

Consultants and firm-level innovation performances: a doubly robust estimation approach

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Abstract

This paper examines firms use of external consultants and commercial labs as an essential source of knowledge for innovation performance and activities in the IT and other information service firms. Consultants are essential conduits to transfer knowledge, technologies and innovations to firms and other economic agents. Using data from the Eurostat Community Innovations Survey conducted between 2012 and 2014 and the doubly robust estimation methodology, this study, as expected, found a positive and statistically significant relationship between product and process innovations, intramural R&D, engagement in R&D, market introduction of innovations, engagement in other preparation influenced firms to rely on the services of external consultants. The results of the propensity-score matching also show that on average, firms that relied on the services of consultants were 61% more likely to improve their product innovations and 62% organizational innovations than those firms that didn't use them. The results are important for firm managers who are aiming to be innovative and can serve as a practical guide on how to improve firm-level innovation potentials and activities.

Keywords: consultants, innovations, knowledge transfers, R&D, Czech Republic

Introduction

Firms' collaborations with external consultants and commercial labs can play a vigorous role in accelerating innovations. External consultants act as mediums for technological and external know-how firms need to improve their innovations performances. Consultants examines business activities to identify aspects where they fall short and advise on how to minimize and plan how to capitalize on their

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strength. Firms do not acquire all their technological knowledge internally, there are times when they have to depend on external sources to augment the shortfalls in internal knowledge. Firms depends on external knowledge sources to complement internal sources; this is known in innovation literature as inbound open innovation (Spithoven *et al.*, 2010; Bianchi *et al.*, 2016). Consultants and commercial labs have become vital sources of external knowledge; firms need to stay innovative and recent studies show that innovative firms are increasingly relying on consultants for their technological knowledge (Srinivasan, 2014).

Consultants and commercial laboratories complement internal knowledge resources with their external expertise, when they interact with firm managers and employees. Consultants can help firms launch a wide array of innovations and can also contribute to other innovation activities such as training, intramural R&D, product designs etc. The European Union has come up with numerous innovation policies, funding support and other policy tools with the aim of supporting open innovations, knowledge sharing and collaborative research across Europe (Bozic and Botric, 2017; Moskovko, 2020). Numerous studies have shown that external consultants and commercial labs positively impact firms' innovation and its related activities (Back *et al.*, 2014; Bianchi *et al.*, 2016; Lee and Seo, 2018). Despite the apparent benefits external consultants and commercial labs provide, many firms completely do not engage them in their innovation's development. Usage of firms varies significantly from countries to countries and thus studies conducted by BEEPS V in 2014 in transition countries of the former Soviet bloc usage of consultant varies; firms that use the services of consultants ranges from 4 to 54% (BEEPS V, 2014). Data from the Eurostat Community innovation survey conducted between 2012 and 2014 show that, 5% of innovative firms in the Czech Republic collaborated with external consultants and commercial labs for their knowledge and innovation needs. The extant literature reviewed showed that there have been no studies that have examined the influence of consultants and commercial labs on firm-level innovation and its related activities in the Czech Republic. Hence this paper intends to fill this theoretical gap and provide a detailed insight into this vital component of firm's innovations. This paper contributes to the growing literature on inbound open innovations as it sheds more light on which aspects of innovations can be influenced by engaging the services of consultants.

The novelty of this research is based on the idea of studying how firm's innovation performance and activities can influence them to collaborate with external consultants using a doubly robust approach to estimate the additional effects that might arise from engaging the services of external consultants and commercial laboratories. The doubly robust estimator will enable us to ascertain the average contributions of consultants on firm level's innovations and activities. We believe that firms in the Czech Republic can depend on consultants to augment their weak innovation potentials. This study focused on firms in the information Technology sector in the Czech Republic. This sector was chosen for this paper because, in the

era of digitization, the IT sector is the main driver bringing new technologies to firms and individuals. This sector is of high importance because it provides modern supporting information and communication technology (ICT) infrastructure that can facilitate innovation and its related activities within firms (Valdez-Juárez *et al.*, 2018). ICT firm's usage of consultants can have a major impact on the likelihood of introducing process and product innovations. So, this implies that these firms constantly need to engage consultants who are knowledgeable and abreast with modern technologies and expertise to help them get familiar with the usage and maintenance of these technologies.

The rest of the article is organized in the following format. The next section describes the empirical and theoretical literature on inbound open innovation that explore firms' external innovations search. Section three focuses on the description of methodology, variables, and presents the source of the dataset for the empirical analysis. The empirical results and the test of their robustness by means of the treatment effects doubly robust estimations are included in Section four, and Section five deliberates on the results from the perspective of the existing literature. The final part concludes with recommendations and suggestions for further research.

1. Theoretical background

There is a paradigm shift from the closed (internal) innovation strategy which has been proven to reach its cutoff point. Firms are in recent decades seeking new ways of participating in open innovations. Open innovation describes the degree firms can utilize external knowledge and information to enhance their innovation performance and its activities (Santoro *et al.*, 2018). By relying on external resources and capabilities, firms can significantly improve their innovation competences (Bogers *et al.*, 2018). Firms increase their competitive advantage when they access novel complementary knowledge and other inimitable resources that are beyond reach in their internal boundaries. Proponents of open innovations view collaborations as means to acquire and absorb new knowledge and contemporary technologies to boost their innovation prospects. The open innovation model is built around the assumption that innovative companies enter into synergies with diversified R&D partners such as external consultants, knowledge institutions (government and private research agencies, university labs). These technical networks allow for the exchange of vital knowledge and information (Un and Rodríguez, 2018). Networks are increasingly essential for firms that engage in innovation pursuit as they allow firms' access to markets, information, technology, and other resources as well as the opportunity to develop new capabilities. According to the growing literature on open innovation, there is one progressively important R&D partner that can infuse new knowledge to firms but has received considerably less attention in open innovation literature. Thus, the role played by external

consultants and commercial laboratories in the knowledge diffusion and innovation process is major (Bianchi *et al.*, 2016).

Firms' search for product innovations can influence them to collaborate with external consultants. These external consultants have the expertise to excavate aspects of businesses, help them to identify disadvantaged areas and help them to minimize and strategize how to exploit these areas of competitive advantage. Product innovations embodies organizational outputs that ends with improved quality of goods and services that consumers might appreciate and demand. External consultants can complement the inbound technology generated within firms. Firms' knowledge and technology base can be increased and augmented through their innovation collaborations with external consultants (Bianchi *et al.*, 2016). Studies conducted by Gómez *et al.* (2016) and Bianchi *et al.* (2016) all concluded that using knowledge from external sources such as consultants do not have any meaningful impact on product innovations. We therefore build on the understanding that external consultants and commercial laboratories can help firms to improve their products. Hence, we hypothesize that:

H1: *Firms product innovations and its related activities significantly influence them to collaborate with external consultants and commercial laboratories.*

Process innovations, on the other hand, refers to the implementation of innovative or significantly enhanced methods of production or delivery; it also comprises significant modifications in techniques and equipment (software). Also, we anticipate that firm's process innovations will influence firms to collaborate with external consultants and commercial laboratories. In the quest to be innovative, firms are constantly seeking new ways to develop and improve their existing processes to suit current demands. Supply-driven factors such as intense competitions from both domestic and foreign sources compels firms to look for modern processes that might help them to withstand and be the market leader. This is where the expertise and knowledge from external consultants can be of help. External consultants have the knowledge and expertise firms need in this regard. They can help firms improve their processes there by reducing their marginal production cost. Studies conducted by Bruhn *et al.* (2018) and Simao and Franco (2018) all concluded that external knowledge from external consultants and commercial laboratories helps firms to improve their process innovations. In accordance with the literature, we hypothesize that:

H2: *Process innovations influence firms to collaborate with external consultants and commercial laboratories.*

External consultants and commercial laboratories can help firms with market research that underpins new products development that meets customers' expectations. The involvement of external consultants in R&D activities is suggested to be positive because their activities allow firms to develop the needed capabilities to acquire technical knowledge and transform it into significantly improved new products and services. Technical knowledge and expert advice from external

consultants can be transmuted into market knowledge that can be outputs in new products development. External consultants and commercial laboratories act as intermediaries that offer market information and expert advice that can improve products (Back *et al.*, 2014). These consulting intermediaries also support firms with both transportation and logistics, thereby helping to expand their supplier networks. Studies conducted by Bruhn *et al.* (2018) and Gond and Brès (2020) found that there is a positive and highly significant association between using external consultants and marketing innovations. Based on this understanding, we summarize the belief that firms will collaborate with external consultants and other commercial laboratories to improve their marketing potentials. We propose the hypothesis that:

H3: *Marketing innovations will significantly influence firms to collaborate with external consultants and commercial laboratories.*

Firms can also rely on the services of external consultants and commercial laboratories to improve their organizational innovations. Organizational innovation refers to the creation or acceptance of novel ideas within organizations. Organizational innovation entails the implementation of new methods in the firm's business practices, organizational planning or external relations. The new ideas adopted by firms in management strategies and its gradual implementation also means that firms cease to rely on process and methods that are not efficient. In the view of Birkinshaw *et al.* (2008), organizational innovations can be created, disseminated, and sustained by relying on external change agents such as independent external consultants. The expert advice of consultants stimulates the development, legitimizes the efficiency and helps to withhold new management practices, the preadoption, adoption and postadoption of organizational innovations highly depending on their knowledge-based or professional relations with consultants simultaneously with other internal mechanisms (Ganter and Hecker, 2014). The research carried out by Bruhn *et al.* (2018) found a positive and highly significant relationship between the use of consultants and organizational innovations, their finding is coherent with the evidence that firms can depend on external consultants to improve their business practices and organizational procedures. However, firms can rely on and assimilate the expertise and expert advice of external consultants to enrich their organizational procedures when they fully develop their absorptive capacity (Damanpour *et al.*, 2018, Gond and Brès 2020). We therefore summarize the idea that knowledge and the expertise of external consultants can be used by firms to improve their organization innovations. We therefore hypothesize:

H4: *Organizational innovations can influence firms' decisions to collaborate with external consultants and commercial laboratories.*

Innovation activities comprise not just all kinds of R&D activities, it also includes other catalysts that aid the innovation, such as trainings, acquisition of machinery and equipment, fixed assets, software, and licenses, product design and marketing among others (Criscuolo *et al.*, 2010). According to the CIS instrument,

firms undertake these activities to specifically implement or develop product or process innovations, and they are subsequently anticipated to impact the organizational and marketing innovations (Cesário *et al.*, 2015).

Due to fast changing technologies and business environments, it is more difficult for enterprises to maintain competitive advantages through in-house R&D alone. The critical element for sustaining innovation is the human capital side of the equation. Innovative firms continuously spend a lot to carry out intramural R&D that helps to improve their innovation potentials. Lokshin *et al.*, (2008) define internal R&D as firms' expenditure devoted to intramural R&D. These also includes allocations for the purchase of other equipment or supplies that support intramural R&D. Firms benefit when they engage in internal R&D through the involvement of external agents like external consultants and other commercial laboratories (Hashi and Stojčić, 2013). A research conducted by Lokshin *et al.* (2008) and Cesário *et al.* (2015) concluded that firms' process innovation was intimately influenced by new ideas generated by external actors such as consultants and commercial laboratories. Contrary, their results showed that firms collaborations with external consultants and commercial laboratories had no significant impact on product innovation. Based on this understand from the literature, we hypothesis that:

H5: *Firms intramural R&D activities significantly impact on their ability to collaborate with external consultants and commercial laboratories.*

Economic agents heavily invest resources in research and development (R&D) to produce novel knowledge. Collaborating with external consultants and commercial laboratories helps firms to reduce the burden of undertaking R&D. Certain activities such as those which cannot be performed directly by firms due to manpower constrains can be subcontracted to external consultants (Delen *et al.* 2016). This can invigorate and build upon prevailing knowledge within firms and their employees. Firms can also outsource or contract out market research activities to external consultants. Consultants can conduct market research capable of helping firms to know the prevailing market conditions, consumers taste and preferences which can be incorporated in the production and distribution needs (Tether and Tajar, 2008). Studies conducted by Bianchi, *et al.* (2016) find that external consultants improve the aptitudes of firms to accomplish R&D activities. Based on this understanding, we provide the hypothesis that:

H6: *Innovative firms engaging in R&D are highly probable to cooperate with external consultants and commercial laboratories.*

We also anticipate that when firms have exhausted their internal (intramural R&D) potentials, they can collaborate or outsource to external consultants and other commercial laboratories. Firms engage in Extramural R&D when they outsource activities related to innovations to external partners like consultants. Firms can engage in collaborative or contract research with external consultants who offer advisory services or research initiated and funded by firms (Lundvall, 2009). A study carried out by Wadhwa *et al.* (2017) and Jha and Bose (2016) find that outsourcing

extramural research and development (R&D), activities to external entities like consultants and commercial laboratories results in beneficial knowledge leakage which can impact positively in all aspects of firms' innovations and its related activities. We offer the hypothesis that:

H7: *Engaging in extramural R&D is highly likely to influence firms to collaborate with external consultants and commercial laboratories.*

Firms exposure to external know-how from consultants is a significant channel in the fulfilment of their innovation needs. Extension consultants can explicitly diffuse new knowledge and technologies which can be very vital in stimulating technological advancement and organizational innovation (Mignon and Bergek, 2016). External consultants can serve as the middlemen who update firms with knowledge on current technologies and how they can be utilized in new product and process developments. Their knowledge and expertise can help firms when they want to procure machinery and equipment to supplement their worn-out existing stock. They can be employed to provide market research underpinning new technologies and how they can be used effectively and efficiently in the production process. A research conducted by Back *et al.* (2014) and Hochleitner *et al.* (2017) found that consultants can be used to introduce new machinery and technologies that can increase their productivity and innovations. Based on this understanding, we therefore hypothesize that:

H8: *Firms' quest for new machinery and equipment can influence them to collaborate with external consultants and commercial laboratories.*

External consultants and commercial laboratories serve as a vital source of external knowledge for firms that can complement inadequate internal knowledge (Tether and Tajar, 2008). External knowledge comprises the obtaining of new knowledge from sources outside the firms' ecosystem. One vital source of external knowledge for firms is their use of external consultants. External consultants share their knowledge and know-how when employees collaborate with them. External consultants disseminate their innovation skills to firms when firms contact them when they are unable to accomplish best result after exhausting their internal knowledge. Consultants can also frequently carry out professional knowledge activities such as conferences, trainings and workshops. Studies conducted by Odei (2018) concluded that firms in Slovakia did not depend on the collaboration with external consultants for their innovation needs. However, a recent study also from the Czech Republic by Odei and Stejskal (2020) found a positive and statistical relationship between using external consultants and innovations (product and process innovations). Hence, we formulate the hypothesis that:

H9: *Firms are not highly probable to collaborate with external consultants and commercial laboratories for their external knowledge needs.*

External consultants can be very important outsiders for firms' human capital innovation trainings. Innovative-driven firms can rely on them to fuel their innovations with novel ideas and strategies (Beidas *et al.*, 2011). Firms'

collaborations with external consultants enables employees and managers to be trained to develop the desirable skills to be innovative. External consultants have the tools and techniques firms need to be innovative. They help firms by organizing workshops, training programs, conferences and mentor schemes that can be a source of knowledge and innovation for firm managers and employees. Studies conducted by (Tudor *et al.*, 2014; Boermans and Roelfsema, 2015) concluded that firms' innovation trainings influence them to collaborate with external consultants and commercial laboratories. We hypothesize that:

H10: *Firms innovation training activities are likely to influence them to collaborate with external consultants and commercial laboratories.*

External consultants and commercial laboratories can assist firms to engage in activities that can help them introduce innovations to the market (Cesário *et al.*, 2015). Consultancy and external consultants can help firms accomplish strategic and short-term innovation objectives and activities. These auxiliary services and activities do not necessarily have direct impacts on innovation output, but they serve as catalysts that support firms to expand their competences (Carrillo *et al.*, 2015, Odei and Stejskal, 2020). These services also help firms to identify critical aspects of their production and processes that need to be innovative. External consultants and commercial laboratories serve as change agents who do not transfer peculiar technologies to firms that depend on them. The expert advices of innovation consultants can help firms to modify their production and processes innovatively and this can help them to introduce innovations to the market. Based on the literature, we therefore hypothesize that:

H11: *Firms' collaborations with external consultants and commercial laboratories can help them to introduce innovations into the market.*

External consultants and commercial laboratories can facilitate firms' innovation design activities with their external know-how and expertise. They can support firms to modify and refine its product design and packaging to make them more appealing to final consumers. Design innovation activities are initiated by firms in new product development to alter their appearance. Firms can explore the market indirectly by engaging the services or collaborating with design consultants (Najafi-Tavani *et al.*, 2018). These consultants usually conduct market research which also includes product designs which consumers would want to buy because of their appealing nature. Studies carried out by Tabeau *et al.* (2017) and Bianchi *et al.* (2016) suggest that exploration activities using external consultants enhance design innovativeness leading to improved market performance. We therefore provide the hypothesis that:

H12: *Design activities can influence firms to collaborate with external consultants and commercial laboratories.*

Firms also undertake certain innovative activities and process that are not directly part of R&D activities, but they are necessary auxiliary activities vital for innovations. Firms engage in other preparation such as tooling up and feasibility

studies. External consultants can help firms with their innovative technologies and tools needed in their production and processes. They can also assist firms to carry out industrial engineering activities by amalgamating existing internal knowledge with their know-how. Firms' collaborations with external consultants can lead to incremental developments, new products and processes that might be novel to the firm. Firms collaborations with external consultants can also result in generating new functions that can modify current product stocks with additional components. Studies conducted by (Planes-Satorra and Paunov, 2017) concluded that external consultants can support firms in identifying new business opportunities by helping them adapt to market needs. Similar studies conducted by Sivam *et al.* (2019) among Portuguese firms also revealed that external consultants help in driving market needs and other innovation preparations.

Based on this, we hypothesize that:

H13: Firms engagement in other innovative preparations can influence them to collaborate with external consultants.

2. Data and methodology

This paper aims at assessing the various factors that influence IT and other information service firms in the Czech Republic to collaborate with external consultants and commercial laboratories. For the empirical analysis, we used the anonymized data from the Eurostat's Community Innovation Survey (CIS) carried out between 2012 and 2014. The CIS datasets provides harmonised information about firms' innovation activities providing detailed information on the various factors that go into developing firm-level innovations, providing in depth information on types of R&D collaborators, sources of knowledge and innovations, public funding and innovation expenditures. In this survey firms are asked about their collaboration arrangements for innovations. In this paper the target population focused on the collaborations firms have with national consultants as a medium of knowledge and technologies transfer. In all, we sampled a total of 324 in the IT and other information services in the Czech Republic. Numerous studies have used the CIS datasets for similar firm-level studies. For the study, we used the constant value method to fill in the missing data, where we replaced all incomplete or missing values by a predefined constant value which allowed us to have a larger sample size.

For our methodology, we used the treatment effect doubly robust estimator. The treatment effect refers to the average causal effect of a dichotomous variable on an outcome variable of policy and scientific interest. The doubly robust estimation allowed us to combine the outcome regression with a model for the propensity scores to evaluate the causal effect on an exposed outcome model (Neugebauer and van der Laan, 2005). The doubly robust method combines both outcome regression model and propensity scores. Using both the outcome regression and the propensity scores approach enabled us to overcome biases from the confounding variable that might

affect the results. The doubly robust estimator fuses these two main approaches and at least one of the two models must be correctly indicated to achieve an unbiased effect estimator. We constructed two separate doubly robust estimators (models): the first model for the dependence of the treatment on independent variables (propensity score model). This model used the inverse of the predictable propensity score in the regression model. The second model for the dependence of the outcome on covariates and treatment. This allowed us to consistently estimate the parameter estimator of interest by reducing residual biases i.e. the causal relationship between consultants and firms' innovation performances and activities (Liu *et al.*, 2019). In order to fulfil the main objective, set out in this paper, we analysed these firms and answered the following research question and main hypothesis:

What are the factors that can influence Information Technology (IT) and other information service firms in the Czech Republic to engage the services of external consultants and commercial laboratories?

Main hypothesis: *IT firms' innovation outcomes and activities can influence them to engage the services of external consultants and commercial laboratories.*

The other thirteen subsequent hypotheses stated above will be tested for their acceptance or rejection based on the main hypothesis. They detail the various components of the various innovation activities that could be capable to influence firms to engage the expertise of external consultants.

Variables

Dependent/Outcome variable

From the Eurostat data, we chose our dependent variable firms that collaborated with consultants and commercial laboratories for their knowledge and innovations. A dichotomous variable that takes the value of 1 if the firm engaged the services of individual consultants or any services from commercial laboratories between 2012 and 2014.

Explanatory Variables

The covariates selected for this study centred on measures of firm's innovation performances and activities. They include a dummy variable product innovation that was novel to the market that significantly improved goods or services between 2012 and 2014. The second explanatory variable process innovations, also a dichotomous variable takes the value 1 if firms employed a significantly improved production and distribution process and 0 if otherwise. The organizational innovation is also a dummy variable with 1 signifying firms have implemented new business practices, methods in their procedures and decision-making processes and 0 meaning otherwise (Mohnen *et al.*, 2018). The market innovations, also a dichotomous variable that takes the value of 1 if the firms, have taken measures to alter their product design or packaging and using the media to promote these products (Bartoloni and Baussola, 2018).

The remaining covariates focused on innovation activities and expenditures firms employed for their products and processes. They include the frequency of firms' engagement in R&D, whether firms engaged in R&D continuously or

occasionally. We also included a variable on engagement in extramural R&D with values of 1 meaning the firms engaged and 0 meaning otherwise. The engagement in acquisition of machinery variable involves whether the firms expended to procure new machines and equipment capable of transforming their production processes (1 meaning yes and 0 no). Engagement in acquisition of external knowledge variables also took the values of 1 if firms acquired knowledge from other external R&D partners such as consultants, universities, other firms in the enterprise group etc. and 0 meaning they didn't resort to external knowledge. Engagement in training for innovative activities can also compel firms to engage the services of consultants. This takes the value of 1 if the firms engaged in any innovative training activities and 0 meaning they didn't have any form of training (Rupietta and Backes-Gellner, 2019). Engagement in the market introduction of innovation variable comprises of 1 if firms engaged or introduced any innovations into the market and 0 otherwise. Firms engagement in design activities has the value 1 representing yes and 0 representing no. Lastly, we included the dummy variable engagement in other preparation aimed at innovations, with 1 meaning yes and 0 meaning no.

Table 1. Description of the variables

Variables	Specifications
Product innovations	1 firm introduced onto the market a new or significantly improved goods or service; 0 otherwise
Process innovations	1 firm introduced onto the market a new or significantly improved production methods; 0 otherwise
Organizational innovations	1 firm introduced new business practices for organizing activities; 0 otherwise
Market innovations	1 firm introduced significant changes to the aesthetic design or packaging; 0 otherwise
Intramural R&D	1 if firms engaged in intramural R&D; 0 otherwise
Engagement in R&D	1 if firm engaged in R&D; 0 meaning otherwise
Extramural R&D	Takes 1 if firm engaged in extramural R&D; 0 meaning otherwise
Acquisition of machinery	1 if the firm engaged in acquisition of machinery; 0 otherwise
External knowledge	1 firm engaged in acquisition of external knowledge; 0 no
Innovative training	1 engaged in training for innovative activities; 0 otherwise
Introduction of innovation	1 engaged in market introduction of innovation; 0 otherwise
Design activities	1 engaged in design activities; 0 otherwise
Other preparations	1 engaged in other innovation preparations; 0 otherwise
Collaborations (consultants)	1 if firms partnered consultants and commercial labs, 0 otherwise

NB: dependent variable = firms' collaborations with external consultants.

Source: authors' representation based on definitions of the community innovation survey

Descriptive Statistics

Table 2 provides summary statistics of the explanatory and dependent variables used in the empirical model. On average, 20% of firms in the sample are product innovators, whilst 17% could be classified as process innovators. On average, 14% could be classified as organizational innovators and 11% are market innovators. These figures show that the general level of innovative firms in the Czech Republic are lower. Similarly, 33% of firms on average engaged or spent on intramural R&D, whilst 18% of firms engaged in R&D activities either continuously or occasionally. On average, 65% constituting half of the firms engaged in extramural R&D. With regards to machinery acquisitions, on average 43% of these firms expended to procure machinery for their innovations. It can also be seen that on average 9% of firms acquired knowledge from external sources for their innovation's activities.

Table 2. Summary statistics

Variables	Mean	Std Dev.
Product innovations	0.202	0.402
Process innovations	0.173	0.378
Organizational innovations	0.136	0.342
Market innovations	0.114	0.318
Intramural R&D	0.330	0.470
Engagement in R&D	0.181	0.385
Extramural R&D	0.650	0.809
Acquisition of machinery	0.428	0.495
External knowledge	0.094	0.291
Innovative training	0.289	0.453
Introduction of innovation	0.291	0.413
Design activities	0.211	0.408
Other preparations	0.276	0.447
Collaborations (consultants)	0.076	0.264

Source: authors' representation

Half of the firms in the sample engaged or carried out trainings for their innovation activities (29%). Approximately 29% of firms engaged in activities that helped to introduce innovations to the market. On average, 21% of firms engaged in design activities that improved the product packaging. Approximately about 28% of these firms also engaged or expended on other preparations for their innovations and their related activities. Surprisingly, only 8% of firms in the IT and information sector engaged or used the services of consultants in the Czech Republic. This can be attributed to the exorbitant transaction cost or charges external consultants demand for their services. This is unbearable for SMEs, that constitute the bulk of firms in the IT and other information service sector in the Czech Republic (Kitay

and Wright, 2007). Another probable reason for the low usage of external consultants and commercial labs in this sector can be that firms could be apprehensive about disclosing vital information about their new processes and products when there are no well-established intellectual property rights (Hoecht and Trott, 2006). This makes firms afraid of losing their inventions to external agents like consultants, hence their unwillingness to collaborate with them.

3. Results and discussions

We begin with the results of the first stage logistic regression results to find the probabilities that firms' innovations and its related activities influence their engagement with consultants and other commercial laboratories. From Table 3, the results show that there is a statistically significant but negative association between firm's product innovations and engaging consultants at the 95% level. This confirms hypothesis 1. The negative sign of the magnitude of the coefficient implies that if firms engaged the services of consultants, it rather decreased their product innovations by 54% percentage points. The result means that firms that offered significantly improved goods and services were not probably collaborating with external consultants for expert advice. The results are expected because the descriptive statistics in Table 2 above proved that just 8% of these firms collaborated with external consultants. It's probable that these firms depended on other R&D partners for product innovations. Our result however differs from other studies conducted in the Czech Republic and Romania by Gołębiowski and Lewandowska (2015) who found no association between firms' collaborations with external consultants and product innovations. The hiring of external consultants comes with exorbitant transaction costs which these firms, mostly SMEs, cannot afford. They might prefer to invest these high charges directly in the innovation process, hence the reason they will not engage external consultants.

Hypothesis 2 is also supported. It can also be seen that the covariate process innovation was positive and statistically significant at the 95% level with an elasticity of 0.319. The result shows that all other things being equal, firms process innovation are highly probable to influence them to collaborate with external consultants and commercial laboratories. The intermediary knowledge from commercial labs and consultants can help firms to introduce significantly improved methods of production, improve their logistics and delivery systems when they collaborate (D'Este *et al.*, 2016). This result is not consistent with the findings of similar recent studies conducted in five other transition countries including the Czech Republic by Prokop *et al.* (2019). They found that external consultants do not exert any significant influence on firms' innovation outcomes. Our results differ from previous studies because we have shown empirically that when innovative firms hire consultants, they become more exposed to external knowledge and know-how which can be vital in transforming their existing technologies and innovation outcomes.

This won't be realized when firms are not engaging these external consultants and commercial laboratories.

Hypotheses 3 and 4 are all rejected. With regards to firms organizational and market innovations, this study finds there is no relationship between engaging the services of consultants and commercial labs and organizational and market innovations. For these firms their organizational and market innovations (business practices and procedures, decision making and external relations) were not probable to influence their collaborations with external consultants and commercial laboratories. The literature has suggested that consultants are known to provide market research sustaining the development of innovative products that better satisfy customers' needs but our results proved contrary to this assertion. It is probable that these firms have their own internal market research departments that help in conducting market research, so they do not engage these external consultants because they do not need them. This result differs from the conclusion reached by a similar study conducted by Odei (2018) in another transition country - Slovenia, where they found that firms that intended improving the marketing of their goods or services were highly probable to engage the services of consultants and commercial laboratories.

This study also finds that there is a positive and statistically significant relationship between intramural research and engaging consultants and commercial labs. This result supports hypothesis 5. This was statistically significant at the 99% level and has the highest elasticity of 5.997. This means that firms that spend more on intramural R&D are highly probable to engage the services of consultants and commercial labs. Consultants and commercial labs can complement firms' internal R&D units and help to develop innovative products and processes (Lundvall, 2009). Internal R&D expenditures stimulated by tax credits incentives provided by governments generates higher innovation output for firms (Czarnitzki *et al.*, 2011).

This research also finds a positive and statistically significant association between firms' collaborations with consultants and commercial labs and engaging in R&D. This means our hypothesis 6 is highly supported. This was statistically significant at the 99% level with a positive elasticity of 1.270. This implies that engaging the services of consultants can help firms to improve their engagement in R&D by 27 percentage point. This is because consultants can deliver market research supporting the development of new products that can satisfy customers' tastes and preferences (Bianchi *et al.*, 2016).

There is also a negative but statistically significant association in using consultants and extramural R&D. Based on the results, we therefore reject our hypothesis 7. The negative elasticity -0.745 is expected, because the results of the descriptive statistics have shown that firms that used consultants and commercial labs is just 8%. For these firms because of the low rates of engaging or using consultants, it leads to a reduction in their extramural activities by 75 percentage point. This means that the majority of these firms are not likely to use consultants, but probably prefer to collaborate with different R&D partners to realise extramural activities.

This study also finds no statistically significant relationships between four covariates acquisition of machinery, external knowledge, innovative training and design activities. This means that our hypotheses (8, 9, 10 and 12) are all not supported. This means that using or engaging consultants didn't impact on these innovation activities of these firms. The results especially for external knowledge and innovative trainings are surprising because it has been widely proven that consultants are reliable conduits firms used for their external knowledge to augment any shortages of internal know-how and training needs. But our results have demonstrated otherwise for IT and other information services firms in the Czech Republic. Also, consultants are known to buttress firms to improve their design and packaging, to make them more alluring to their loyal and prospective customers, but our results didn't support this assertion affirmatively. The insignificant results mean that these firms rely on their own internal knowledge and expertise to carry out these innovation activities, hence the reason why they will not hire external consultants for these important innovation support activities.

The hypothesis 11 is supported. The study finds a positive and statistically significant relationship between the introduction of innovations and firms' decisions to collaborate with external consultants and commercial laboratories ($\beta = 0.592$, $p < 0.006$). As shown by the literature, the knowledge and expertise of consultants can be used by firms when they collaborate, and this can positively impact on innovations. Our result is consistent with other studies conducted in other emerging economies by Back *et al.*, (2014), who found that consultants are vital distributors and generators of new knowledge that can help firms in their innovation activities. A similar study by Kafourous *et al.* (2020), also find out that consultants help firms to introduce innovations, but not with new product development.

Lastly, the results show a positive and statistically significant relationship between other preparations and using consultants and commercial labs. This support our hypothesis 13. This was significant at the 90% level with a positive elasticity of 0.585, meaning that using consultants can positively impact on other preparations and activities aimed at improving innovation within these firms by 59 percentage point.

Table 3. Results of logistic regression model estimates

Variables	Coefficients	Robust std errors	Z	P>z	Hypotheses decisions
Product innovations	-0.538	0.264	-2.04	0.041*	Accepted
Process innovations	0.319	0.191	1.67	0.095*	Accepted
Organizational innovations	0.126	0.197	0.64	0.522	Rejected
Market innovations	0.150	0.196	0.76	0.445	Rejected
Intramural R&D	5.997	1.172	5.12	0.000***	Accepted
Engagement in R&D	1.270	0.194	6.56	0.000***	Accepted
Extramural R&D	-0.745	0.191	-3.89	0.000***	Accepted
Acquisition of machinery	0.113	0.227	0.49	0.623	Rejected
External knowledge	0.261	0.208	1.26	0.209	Rejected

Innovative training	-0.168	0.225	-0.75	0.454	Rejected
Introduction of innovation	0.592	0.216	2.74	0.006**	Accepted
Design activities	-0.214	0.213	-1.01	0.314	Rejected
Other preparation	0.585	0.249	2.35	0.019**	Accepted

Model Summary

Pseudo R ²	0.4077
Log pseudolikelihood	-433.09361
Wald chi ²	155.02
Prob > chi ²	0.0000
Observations	324

Note: *** Parameter significant at 99 % level, ** significant at 95 % level, * significant at 90 % level.

Source: authors' representation

While the binary logistic model is an unbiased estimator, it can adversely be affected by the presence of confounding variables in the model leading to false estimations of causal treatment effects (Gore and Reynolds, 2012). The presence of confounding problem results in biased and inconsistent estimates might reduce the effect of consultancy services on firms' innovations and their related activities. Moreover, using the services of consultants and commercial labs is not without measurement errors due to differences in responses provided by different firms that undertook the survey within countries at different time periods. Additionally, the other covariates may also have measurement errors. Therefore, we anticipate that firms that didn't use the services of consultants and commercial labs can affect the overall influences of the firms that used these services leading to selection bias. To correct the issues of confounding and selection bias, the treatment effect propensity-score matching analysis was used. This helped to eliminate the unbiased estimates by adjusting for all confounding factors by determining their various significances based on their average results (Abadie *et al.*, 2004). Propensity score matching estimators are widely used to estimate average treatment effects. Propensity score matching allowed us to estimate the averages of those firms that used the services of consultants as the treated group and the untreated subjects are those firms that didn't use the services of external consultants, so that matched subjects have comparable values of propensity score. The propensity-matching analysis allowed us to determine the additional effect of consulting services on firms' innovations and their related activities. We modelled our outcome variables as measures of firms' innovations and their related activities, while the treatment dependent variable was engaging the services of consultants and commercial labs. The estimated propensity score is the projected probability of treatment resulting from the fitted regression model. We estimated our treatment effect as the difference between the proportion of firms that collaborated with consultant and commercial labs and those that didn't collaborate with these consultants. The estimation was done for each of these two groups (treated vs. untreated) in the fitted

sample. The model was run with the same variables in Table 1. The results of the Average Treatment Effects (ATE) of the population are presented in Table 4 below. It can be seen from the coefficient table that on average, the product innovation of firms that engaged the services of consultants and commercial labs was 61 percentage higher than firms that didn't engage the services of these consultants.

Table 4. Average treatment effect of using versus not using consultants

Variables	Coefficients	AI Robust std errors	Z	P>z
Product innovations	0.607	0.290	2.09	0.036*
Process innovations	0.017	0.288	0.06	0.954
Organizational innovations	0.624	0.281	2.22	0.026*
Market innovations	0.004	0.275	0.01	0.989
intramural R&D	0.650	0.011	61.11	0.000***
engagement in R&D	0.103	0.358	0.29	0.774
extramural R&D	-0.005	0.581	-0.01	0.993
acquisition of machinery	-0.000	0.292	-0.00	1.000
External knowledge	0.003	0.010	0.31	0.755
innovative training	-0.000	0.289	-0.00	0.999
introduction of innovation	0.006	0.017	0.38	0.703
design activities	-0.004	0.017	-0.26	0.793
other preparation	0.659	0.301	2.19	0.028*
Model Summary				
Estimator	teffects psmatch			
Observations	324			

Note: *** Parameter significant at 99 % level, ** significant at 95 % level, * significant at 90 % level.

Source: authors' representation

Also, it can be seen that on average, firms that used the services of consultants and commercial labs increased their process innovations by 1.7 percentage; albeit this can be seen as a marginal increase, it represents an overall improvement demonstrating that using external consultants contributes to overall increase in firms' process innovations and their related activities in comparison with firms that didn't collaborate with these external consultants.

The results also show that on average firms that used the services of consultants and commercial labs increase organizational innovations by 62 percentage more than firms that didn't collaborate with consultants. Consultants assisted firms to introduce new or significantly improved organisational management practices, and new methods for organizing external relationships. This is consistent with evidence that commercial labs and external consultants can aid firms to be organizational innovators (Back *et al.*, 2014).

For our covariates with intramural R&D, our results show that, on average, firms that use external consultants and commercial labs could increase their internal research and development potential by 65 percent vis-à-vis the firms that didn't engage the services of consultants. The results show that external consultants can complement the internal knowledge base of employees, and this can provide insight into innovative ways of researching into industrial and commercial activities that can boost productivity and competitiveness (Paas and Poltimäe, 2012).

The results of the ATE also show that for firms that engaged in R&D between 2012 and 2014 in the Czech Republic, using the services of external consultants on average increased their R&D potential by 10 percent, in comparison with those firms that never engaged consultants. For not using external consultants, firms would be stacked in their old ways of doing business and this might not lead to any improvements in their approach to R&D. But when occasional firms engage with new minds, it can help to augment the old ways leading to innovations. The results show that using consultants improve firms R&D potentials by 10 %. The last significant variable shows that using commercial labs and consultants on average help firms to increase their other preparations or activities for innovation by 66 percent in comparison with firms that didn't collaborate with these external knowledge agents. There might be a missing link in firms' innovations, but when they engage the services of consultants, they can help to point out other activities or preparations firms must carry out to stay innovative.

The results show that, on average, for firms in the IT sector in the Czech Republic, using external consultants didn't influence all innovation activities. The results of the ATE show that nine variables proved to be statistically insignificant, showing that they do not produce any additional effects and have no potential to influence firms to engage the services of these external consultants and commercial laboratories. Using consultants didn't influence firms' market innovations, extramural R&D, machinery acquisitions, external knowledge components, innovative trainings, market introductions of innovations and design activities. The insignificance of the ATE results demonstrates that using external consultants didn't offer any meaningful impact to these innovation measures and activities.

Conclusions

In this paper, we studied the importance of how firms' innovations and their related activities influence their decision to collaborate with external R&D partners that have not been given considerable attention; consultants and commercial laboratories. The results lead us to two conclusions. Firstly, they show that the product and process innovations are highly probable to influence firms to engage the services of external consultants and commercial laboratories. These results are consistent with previous literature that found that firms' innovations quest are likely to lead them to collaborate with external consultants (see for instance Cesário *et al.*, 2015). Our result

however contrasts with other studies conducted in the Czech Republic and Romania by Gołębiowski and Lewandowska (2015) who found no correlation between firms' collaborations with external consultants and product innovations. Additionally, we have demonstrated that five innovations activities firms spend on are intramural R&D, those engaging in R&D, extramural R&D, introduction of market innovations and other preparations were highly significant to influence firms to collaborate with external consultants and commercial laboratories. The results imply that to carry out these activities, firms were likely to depend on the expert advice of consultants and commercial laboratories. These results conform to the findings of other related studies such as (see Back *et al.*, 2014; Bianchi *et al.*, 2016). All the remaining innovation activities and expenditure didn't significantly influence these firms to collaborate with these vital innovation partners. External consultants provide firms with diverse solutions to multifaceted problems and this helps to generate new ideas, which can positively influence firms' aptitude to innovate.

Secondly, we find the additional effect that engaging the services of external consultants can have on firms' innovations. Our Average Treatment Effect (ATE) findings show that for firms that used the expert services of consultants and commercial laboratories, they were likely to increase their product innovations on average by 61% and organizational innovations by 62%. With regards to innovation activities, the ATE results show that these firms that used the services of external consultants were likely to increase their intramural R&D on average by 65% and other preparations by 66% vis a vis firms that didn't engage these vital external R&D partners. These results mean that on average terms external consultants didn't exert great influence on firms' level innovations and their related activities in the Czech Republic.

Contributions to theory and practice

Our results have theoretical and practical implications for understanding how firm-level innovations can be achieved and studied. This research extends previous works that recognized the role of external consultants in IT firms' innovations and their related activities and offers guidance for firms' managers who superintend innovation related activities. The results suggest firms need to pay greater attention to collaborating with external consultants and commercial laboratories, this having a greater potential to influence innovation performances and activities because these consultants have the knowledge and expertise. This study contributes to the growing recent evidence that show that the various factors that are probable to influence firms' decisions to collaborate with external partners such as consultants and commercial laboratories. We have shown empirically that these firms' product and process innovation and their related activities are likely to influence them to collaborate with external consultants. These findings contribute to the literature on open innovations as this is yet to be explored by both firms and researchers. We find

that collaborating with consultants provide additional effects on innovations and their related activities when firms engage these consultants, in comparisons with not collaborating with them.

In accordance with the literature, this study finds that firms that engaged the services of consultants are inclined to be more innovative, because consultants expose them to external know-how that is important in the fulfilment of their innovation potentials. In terms of policy remedies, these findings suggest that firm managers should have in place policies that encourage frequent collaborations with these external consultants and commercial laboratories as they can complement the stagnant knowledge within firms with new knowledge, ideas and researches. However, consultants should also be aware of their importance in firm-level innovations and should not resort to charging exorbitant prices that might be unbearable for firms.

This study has limitations. We recommend future research should explore why this vital conduit of innovations are not considered by all firms. These studies can focus on the various reasons that prevent firms from engaging the services of external consultants and commercial laboratories. Knowledge of this will broaden the understanding of why just a little fraction of firms collaborate with external consultants. We also recommend other studies be replicated in other transition countries to corroborate our findings.

Acknowledgement: The authors would like to acknowledge the Internal Grant Agency of the Faculty of Management & Economics of Tomas Bata University in Zlin for providing financial support to carry out this research. Funding was extended through: TBU No. IGA/FaME/2021/004.

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