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DEMYSTIFYING THE FACTORS CONTRIBUTING TO SUCCESSFUL PROCESS INNOVATIONS IN THE CZECH AUTOMOTIVE INDUSTRIES

There is a need for firms to know the factors driving their process innovation. Knowledge of these determinants will help firms to withstand the tough market competitions from their rivals leading to growth and increased productivity. The purpose of this paper is to examine the determinants probable to influence firms process innovations. We focused on the automobile industries in the Czech Republic using data from the Eurostat Community Innovations Survey (CIS) conducted between 2012-2014 and the Structural Equation Model. Our results have shown that the main driving factors probable to contribute to process innovation in these industries were innovation expenditures, collaborations with different partners, engaging in research and development and innovation financial support. Contrary to the literature, we found out that firm's competition in international markets didn't have any influence on their process innovations. Practical implications are also provided for policymakers and management of these industries.
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Introduction

Endogenous theories of economic growth rose to prominence based on its focus on the role played by knowledge in countries economic growth process (Romer, 1990). Other traditional growth theories ignored the vital role of knowledge in the growth process (see Solow, 1956). Solow and Swan suggested that the level of technological development was influenced by external scientific processes which are independent and not influenced by economic forces. But according to proponents of new growth theories knowledge is not an accidental occurrence, it takes conscientious means and both public and private resources to produce. Economic agents heavily invest resources in Research and Development (R&D) for innovations.

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Innovation is highly expected to stimulate wealth, economic growth (national and regional) and competitiveness in firms and countries (OECD, 1997). OECD identifies four types of innovations within firms, namely product, process, organizational and marketing innovations (OECD, 1997). In this paper, we focus on process innovations which is defined as is the swiftness with which firms can implement new or significantly improved methods of production or delivery (Klewitz and Hansen, 2014). These improved methods can occur if firms alter their production techniques, upgrade their equipment and software. Firms cannot be innovative in isolation (Odei and Stejskal, 2018), they, therefore, need some partners who can help in their innovations pursuits. Firms can derive their innovations from diverse sources. The first sources of these innovations can be from the firm's internal sources, where firms can carry out research and development related activities by boosting their manpower base and learning from experiences (Blind et al., 2017). They can also employ skilled labour who are more knowledgeable and can apply knowledge and transform it into economic outputs. When firms realize there is low absorptive capacity in their employees, they can resort to organizing regular intramural education and training activities to expand and improve their internal knowledge capacity. All these measures can go on to affect firms process innovations i.e. productions and delivery methods.

When these internal measures are not enough to trigger innovations, firms can resort to open innovations strategies (Chesbrough, 2006). They can do this by engaging in synergies with partners such as clients and customers, knowledge institutions (universities and public research organizations), and with other firms and competitors. Higher educational institutions and other public research institutions are the birthplaces of scientific and technological knowledge firms need to increase their innovations and competitiveness. Universities can be the dependable resources that industrial innovation policies can rely on. University research output is an important source of significant technological innovation which can give firms a competitive market advantage (Calantone and Stanko, 2007). Beside educational sources, market partners such as suppliers of machinery and equipment can also influence the firm's process innovations. Suppliers of equipment and machinery can offer a significant understanding of firms' production, distribution and logistics activities. They can teach firms about new technologies and through their initiatives, firms can learn and become conversant with these modern and improved technologies.

Certain spontaneous decisions taken by firms also escalate their process innovations. One of such decisions is the extent of internationalization or firms' competitions in international markets by exporting their goods and service. Firms decisions to export can be a strong incentive for them to be innovative (Ramadani et al., 2017). Exporting exposes firms to competitions from other foreign firms and customers. So, their product quality, branding and design need to conform to or be more than that prevailing in the international market (Coccia, 2017). When this is not the case, international market competitions can be a learning platform for these firms. International market competitions can increase firms' capabilities to implement new techniques of production when the local innovation ecosystem is weakly developed. Competing in foreign markets prepare the grounds for firms process innovations, this is because it allows firms to learn and stay ahead of their rivals.

The success of these innovations (process) within firms also rests on the financial support they receive from governments. Shortage of capital poses as a great challenge for firms that want to be innovative. But governments across the globe have come to the rescue of firms that lack the necessary capital for innovation and its related activities. Governments are increasingly getting involved in the innovation process because of the market failures syndrome. Market failure is the key rationale for governmental innovation interventions (Guan and Yam, 2015). Some policy tools mostly employed by governments to boost firm-level innovations include research and development (R&D) tax credits, which is targeted at helping firms to narrow the financial gap that acts as major hindrance to innovation (Hölzl and Janger, 2014).

The Czech automotive industry is the focus of this paper. This sector is the foundation on which the Czech economy is built. This sector plays a key role in the European as well as the global economies (Winter, 2017) The Czech automotive sector alone employs about 150,000 people, making it the main gross value employer in Central Eastern Europe (Pavlínek, 2018). Owing to the enormous contribution this sector brings to the Czech Republic, this paper aims to examine the factors driving and sustain its process innovations. This will share more light on the factors driving the success of this sector. It will at the same time serve as a guide to management and policymakers as it will enable them to know where to channel their scarce investment resource.

The remaining sections of this paper are structured in the following order: Section 2 is devoted to the theoretical background providing reviews of the literature on process innovations. Section 3 focuses on the data and methods used for our empirical analysis, Section 4 provides the results of empirical analysis and discussions. Section 5 concludes the paper and draws attention to some policy implications and suggestions for future research.

Determinants of firms' innovation performance

The OECD Oslo Manual uses the term innovation to denote "scientific, technological, organizational, financial and commercial activities which lead or intended to lead to the implementation of technologically new or improved products or services" (OECD-Eurostat, 1997). The sources of these scientific and technological inventions have been traced to the firms confines, the business environment, universities and other higher educational as well as government research centres. Firms can rely on universities scientific research to reap high turnover and offer improved goods and services to the market. The propensity of firms to introduce newly improved products into the market depends on the whole lots of factors. Hagedoorn and Cloodt (2003) have suggested that, to determine these innovative performances, researchers need to rely on multiple indicators because these innovations do not arise from single sources but rather through various combinations of sources and efforts.

The most essential determinant of firms' innovation performance and their ability to introduce significantly improved products is contingent on the expenditure they devote to finance innovation. With readily available funds, firms can undertake novel research in collaboration with important partners such as universities and public research

organizations. These new ideas from knowledge institutions can transform industries ultimate economic interests of making huge profits. Firms' innovation expenditure is an input that can be utilized to appraise their process innovation performance (Klomp and Van Leeuwen, 2001). Firms' expenditures on R&D can have a critical and direct impact on their innovation activities and their propensity to soak up external knowledge, when firms have enough and reliable sources of funding, it can increase their gross earnings and competitiveness (Frenz and Ietto-Gillies, 2009). R&D funding can balloon companies' total productivity and reduce their production cost (process innovation) and increase the quality of their products.

Governments provide funding and subsidies to stimulate innovation activities of industries. The rationale behind government supporting firms R&D with subsidies is because of the positive spillover effects and social returns to the economy (Arrow, 1962). Excessive spending by national governments can also result in innovation paradox, due to the fact that most of these firms have a lower absorptive capacity to use earmarked funding aimed at promoting innovation. Government funding does not always contribute to improved innovative performance, Chesbrough (2006) has argued that innovative firms do not spend hugely on R& D; instead they can rely on knowledge and expertise from diverse external sources to enhance their innovation performance. From the above mentioned, we provide the hypotheses that,

H_1: The availability of funding support does not improve firm's process innovations.

As stated above, decisions made by firms affect their innovations potentials, an important of such decisions is to collaborate with other partners. Firms cannot innovate in isolation, so they need to look beyond their internal confines. They can also derive their innovations externally by forming synergies with another partner, such as science system (universities and public research organizations), clients, customers and suppliers and other market competitors (Maietta, 2015). These external innovation collaborations help firms to overcome their innovation barriers and allow them access to knowledge which is seen as a kernel in the innovation process (West and Bogers, 2014). Firms innovations collaboration with other partners increases the likelihood of accomplishing process innovation (Un and Asakawa, 2015). Universities especially can primarily be relied upon for achieving process innovations and conducting basic research into technologies. Universities are a significant source for the firm's product innovation especially in emerging technology. Numerous empirical studies have proven that when firms engage in R&D collaboration their process innovation performance soars (see Lööf and Heshmati, 2002; Criscuolo and Haskel, 2003). Therefore, forecast that,

H_2: Firms collaborations with other partners significantly improve their process innovation.

In addition, the strengths and prospects of the firm's process innovation performance can be influenced by R&D expenditure. Firms need to invest a lot to be able to produce goods and services (Klette and Kortum, 2004). The expenditures firms spend on R&D could yield

innovations relevant to any goods and processes with equal probability. Using econometric analysis Chudnovsky et al. (2006) have demonstrated that in house technology acquisition and R&D expenditures have a positive impact on firm's probability to offer new products and processes to the market. Crépon et al. (1998) also proved that when firms increase their R&D intensity by 10% it can trigger a corresponding 5% increase in their innovation sales. Similarly, a study by Baldwin and Lin (2002) conducted in the manufacturing firms in Canada concluded that the probability of firms to introduce a new process increased by 15% within firms that engaged in R&D spending and activities. Based on the above-mentioned arguments, we provide our third hypothesis as,

H_3: Expenditures devoted to research and development contribute to firms' overall process innovations.

Firms that make the decision to compete in international markets by exporting their products can be more innovative than those with just domestic market orientations (Belderbos et al., 2015). Domestic firms compete in foreign markets when they export their products, this exposes them to tougher competition usually from subsidized and quality foreign products, this compels and incentivize local producers to innovate. Additionally, when exporting firms participate in foreign markets it expediates their acquisitions of extraneous technologies. Market competitions compel firms to innovate to be the market leader by winning large shares of the market ahead of their competitors (Berry and Berry, 2018). According to Bratti and Felice (2012) exporting firms are more likely to undertake R&D which can affect their ability to introduce new processes than their counterparts with domestic market focus. This is because exporting to new markets can improve firms' knowledge of foreign production processes and increase their aptness to assimilate new technologies (Johanson and Mattsson, 2015). Studies conducted by Damijan et al. (2010) for large and medium-sized firms in Slovenia concluded that exporting swells the likelihood of becoming process innovators. Based on the literature, we provide the fourth hypothesis as follows,

H_4: Firms that export their products are likely to be process innovators.

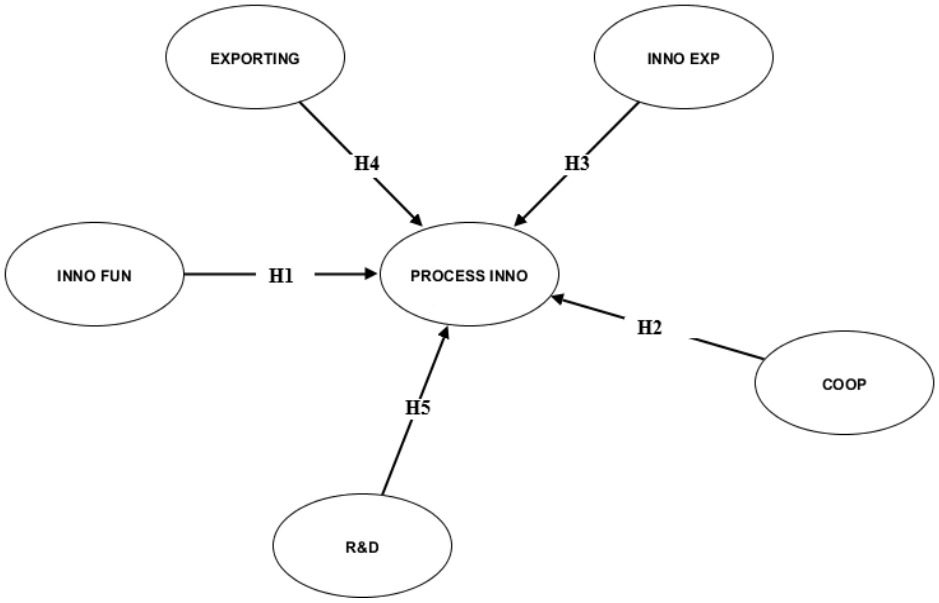
Engaging in research and development (R&D) activities is crucial for firm's growth and success (Baumann and Kritikos, 2016). R&D equip firms with the requisite knowledge-based resources and increase their absorptive capacities. Investments in R&D contribute to ameliorating firms' absorptive capacity and makes them able to acknowledge the value of new knowledge and information and been able to assimilate and commercialize (Odei, 2017). R&D investments enhance the learning capabilities of firms and improve their aptitude to use advanced technologies (Maietta, 2015). When firms make the decision to conduct R&D, it influences their prospect of introducing new products and processes (Raymond and St-Pierre, 2010). Here the hypothesis we propose is that,

H_5: Conducting R&D is likely to positively influence firms process innovations

This paper intends to contribute to the growing literature on firm-level innovations. Understanding the factors contributing to process innovations would be of immense help to these industries because it would allow them to come out with innovative ways of improving their production and distribution methods, leading to customer satisfaction and firm growth. In a nutshell, it will shed more light on the drivers of process innovations in a vital sector of the Czech economy. The hypotheses stated above and the factors that can drive firms process innovations are summarized in the conceptual framework depicted in Figure 1 below.

Figure 1

Conceptual framework model



Note: INNO FUN= innovation funding, INNO EXP=innovation expenditures, PROCESS INNO= process innovations, COOP= innovations collaborations, R&D= research and development activities.

Data and method used

In pursuant to meeting the objective set for this paper, we used data from the Eurostat Community innovation survey (CIS) carried out between 2012-2014 for the empirical analysis. The CIS is conducted by the European Union (EU) to collect data on innovation activities at the firm and country-level in all member states. The CIS is a survey of innovation activity in enterprises that is designed to provide information on the innovativeness of sectors by type of enterprises, on the different types of innovation and on various aspects of the development of innovations, e.g. *(i) the objectives; (ii) the sources of*

information (iii) the public funding (iii) the innovation expenditures (Prokop, 2015). We, therefore, considered 280 companies in the automobile industry in the Czech Republic. These industries fall within the Nace 2 classification 29-30.

To analyse the relationship that exists between the variables, we used the structural equation model (SEM). The SEM offers a one-step, broad-spectrum and convenient framework for statistical analysis as it combines most of the numerous traditional statistics such as factor analysis, regression analysis, multivariate procedures, canonical correlation and discriminant analysis (Hox and Bechger, 1998). SEM is capable of modelling latent variables by considering all the numerous types of measurement errors, while it simultaneously allows researchers to test causal theories structurally. The path diagram in SEM allows for easy graphical visualization. Many studies have used the structural equation model to measure firms' innovation performance (Rhee et al., 2010; Gunday et al., 2011). The SEM shows standardized regression coefficients estimates (path coefficients) therefore it can be used to measure the relationships among latent variables.

All calculations in this paper were done with the Adanco statistical software. We first tested the statistical significance of the path coefficients by running the bootstrapping (Efron and Tibshirani, 1993). Bootstrapping enables calculating p-values, t-values and confidence intervals to measure the significance of PLS-SEM results, the results are presented below.

Measurement reliability and validity

We first provide the results for measures of reliability and validity of our constructs using the confirmatory factor analysis (CFA). There are three measurement approaches that can be used to measure constructs reliability (see Cheah et al., 2018), in this paper, we preferred the Jöreskog's rho (ρc) criteria to the remaining two. Jöreskog's rho (ρc) reliability measure relies on the sum of scores instead of construct scores (Henseler et al., 2016), so it's considered an upper boundary reliability measure (Hair et al., 2016). Minimum values of 0.70 designate acceptable reliability, with the maximum threshold of 1 (Chin, 2010).

From table 1 above, all our constructs passed the minimum acceptable 0.7 threshold. This indicates that all our constructs demonstrated to have moderate higher internal consistency reliability. The information about the cross-loadings, which provides information about the correlations among indicators and their corresponding constructs also show that loading values of equal to or greater than 0.40 are acceptable, but values less than this threshold need to be eliminated from the model (Gorsuch, 1974). From table 1, it is evident that all our construct had loadings attaining the minimum 0.40 limit.

Also, for our convergent validity assessment, we used the two most widely used measurement criteria namely the average variance extracted (AVE) and discriminant validity (Cheah et al., 2018). The AVE measures construct unidimensionality which some authors believe should be equal to or greater than 0.5, so as can be seen from table 1 and 2 above, all our constructs attained the minimum thresholds except for the collaborations construct. Also, for the discriminant validity, the Fornell-Larcker criterion (Fornell and Larcker, 1981) assumes that all the construct's average variance extracted (AVE) needs to

be higher than the squared inter-construct correlations of all the model' constructs. As can be seen from table 2 all our latent variables have values surpassing the highest correlation coefficients.

Table 1

Constructs reliability and validity measurements

Constructs	Items	Loadings	Jöreskog's rho (ρc)	AVE
Process Innovations	P1	0.811	0.847	0.648
	P2	0.777		
	P3	0.827		
Exporting	X1	0.590	0.735	0.592
	X2	0.915		
Innovation funding	F1	0.555	0.767	0.529
	F2	0.811		
	F3	0.789		
R&D	R	1.000	1.000	1.000
Collaborations	C1	0.598	0.831	0.389
	C2	0.693		
	C3	0.621		
	C4	0.540		
	C5	0.352		
	C6	0.675		
	C7	0.729		
	C8	0.694		
Innovation Expenditures	E1	0.736	0.875	0.471
	E2	0.591		
	E3	0.720		
	E4	0.545		
	E5	0.791		
	E6	0.713		
	E7	0.579		
	E8	0.767		

Source: Own calculations

Table 2

Fornell-Larcker discriminant validity

Construct	PROCESS INNO	Exporting	INNO FUN	R&D	COOP	INNO EXP
PROCESS INNO	**0.648**					
Exporting	0.046	**0.592**				
INNO FUN	0.198	0.037	**0.529**			
R&D	0.157	0.062	0.258	**1.000**		
COOP	0.220	0.073	0.224	0.213	**0.389**	
INNO EXP	0.421	0.073	0.296	0.477	0.272	**0.471**

Source: Authors calculations.
Note: squared correlations; AVE are boldened and shown in the diagonal.

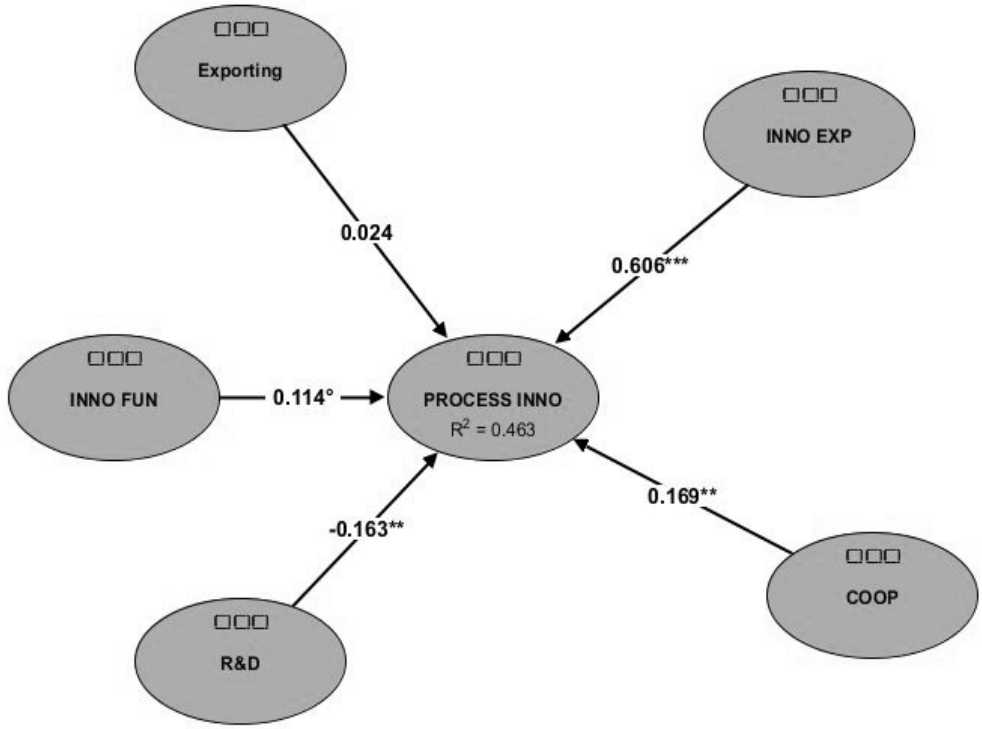
Results and discussions

The structural Equation Model (SEM) is used to measure the effects of innovation funding, competitions in international markets (exporting), innovation expenditure, engaging in R&D, and innovation collaborations influence on process innovations within the automobile sector in the Czech Republic.

We begin the results and discussion by first looking at the predictive power of our model. From Figure 2 below, the predictive power (accuracy) of our model measured with the coefficient of determination (R^2) is 46%. Meaning that the variance explained in the endogenous variables, or in other words, all the determinants considered were probable to predict firms process innovations by 46%. This can be viewed as having a strong predictive accuracy going by Cohen's f^2 criteria (Cohen, 1988).

Figure 2

Path model for industries process innovations



Note: significant at*; p<0.05, **; p<0.10, ***; P<0.001

Table 3 allows us to test the five hypotheses stated above. It can be evidenced that, public support for innovation i.e. funding from the EU, public funding from local or regional authorities as well as public funding from central governments were all positive and significant sources of funding for these industries process innovations. These funding

supports for innovation can help firms to introduce and carry out newly improved production method as well as helping firms to boost their distribution processes. This is because implementing new methods and process is costly and without an adequate amount of money, firms might not be probable to carry out these costly activities. From the above, we can, therefore, accept our first hypothesis (H_1) that innovation funding helps firms to improve their process innovation performance. Our results corroborate the findings of previous conclusions reached by (Czarnitzki et al., 2007; Artz et al., 2010).

Table 3

Standard bootstrap results

Relationships	coefficients	Mean value	Standard error	p-value (2-sided)	Decisions	Cohen's f^2
INNO FUN -> PROCESS INNO	0.114	0.114	0.067	0.087*	Accepted	0.015
COOP -> PROCESS INNO	0.169	0.181	0.062	0.006**	Accepted	0.035
INNO EXP -> PROCESS INNO	0.606	0.609	0.071	0.000***	Rejected	0.302
EXPORTING -> PROCESS INNO	0.024	0.026	0.043	0.577	Rejected	0.001
R&D -> PROCESS INNO	-0.164	-0.170	0.063	0.010**	Rejected	0.024

Source: Own calculations,
Note: significant at*; p<0.05, **; p<0.10, ***; P<0.001

Again, our results show that firms' collaborations are positive and statistically significant factor influencing process innovations. Firms collaborations with other partners such as those in the enterprise group, universities, government and other research institutes, clients and customers play a very significant role in influencing these firm's knowledge sharing and process innovations. When firms enter into synergies, they can acquire and absorb new knowledge through the numerous interactions, and these can subsequently influence their prospects to improve their supporting activities such as maintenance and operations. In addition, through these collaborations and competitions, firms can learn from their rivals especially those in the market group, and this can influence their possibility to introduce significantly improved production techniques to improve their goods and services. This indicates that although firm's innovation collaborations are having a positive influence on process innovations. The result of the effect size also shows that collaborations have an effect size of 0.035. This effect size result demonstrates that collaboration has a weak effect influence on process innovation (see Cohen, 1988). Our results confirm our second hypothesis (H_2), that firm's collaborations help to improve their process innovations. Our result is akin to another conclusion reached by other related studies (Un and Asakawa, 2015; Enkel et al., 2018).

The findings of the study back the claim that there is a positive and statistically significant relationship between innovation expenditures and process innovations. When firms have ample amounts of money, they can engage in R&D activities such as acquiring external

knowledge and machinery, in-house R&D and training for innovations. These expenditures can also contribute to firms' market innovation because it can help them to carry out activities such as conducting market research and advertising campaigns, which can go a long way to make them stand out among their competitors in the market. These expenditures can also contribute to firms tooling up process required for innovation and implementing new process within firms (Appleyard, 2015). The result also shows that firms innovations expenditures have the highest substantial direct effect on these firms process innovations (0.302). Our results have therefore proven contrary to our hypothesis H_3, but instead, firms expenditure devoted to innovation activities contributes to their process innovations. Our results, therefore, corroborate similar researches that all concluded that innovation expenditures contribute to firms process innovation and its related activities (Belderbos et al., 2015; Grimpe et al., 2017; Peters et al., 2017).

The results have demonstrated contrary to the claim that exporting firms are more likely to be process innovators. Our results rather showed an insignificant relationship between competing in international markets and its prospects to impact firms' process innovations. From our results, when these firms compete in other foreign markets, it doesn't have any probable positive influence on their ability to acquire and apply new and significantly improved methods of production as well as their distribution and supporting processes. Exporting, in this case, reduces the likelihood of contributing to these firms' production process and methods. Exporting has an unsubstantial direct effect on process innovation (0.001). This result, therefore, contradicts previous conclusions reached by authors such as (Damijan et al., 2010; Bratti and Felice, 2012; Johanson and Mattsson, 2015). Based on the following conclusion, we, therefore, reject our hypothesis H_4 that stated that exporting helps firms to improve their process innovations.

Finally, our findings have shown that there is a significant but negative relationship between engaging in research and development (R&D) and process innovation. When firms engage in R&D, it rather does not increase the likelihood of impacting on their prospect of executing newly improved production and distribution methods and supporting activities. The reason for the negative relationship can be that these firms do not expend more on conducting research and development activities. Research and development activities carried out by firms helps in generating new knowledge which can be of significant help to firms in overcoming challenges relating to their process and product innovations. This result also shows that conducting R&D has an unsubstantial effect on process innovations, meaning it has a relatively low relative impact on process innovation (0.024). This result contrasts the previous assertion that when firms conduct R&D, it influences their prospect of introducing new products and processes (Raymond and St-Pierre, 2010). The results mean that we reject our hypothesis H_5, because for these firms, conducting R&D was not probable to contribute positively to their process innovations.

Conclusion and practical implications

The aim of this study was to examine the factors that have the propensity to drive process innovations in the automobile industries in the Czech Republic. Knowledge of these

determinants will enable firms to focus their limited resources on these factors so that they can be innovative. Using the Structural Equation Model, we analysed 280 industries in the automobile sector in the Czech Republic. From the empirical results, the study found out that the major drivers of successful process innovations in these industries were the amount of expenditures devoted to innovations, collaborations with both internal and external partners, and innovation support or funding from governments. The study also came to an interesting conclusion which contradicted previous studies that when firms compete in international markets through exporting their goods and services, they can learn and gain new knowledge and ideas from other industries in the foreign countries that can be beneficial to their innovations domestically. Surprisingly, we reached the conclusion that conducting research and development rather had a negative influence on firms process innovation. The conclusion from here is that although conducting R&D increases the probability of effective innovation, it is not a prerequisite in the case of these industries.

Our research has confirmed that innovation expenditures have the highest effect on process innovation for firms in this sector. We, therefore, recommend firms to expend more on their innovation activities. Here financial support for innovations from governments can be utilized and channelled to cater for the numerous innovation activities carried out by these firms. Firms can also plough back their profits and reinvest them in their innovation activities. Lastly, these firms can also borrow from financial institutions to finance their innovations and their related activities.

The results of our analysis have again shown that firms innovations collaborations for knowledge and innovations have the highest probabilities to influence process innovations. These collaborations involve markets partners and customers, public and higher educational institutions among others. We, therefore, recommend these firms to intensify these technological collaborations and knowledge networks, when this is done then these firms can have access to reliable economic knowledge that can sustain their process and general innovations performance.

This study contributes to and build on the burgeoning literature on drivers of firm-level innovations. The findings of this study cannot be used for generalization purposes because of the following limitations. The sample size used for the analysis i.e. 280 firms was comparatively small bearing in mind the size and structure of all industries in the Czech Republic. Secondarily, this study focused on only internal factors driving firms process innovations, we therefore suggest further studies that will focus on other external factors such the business environment that can incentivise and increase firms' capability to implement new methods and activities for its innovations. This study can also be replicated in other Central and Eastern European (CEE) countries such as Slovakia, Hungary and Poland where the automobile industries play a key role in the growth and economic development to validate our findings.

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