-side policy instruments include more direct interventions to provide financial incentives (such as grants, subsidies, or tax incentives) for research and development (R&D) activities undertaken in private sector firms (Leyden & Link, 2015). According to (Guo et al., 2016), government supports firms to reduce market failures, improve innovation efficiency, and enhance social welfare. Numerous literatures have done empirical studies of the supply-side policy (such as government subsidies) to improve the innovation performance of firms (for example, Guo et al., 2016; Wu et al., 2020; Zuo et al., 2022). However, there are some limitations of supply-side policy such as crowding out effect of R&D subsidies (Bong et al., 2020), the inefficient use of the government budget (Kundu, James & Rigby, 2020), and high level of uncertainly to investing in R&D (Chaminade & Esquist, 2010).

Therefore, the government approach has changed significantly towards demand-side policy recently (Edler et al., 2012). Interest in public procurement which is utilized in the innovation policy framework has increased (Crespi & Guarascio, 2019; Uyarra et al., 2020). This is called the public procurement for innovation (PPI), the concept of demand-pull innovation. Theoretical reviews have been done in demand-side policy to develop innovation in firms (see for example Chicot & Matt, 2018; Miller & Lehoux, 2020). Lately, public procurement as a demand-side policy tool has been recognized as an important driver for encouraging innovation (Knutsson & Thomasson, 2013; Uyarra et al., 2014) and it supports products and services much more efficiently and effectively, as well as provides citizens with better services (Edler & Yeow, 2016). Moreover, it is a powerful tool for supporting private-sector innovation through innovation demand (Edquist & Zabala-Iturriagagoitia, 2012) and can be used strategically to promote ecosystem innovation (Rainville, 2017). In addition, procurement can be served as a substantive tool because government interference in the procurement process can result in more innovations than government R&D subsidies (Demircioglu & Vivona, 2021).

A study conducted by Demircioglu & Vivona (2021) found that procurement activities are positively related to innovation within public organizations. They further mentioned that R&D procurement has a significant and meaningful impact on new technologies and services. Likewise, Dai et al. (2021) revealed public procurement significantly increases firms' R&D investment, promotes high-tech product sales, and enhances firms' access to

external finance in China. Moreover, another scholar Stojčić et al. (2020) suggested that PPI has a large effect on innovation and output, and the highest additionality is sometimes achieved when firms receive both financial support and innovation-oriented public procurement. Looking at the above works of literature, most of the studies are literature reviews and less attention to empirical analysis. In addition, majority of them are qualitative and single-case analyses with limited generalizability (Obwegeser & Müller, 2018).

Government procurement is a significant driver for certain high-tech industries (e.g., defense and aerospace industries) (de Freitas Dewes et al., 2015). These industries are identified by the development of high value-added and technology-intensive products to address complex issues and current business risks (Coad & Rao, 2008). As a result, R&D activities have become an important part of resolving complex technical issues in these industries. R&D activities can assist industries in identifying and investigating new technologies, materials, and processes that can be used to develop innovative products, services, and solutions (Prokop & Stejskal, 2019). These R&D activities are particularly important in transition and catch-up economies like Czech Republic. The country is weaker in innovation and lacks development within local and regional innovation networks (Prokop et al., 2019). Hence, to the best of our knowledge for filling the gap from previous research, the aim of this research is to analyse the influence of the demand-side policy on firm innovation mediated by R&D activities.

The rest of the paper is structured as follows: The next section presents the theoretical background. The third section defines the methodology part including data analysis and sample. The fourth section presents the results of the analysis, and the fifth section describes the discussion. Conclusions are dedicated in the last section.

2. Theoretical Background

Demand can be considered as the market size and users' sophistication (Guerzoni, 2010; Zahler et al., 2022) and is recognized as one of the innovation policy approaches of the national innovation system, but the demand-side approach has been neglected for a long time in many OECD countries (Edler, 2009). Policymakers have paid less attention to a demand-side policy that can stimulate the creation and diffusion of innovation. However, in recent years, researchers have turned their attention to the demand-driven approach to innovation. According to Edler et al. (2016), demand-side innovation policy aims to stimulate innovation or accelerate innovation diffusion by increasing demand for innovation, characterizing new business requirements for products and services, and promoting user involvement in innovation production. Demand-side innovation policies seek to encourage the adoption of new technologies and can address global and societal challenges such as climate change and aging populations (Boon & Edler, 2018; Reyes-Mercado et al., 2020). Under the demand-driven approach, there are three forms of innovation-based public procurement, performance-based regulations and standards, and technology-based regulations and standards. Among them, innovation-oriented public procurement is one of the most popular and powerful demand-driven and underused innovation policy tools. Public procurement is a powerful tool that enables national and local authorities to achieve sustainable development goals while purchasing needed goods and services (Edquist & Hommen, 2000). Public procurement of innovation occurs when a public agency places an order for a product or a system that does not exist at the time, but which could probably be developed within a reasonable period (Edquist & Zabala-Iturriagagoitia, 2012).

In addition, some empirical studies described the potential of innovative public procurement (IPP) in driving innovation and economic growth in recent years. In a study conducted by (Dai et al., 2020), public procurement significantly boosts firms' R&D investment, encourages the sale of high-tech products, and improves firms' access to external finance. Innovative public procurement is crucial in the application and dissemination of sustainable manufacturing technologies (Ghisetti, 2017). Public procurement can provide critical support to investments in innovation and complement other types of finance (Georghiou et al., 2014). Public procurement for innovation can contribute to the transformative processes of (1) the articulation of societal demands to direct challenge-driven transformation; (2) the development and production; selection; and (4) the diffusion and use of new technologies to meet these societal demands (Wesseling & Edquist, 2018). Public procurement can encourage business innovation by supporting the formation of markets for new products, technologies, and services (Bleda & Chicot, 2020). Innovative public procurement has a strong and significant impact on turnover from new products and services. The impact is obviously attributable to innovations of an incremental nature rather than market innovation (Czarnitzki et al., 2018).

Moreover, by using demand as a tool for innovation, governments can encourage firms to invest in R&D and develop new solutions to societal challenges (Lember et al., 2015). It can stimulate R&D investments, encourage innovation, and lead to the development of new products and services. A study conducted by

Selviaridis (2021) found that public procurement stimulates collaboration and R&D interaction and also allows small businesses to gain access to relevant innovation ecosystems, expand their knowledge and capabilities, and explore potential routes to market. Furthermore, innovative procurement can encourage collaboration between public and private sector entities, resulting in knowledge sharing and the development of new technologies (Thai, 2015). Furthermore, innovative public procurement can help to improve the efficiency and effectiveness of public services and reduce costs (Edler & Yeow, 2016). It means that firms are likely to invest in R&D activities to advance their technology in the manufacturing process to offer quality service to the public sector.

Based on the above argument, we develop the following hypothesis;

H1: Demand-side innovation policy positively and significantly affects firm product and process innovation in the Czech Republic.

H2: Demand-side innovation policy has a positive and significant indirect effect on firm product and process innovation in the Czech Republic.

3. Data Collection and Method

Data is collected from Community Innovation Survey (CIS) 2012 – 2014. CIS provides innovative public procurement variable which is used as demand-side policy. CIS is a harmonized survey that is also a component of the EU's scientific and technological statistics. It is conducted in EU Member States every two years. CIS is frequently used to examine a firm's innovation efforts. Previous recent studies (for example; Stojčić et al., 2020; Caravella, & Crespi, 2021; Odei & Hamplová, 2022) used the CIS (2012-2014) to analyse the effect of demand-side policy on firm innovation. 5198 firms from the Czech Republic are analysed in the paper. Structural equation modelling (PLS-SEM) is used to capture our hypothesis. SEM is a helpful technique for assessing complex theoretical relationships between numerous variables, particularly in social science research (Hair & Alamer, 2022). PLS-SEM allows researchers to build and predict complex cause-effect relationship models that include both latent and observed variables (Hair & Ringle, 2017). The PLS-SEM method improves the explained variance of endogenous constructs and functions similarly to multiple regression analysis (Hair et al., 2011). The Explanation of the Variables is Described in Table 1.

Table 1: The Explanation of the Variables is Described in the Following Table

Variable description	
Independent Variables	
Firms especially undertake innovation activities as part of a contract to provide goods or services to a public sector organization (PBINCT)	(Stojčić et al., 2020)
Mediation Variables	
Firms undertake Research and development activities to create new knowledge or to solve scientific or technical problems (RRDIN)	(Sein & Vavra, 2020)
Firms undertake in-house training for personnel specifically for the development of new or significantly improved products and processes (RTR)	
Firms undertake in-house activities for the market introduction of new or significantly improved goods or services, including market research and launch advertising (RMAR)	Prokop et al. (2018)
Firms undertake in-house activities to alter the shape, appearance or usability of goods or services (RDSG)	Duarte et al. (2022)
Firms undertake in-house activities to implement new or significantly improved products and processes such as feasibility studies, testing, tooling up, industrial engineering, etc. (RPRE)	
Dependent Variable	
Firms introduce new or innovative products to the market based on customer's needs (INPDGD)	Zhylinska et al. (2020)
Firms introduce new or significantly improved production or delivery method, including changes in techniques, equipment in manufacturing process (INPSPD)	

4. Results

4.1 Factor Analysis

All outer loading values are greater than 0.4 shown in Table (2). Outer loading above 0.4 can be considered acceptable (Hair et al., 2019). Moreover, the Variance Inflation Factor (VIF), shows that the VIF values are lower than 5. Hence, the model shows no collinearity problem in all values shown in Table (2).

Table 2: Outer Loading and Collinearity Validity (VIF)

Variables		Product Innovation		Process Innovation	
		VIF	Outer loading	VIF	Outer loading
INPDGD	Product Innovation	1.000	1.000		
INPSPD	Process Innovation			1.000	1.000
PBINCT	Demand-side policy (Procurement)	1.000	1.000	1.000	1.000
RDSG	R&D Activities	2.114	0.808	2.114	0.796
RMAR		2.177	0.821	2.177	0.812
RPRE		2.387	0.851	2.387	0.859
RRDIN		1.698	0.788	1.698	0.780
RTR		1.920	0.785	1.920	0.805

The reliability and validity of variables constructs measurement are shown in Table (3). Cronbach's Alpha, rho_A, Composite Reliability values greater than 0.6 and Average Variance Extracted (AVE) greater than 0.5 can be said that model is consistent.

Table 3: Construct Reliability and Validity

	Product Innovation				Process Innovation			
	CA	RA	CR	AVE	CA	RA	CR	AVE
Product Innovation	1.000	1.000	1.000	1.000				
Process Innovation					1.000	1.000	1.000	1.000
Demand-side policy (Procurement)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
R&D Activities	0.870	0.874	0.906	0.657	0.870	0.873	0.906	0.657

CA = Cronbach's Alpha; RA = Rho_Alpha; CR = Composite Reliability; AVE = Average Variance Extracted

The Heterotrait-Monotrait (HTMT) ratio of the correlations is used to access the discriminant validity of the model shown in Table (4). According to Henseler et al. (2015), HTMT ratio is less than 0.85 or 0.9. Hence, discriminant validity has been established between two reflective constructs in the model.

Table 4: Heterotrait-Monotrait Ratio (HTMT)

	Product Innovation	Demand-side policy (Procurement)	R&D Activities	Process Innovation	Demand-side policy (Procurement)	R&D Activities
Product Innovation	-					
Process Innovation				-		
Demand-side policy (Procurement)	0.070	-		0.073	-	
R&D Activities	0.707	0.138	-	0.592	0.138	-

The Saturated and Estimated models measure the relationship between all concepts. SRMR values that are less than 0.095 can be assumed as good functioning of the model. NFI values should be between 0.0 and 1.0 with values closer to 1.0 indicating a good fit. Therefore, the model shown in Table (5) can be assumed a good fit model.

Table 5: Model Fit

	Product Innovation		Process Innovation	
	Sat. Model	Est. Model	Sat. Model	Est. Model
SRMR	0.062	0.062	0.060	0.060
Chi-Square	1507.628	1507.628	1221.379	1221.379
NFI	0.903	0.903	0.915	0.915

Legend: Sat. = saturated, Est. = estimated, SRMR—standardized root mean squared residual, and NFI—normed fit index.

4.2 Path Analysis

For path analysis, the study applied bootstrapping techniques using PLS-SEM to assess the hypothesis. The results show that demand-side policy is not significant and doesn't have any impact on firm product innovation with P Value (0.336) and has no impact on process innovation with P Value (0.564) in the Czech Republic in Table (6). Therefore, H1 is rejected. Moreover, the statistical value shows the relationship between demand-side policy and R&D activities with P Value (0.000). Another statistic value shows the indirect relationship between demand-side policy and firm product and process innovation mediated by R&D activities with P Values (0.000). Hypothesis H2 is accepted and therefore, the demand-side policy has a significant and positive on firm product innovation in the Czech Republic through R&D activities in Table (6). Besides, the demand-side policy has a positive and significant effect on R&D activities and R&D activities have a positive and significant effect on product and process innovation.

Table 6: Results of Path Analysis

Product Innovation		
	T Statistics	P Values
Demand-side policy -> Product Innovation	1.462	0.144
Demand-side policy -> R&D Activities	7.330	0.000***
R&D Activities -> Product Innovation	61.151	0.000***
Demand-side policy -> R&D Activities -> Product Innovation	7.192	0.000***
Process Innovation		
	T Statistics	P Values
Demand-side policy -> Process Innovation	0.048	0.962
Demand-side policy -> R&D Activities	7.672	0.000***
R&D Activities -> Process Innovation	44.691	0.000***
Demand-side policy -> R&D Activities -> Process Innovation	7.543	0.000***

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

5. Discussion

Most previous studies focused on supply-side policy on firm level innovation and few studies emphaised on direct relationship between demand-side innovation policy on firm level innovation in the context of the Czech Republic. These studies neglected the mediating role of R&D activities. Therefore, the aim of this paper is to analyse the influence of demand-side innovation policy on firm innovation mediated by R&D activities in Czech Republic.

In our analysis, demand-side innovation policy has no significant direct effect on firm product and process innovation in the Czech Republic. Therefore, Hypothesis H1 is rejected. Our results against the findings of Stojčić et al. (2020) and Czarnitzki et al. (2018) who found that demand-side innovation policy (public

procurement for innovation) has a significant effect on firm's innovation output (product and process innovation) and drives the success of firm's innovation. However, our finding supports the result of Gyamfi et al. (2019), who found no significant effect on firm product innovation. Our results can indicate that demand-side innovation policy is not likely to be a main driver of firm innovation directly. Some factors such as resources, and competition can influence on firms to innovate (Porter, 1990). In addition, government may have some specific requirements and standardized specifications which can limit some extent of firm's innovation.

Secondly, demand-side innovation policy has a positive and significant indirect effect on firm product and process innovation mediated by R&D activities in the Czech Republic. Therefore, H2 is accepted. This is the study that performs the mediating role of R&D activities between demand-side innovation policy and firm's product and process innovation. Based on the previous works of literature, there is no empirical argument regarding such a relationship. The results of our analysis where R&D activities serve as a mediator between demand-side innovation policy and the firm's innovation. In this case, the full mediator role of R&D activities made the previous studies such as Stojčić et al., 2020; Odei & Hamplová, 2022 which conducted a direct relationship between demand-side innovation policy and firm's innovation insignificant.

Our analysis indicates that government or public agency creates a demand which contains some specific functional requirements. In this case, firms are required to meet a specific condition such as developing new technologies or providing innovative solutions. This condition encourages firms to invest more in R&D to meet these government or public agency standards and win public contracts. An increase in R&D investment could stimulate innovation within the firms and result in the development of new products, processes, or services. Moreover, firms are likely to be encouraged to collaborate with other research institutes or universities to fulfill procurement requirements. This interchange of ideas and skills can result in the development of new knowledge, technological improvements, and innovation. Moreover, the analysis results showed that R&D activities have a positive and significant effect on firm's product and process innovation in the Czech Republic.

6. Conclusions

The aim of this paper is to analyze the effect of demand-side policy on firm product and process innovation mediated by R&D activities in the Czech Republic. Our analysis showed that demand-side policy has no direct significant effect on firm product and process innovation in the Czech Republic (H1). However, the demand-side policy has a positive and significant effect on firm product and process innovation in the Czech Republic. Looking at our analysis results, government policies are vastly effective only when firms have strong readiness to engage in R&D activities to improve new products and technology.

Therefore, the implications are that firms should strongly emphasize undertaking R&D activities to develop new and improved products and processes. Engaging in R&D activities in firms not only can attract government incentives but also can survive in a competitive market. There are some limitations in our paper. Due to the availability of data, only data from 2012-2014 was used. Only one sample country was conducted for analysis. In the future, the latest data and many countries, and different analysis methods can be used for analysis.

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