FIRMS PURSUIT OF INNOVATIONS THROUGH INTERNATIONALIZATION: A TREATMENT EFFECT ESTIMATION

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Abstract. Firms participations in international markets is known to stimulate innovations as well as expose them to both international and domestic partners that can influence their innovation prospects and activities. Countries with weaker innovation potentials acquire advanced knowledge, technologies and innovations when they interact and collaborate with partners in the international ecosystem. The focus of this paper is to explore the linkage between firm's decisions to internationalize and its additionality effects on firm-level innovations. Our results show a positive and significant correlations between these firms' participation in international markets and their product, process, research and development and acquisition of external knowledge. We also find that, the foreign enterprise group, foreign clients and customers from the private sector as well as foreign consultants were vital for firms' innovation. In contrast we find that there is no relationship between foreign ownership and firms' innovations as can be seen from the insignificant coefficients results. The ATE results show that the extent of internationalizations increased the probabilities of stimulating product, process innovations and R&D on average by 21, 14 and 9 percentage points in comparison with firms that didn't internationalize. Implications and suggestions for future research are discussed.

Keywords: internationalization, innovations, knowledge, technologies, collaborations, partners, Czech Republic.

JEL Classification: L62, 030, 031.

Introduction

The end of communism has brought about rapid structural changes in the economies of the former soviet countries. These countries classified as transition countries are changing over from the soviet bloc to market economies (democracies) and this has opened-up these economies and they are gradually been integrated into the global value chains (Hudec & Prochádzková, 2018). Global market competitions compel firms to expand their businesses by discovering new markets domestically and in foreign countries. Firms participation in

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international markets means that they can now be exposed to advanced technologies and knowledge from other technologically advanced countries. Foreign markets serve as important platforms that offer firms the opportunities to gain new knowledge and innovations (Morrison et al., 2008). This can help to spur local innovations within firms and general innovations at the national level. Numerous studies have concluded that firm's participation in foreign markets through exporting spurs innovation and drives firm's productivity (see Lee et al., 2018).

Globalization has broadened firms market orientations by allowing them uninterrupted access to other foreign markets in addition to the local markets (Porter, 1998). Local firms' participations in foreign and domestic markets can help induce their innovation performance. Their interactions especially with foreign partners and serving foreign customers enables them to learn and compels them to innovate (Park et al., 2010). Foreign markets are characterised by intense competitions and firms that take the decision to export to these markets need to embrace themselves to face stiff competitions. These intense competition means that firms need to adopt modern methods of production, packaging and distribution. Hence, this forces firms to invest in technologies and knowledge as well as modern production methods. In the absence of these foreign competitions, firms will not be under any compulsion to innovate. At the same time, these foreign markets are learning environment for firms from low technology countries (Li et al., 2016). They can tap into the knowledge of the dominant market leaders, enquire into their production technologies and then transfer these ideas and knowledge in their production back home. Several studies have confirmed that foreign markets are avenues for firms to acquire knowledge and adopt modern technologies that can increase their productivity and innovations potentials (Ramadani et al., 2017).

Another vital aspect where firms seem to benefit from their decisions to internationalize is their interaction with both foreign and local innovation partners (Hsieh et al., 2018). Firms participation in foreign and local markets means that they can regularly interact and compete with other partners in the enterprise group, suppliers of equipment, foreign clients and customers, foreign knowledge institutions such as universities and other research organisations (Un & Rodríguez, 2018). These foreign collaborators can stimulate innovations in domestic firms when local innovation potentials are low. For instance, when firms collaborate with both local and foreign suppliers of equipment, they can have access to modern technologies that can influence their ability to introduce innovative products and services (Halaskova et al., 2018). Due the increasing importance of knowledge to firms' innovations, both the foreign and domestic knowledge partners can equally be of great importance. Local and foreign consultants are known to serve as a conduit for external knowledge that firms can use for their market research to develop new products and services (Back et al., 2014). Both local and foreign knowledge producing institutions such as universities can be relied upon to conduct commercially viable economic market research that will have the propensity to influence firms' products and processes. In countries with low innovation potentials, firms access to these foreign partners will help to augment for the weaknesses as these partners are reliable means to transfer knowledge and technologies.

Transition countries like the Czech Republic are gradually been integrated into the regional and global value chain. But it still has the top-down innovation policies and models that are still overly centralized and characterized by low sectoral policies on Research and

Development, and this has subsequently led to weak innovation performance and unexploited national and regional innovation networks (Hudec, 2015). In the Czech Republic as in other transition countries, there are marginal state subsidies for applied research needed to boost innovations. This means that Czech firms in the manufacturing sector are engulfed in weak innovation milieu and are not innovative enough. Ones firms cannot fully innovate domestically, they can look beyond their national boundaries and tap into the strong innovation potentials in foreign countries especially Western European countries for their innovation needs. The Czech Republic has significant share of imported and exported goods as a share of GDP, implying that they are been integrated in the global value chain. This paper therefore seeks to empirically examine whether firm's competitions in foreign markets has a positive impact on their product and process innovations, research and development and acquisition of external knowledge. We examine whether firms R&D collaborations with domestic and foreign partner stimulates innovations in the Czech Republic.

Multitudes of studies have concluded that firms' interactions and competitions in international markets induce innovation (Wu et al., 2016) but studies of this kind are scarcely carried out in the Czech Republic until now. Recent studies on firms' internationalizations in the Czech Republic (see Zapletalová, 2018; Pavlák, 2018) focused on the processes firms take to participate in foreign markets and the barriers they face in their quest to internationalize. All these papers neglected a vital component of firms' growth i.e. firms taking advantage of foreign market competitions as a source of knowledge needed to boost up innovations. Hence this study intends to fill this gap by focusing on the international innovation milieu that can complement for the shortfalls in the Czech innovation potentials. The novelty of this paper is based on the believe that firms in the manufacturing sector in the Czech Republic can benefit and improve their innovation performances and activities by augmenting their weak innovations potentials with foreign knowledge, technologies and expertise. This paper therefore builds on the theories of internationalization and networking for knowledge and innovations that can improve firms' competitiveness. By using a doubly robust inverse-probability-weighted regression adjustments estimator we provide new evidence of the additionality effects that the international and domestic innovation environments and collaborators can interact and impact firm-level innovations in the Czech Republic. Firms internationalizations and their ability to tap into foreign knowledge, expertise and innovations have become the centre of attention for policy and firm managers. We analysed 3069 firms in the Czech manufacturing sector. These industries were selected in accordance with the literature because it has a diverse composition mainly consisting of technology and knowledge intensive firms that thrives on both internal and external knowledge sources for their survival. This paper contributes to the growing literature on firm level innovations because knowledge of the most important collaborators influencing innovation can help drive innovation policies both within firms.

The rest of this article is arranged as follows. The next section focuses on the theoretical and empirical literature that explores the relationships between firm's participation in foreign markets and how collaborators can influence firms' innovations. The third section describes the methodology, the variables used, and the source of dataset. The results and discussions are included in the fourth segment, and section five concludes and proposes areas for possible replications in further research.

1. Theoretical background and hypothesis development

Transition economies or post-communist economies are countries that are transmuting from socialist (centrally planned) to market economies (Velichkovsky et al., 2019). Transition economies undertake series of structural reforms aimed at developing their market-based institutions. These transformations include economic liberalization, which allows market forces rather than central planning organizations to determine prices of goods and services. The transition process is also typically characterized by the metamorphosis and creation of institutions, especially private-owned enterprises (promoting entrepreneurship). The transition process also calls for minimal state intervention in economic activities allowing for the creation of oversight different governmental institutions. Because of the inefficiencies of governments, there are also calls on governments to wean itself from managing businesses and this led to massive privatization of state-owned enterprises. The opening up process have also boosted foreign direct investments (FDIs) that enabled foreign investors to acquire existing or established new enterprises. A very important step in the transition process is the removal of trade barriers that allows free movement of goods, services and knowledge and innovations (Ramadani et al., 2017). This vital process has paved way for transition countries to gain knowledge and technologies from countries with well-developed innovation potentials. Firms in transition economies may also capitalize on the removal of trade barriers to internationalize to benefit from advanced technologies and knowledge elsewhere. Internationalizations are significant for firms in transition countries as these industries lack the required resources and competences to carry out their own comprehensive research. Earlier literature on firms' internationalizations were inspired by marketing theories. Internationalization during these periods dealt with the decision of foreign direct investment (FDI) and exporting. However, in recent times, internationalization focuses on networks and interactions, through which different relationships emerge with other partners and institutions in the domestic and foreign environments. One of the basic assumptions in the network model is that firms cannot be analysed in isolation, but in relation to their interactions for knowledge and innovations with different actors in the domestic and international milieu. This is because firms are dependent on decisions and resources usually managed by others. Firms domestic synergies can be extended to other networks in foreign countries (Johanson & Mattsson, 2015). Internationalized firms initially engage in domestic networks and then spread this abroad, to benefit from advanced technologies. Internationalizations paves the way for firms to export their products to foreign markets, this also enhances their collaborative potentials which enables them to examine and positively cooperate with foreign innovative partners, that can guide them to sustainable growth and development. Firms can overcome their resources and innovation constrains with foreign knowledge. Recent studies (Belderbos et al., 2018) have shown that firms R&D collaborations with others, can help them to prevail over their innovation's constraints.

Innovation networks in foreign countries give firms indispensable competitive advantage. Internationalization enables firms to adapt and compete in foreign markets and serves as a learning platform that can stimulate innovations. Internationalized firms use their networks or collaborations to acquire new knowledge about prevailing market conditions, technologies and know-how needed for their innovations. Firms first take their domestic advantage by

exploring network relationships with domestic R&D partners, this influences their competence development and survival strategies needed for sustainable long-term success. On the other hand, international interactions enable firms' access to would-be clients and customers, knowledge institutions (universities and other research organizations), etc. and this can expedite their innovation potentials and learning capabilities.

Numerous motives drive firm's internationalisation decisions. One of such vital motives is to acquire knowledge, innovations and technology that will give them the competitive edge above their market rivals. Exporting to foreign markets represents one of the customary ways in which firms can become international (Cassiman & Golovko, 2011). The internationalization process to foreign markets enables firms to gradual acquire and utilize knowledge about advanced technologies and production methods in foreign markets. Exporting exposes domestic firms to brawnier competition from foreign producers and products and can serve as a strong incentive for them to innovate. Exporting to markets in technologically advanced countries will enable firms from weak innovation countries to tap into how they organize their production activities, technologies used in the production process as well as how these goods are distributed to reach the final consumers. Knowledge about production processes from other countries can help firms in transition to introduce new products and technologies back home. The vigorous competitions in foreign markets also means that firms need to acquire new knowledge, logistics and technologies to improve their products before they can be accepted by foreign customers. Numerous studies have concluded that firm's decision to internationalise significantly impact on their innovation abilities (see Cavusgil & Knight, 2015). An extensive study conducted in 14 transition countries (nine new EU members in CEE including the Czech Republic and five in Southeast Europe) concluded that firms innovation improves when they internationalize through exports (Gërguri-Rashiti et al., 2017). We assume based on the conclusions of this extensive study that firms learn from foreign market participations in terms of innovation, and thus exporting firms will better their innovation activities to stay competitive in foreign markets. Hence, we hypothesis that

Hypothesis 1: *Firms' product and process innovations, R&D and external knowledge are highly probable to be influenced by the extent of internationalizations.*

Additionally, the decision to internationalize also influence firms' innovations because it enables them access to both local and foreign external partners that can help drive their R&D innovations (Un & Rodríguez, 2018). These partners can be from the domestic countries where these firms operate, or they can be from the foreign countries or export destinations. These innovation partners can be from the market environment locally or internationally such as other firms in the enterprise group, suppliers of equipment, clients and customers and other competitors in the business sector (Belderbos et al., 2018). They can also collaborate with knowledge institutions such as universities and research organizations either locally or internationally (Guimón & Salazar-Elena, 2015).

Belonging to the local and foreign enterprise group can play kernel impact on firm's innovations performance. Firms part of an enterprise group are connected financially or legally with a centralized command. Being part of the enterprise group means that, each single firm cannot take vital economic decisions in isolation. They can take certain critical decisions collectively and see to the successful implementations of such decisions. Firms belonging to

a group are motivated to collaborate between themselves for their innovation. Studies carried out by Busom and Fernández-Ribas (2008) revealed that firms' in the enterprise group collaborate among themselves for their innovations than with other firms. Firms part of the group are highly probable to benefit from improved communication and are more knowledgeable about possible methods to improve their product and process innovations. Subsidiary firms' part of a foreign enterprise group can also benefit from advanced technologies prevailing in countries of their headquarters. This can be transferred to the domestic country where their subsidiaries operate, and it can influence their innovations. A recent study conducted by Odei and Stejskal (2019) in the manufacturing sectors in Hungary and the Czech Republic concluded that belonging to the enterprise group improves product and process innovations. We therefore conclude and build on the believe that firms part of the enterprise group in transition countries can interact among other members of the domestic and foreign enterprise group for the innovations. Therefore, we provide the following hypotheses:

Hypothesis 2a: *Product and process innovations, R&D and external knowledge can highly influence firms' decisions to internationalize and interact with other members in the domestic enterprise group.*

Hypothesis 2b: *Product and process innovations, R&D and external knowledge can significantly influence internationalization decision and interactions with other members in the foreign enterprise group.*

Firms' collaborations with local and foreign suppliers of equipment can induce their innovations. According to Un and Asakawa (2015) suppliers are the first point of call for firms aiming to be innovative. They contribute to firms' innovations by providing them with advanced technologies and machinery needed in the production process. They first provide knowledge for firms on how to use the machines and technologies they procure from them. When firms collaborate with suppliers of equipment, they acquire new technical ideas and knowledge about how to use these sophisticated machines and how they can be incorporated to produce new products. Suppliers have become a formidable part of product and process development because they serve as the mediators by facilitating the transfer of knowledge between their clients and their end-users. Studies conducted by Un (2017) revealed that suppliers play a crucial in the global knowledge diffusion process. When firms partner with them, they provide them with information about how industrial inputs used in advanced countries can be transferred to other countries. Suppliers also provide the after sales services to firms, regularly visiting and interacting with them on how to keep these machines running, how to maintain them. A study conducted by Pilav-Velić and Marjanovic (2016) in Bosnia and Herzegovina find that suppliers of equipment significantly influence firms' business process innovations. In summary, we believe that firms quest for innovations can influence them to internationalize and collaborate with foreign suppliers of equipment when the domestic ones are not efficient enough. These internationalization decisions and interactions can contribute to firms' improving innovations potentials. Therefore, we focus on innovations from suppliers of equipment and hypothesis that:

Hypothesis 3a: *Firm-level innovations and activities significantly influence firms' internationalization decisions and the probability to collaborate with domestic suppliers of equipment.*

Hypothesis 3b: *Firms product and process innovations, external knowledge and R&D search can significantly boost internalization decisions which can be facilitated through collaborations with foreign suppliers of equipment.*

Domestic and foreign clients and customers are also important source of knowledge for firms' innovations. Clients and customers furnish firms with new knowledge and ideas about their taste and preferences and this informs firms production and packaging decisions (Odei & Stejskal, 2018a). Customers provide firms with end user localized knowledge pertaining to the local market conditions. Firms can adopt this entrenched local knowledge and incorporate it in their products development to meet consumers taste and preferences and those of other rival customers in the local market. Customers in foreign countries can also significantly influence local firms' innovations and production decisions. Serving clients and customers in foreign countries requires that firms need to ameliorate their logistical needs, their packaging and delivery approaches (Pietrobelli & Rabellotti, 2011). When these measures are strictly adhered to, firms can win the heart of foreign consumers and survive the intense competitions prevailing in the foreign market. A study by Prokop, Stejskal, and Hudec (2019) conducted in five CEE countries in transition (Czech Republic, Slovakia, Hungary, Estonia and Slovenia) find that, collaborations with clients and customers influenced product innovations in all these countries. Based on the aforementioned, we can conclude that firms' innovations can exert greater influence on their extent of internalizations so that they can collaborate with both foreign and local clients and customers. These partners can stimulate new product development by providing firms with complementary knowledge about their preferences. We sum up and propose the hypothesis that:

Hypothesis 4a: *Firms innovations and its related activities can significantly influence them to collaborate with domestic clients and customers.*

Hypothesis 4b: *Product and process innovations, external knowledge and R&D can significantly influence firms to internationalize to collaborate with clients and customers in foreign countries.*

The link between competitions (competitors) and innovations has been well established (see Nieto & Santamaría, 2007). Collaborations with competitors serves as a strong incentive for firms to innovate to stay ahead of them. Firms collaborations with their competitors boost their innovative competences because it enables them to learn from each other (Un & Rodríguez, 2018). Firms innovation collaborations with competitors, helps them to gain valuable insight into areas where these competitors possess the market advantage, and learn from them to close the competition gap. Recent literature has also coined the term co-competitions which refers to competitions and collaborations among firms within the same competitive environment (Zhang et al., 2014). Proponents of co-competitions are of the view that firms in commercial networks or competitive environment need to be cooperative and interact mutually among themselves, but their relationships with other firms outside their cluster need to be competitive. Despite this, numerous studies see this form of collaboration as minimal because, competing firms do not openly allow themselves for collaboration for fear of losing out their knowledge and expertise to their rivals (Henttonen et al., 2016). Foreign competitors especially can stimulate local innovations because of the advanced technologies

they use in their production process (Fu et al., 2011). When local firms collaborate with foreign competitors, they can learn from their improved methods of production and this can influence their product and process development. A recent study of firm-level innovations by Prokop, Stejskal, and Hudec (2019) conducted in five CEE countries in transition (Slovakia, Czech Republic, Hungary, Estonia and Slovenia) conclude that, R&D collaborations with competitors influence innovations but this was significant only in the Czech Republic. In all the remaining countries there was no significant relationships between firms' collaborations with competitors and innovations. We therefore conclude innovative firms that are willing to sustain their innovations will be influenced to take the decision to internationalize to take advantage of the tough competitions prevailing in foreign markets because they can learn new methods and techniques that can stimulate their innovations. We therefore propose that:

Hypothesis 5a: *Firms innovations can highly influence them to interact with domestic competitors.*

Hypothesis 5b: *Firms innovations and related activities can affect their decisions to interact with foreign competitors.*

Firms collaborations with local and foreign consultants can also have tremendous impact on their innovations and external knowledge acquisitions. Local and foreign consultants contributes to external knowledge transfers to firms by providing expert advice. Firms that engage consultants are more innovative because consultants are significant conduits of external know-how that can help firms accomplish their innovation potential. Consultants facilitate innovations by acting as intermediary mediums for external knowledge by providing firms with vital information about market research such as on consumers' taste and preferences (Alexander & Martin, 2013). Firms can engage the services of consultants in their reorganization as they can help them to morph their industrial needs. Both local and foreign consultants also induce innovations by carrying out market research that can help them transform their new products development, design and packaging to make them more appealing to their customers. Studies conducted by Bianchi, Croce, Dell'Era, Di Benedetto, and Frattini (2016) concluded that external consultants help firms to increase their innovation performance and are a significant source of external knowledge. Studies conducted by Prokop, Stejskal and Hudec (2019) found no evidence of consultants influence innovations in five new EU countries in transition. Based on this evidence, we conclude and incorporate the role of consultants in innovations and provide the hypotheses as:

Hypothesis 6a: *Product and process innovations, external knowledge and R&D are probable to influence firms to internationalize and collaborate with domestic consultants.*

Hypothesis 6b: *Product and process innovations, external knowledge and R&D are probable to influence internationalizations and collaborations with foreign consultants.*

Local and foreign higher educational institutions such as universities can also play key roles in firms' innovations quest. Universities are knowledge centres firms can depend on for advanced innovations that can increase their productivity, new products and process innovations (Santamaria & Surroca, 2011). Universities produce and diffuse knowledge and are in recent time urged to share their knowledge with other social partners such as industries for

appropriation. Firms can complement their in-house knowledge with basic research conducted at universities and other research institutions (Soh & Subramanian, 2014). Universities contribute to industrial innovation through their faculty who double as consultants to firms. They can also transfer their tacit knowledge through their graduates who can work with industries. When firms partner with universities, they can stand a towering chance of introducing onto the market a new or significantly improved goods and services. Firms collaboration with higher educational institutions permit them to have access to how industrial processes are conducted, and this helps them to improve upon their product quality thereby making them highly efficient. R&D collaborations allow university researchers to gain detailed insight into industrial processes and it positions them better to provide advisory or consultancy services that can help in improving their products and processes. Studies conducted by Rõigas, Mohnen, and Varblane (2018) across Europe concluded that both foreign and local universities are significant source of innovations and external R&D for firms. Universities and other public research organizations play crucial roles in generating knowledge and deciphering it into innovative products and services, in close partnership with businesses. Universities and research organizations helps to create and advance new knowledge and technologies that can contribute to firms' innovations. Studies conducted by Hájek and Stejskal (2018) in the Czech Republic find that firms collaborations with universities resulted in creating less innovations frequently as compared to R&D institutes. We sum up the idea that firms' innovations can influence them to collaborate with R&D focused domestic universities. But in instances when these domestic universities are not proactive in engaging in commercially viable R&D that can be appropriated by firms, it can influence their decisions to internationalize and collaborate with foreign universities. We offer the hypothesis that

Hypothesis 7a: *Innovations can influence firms to collaborate with domestic universities and other public research.*

Hypothesis 7b: *Levels of firms' knowledge and innovations significantly improves when they collaborate with foreign universities and other foreign public research institutions.*
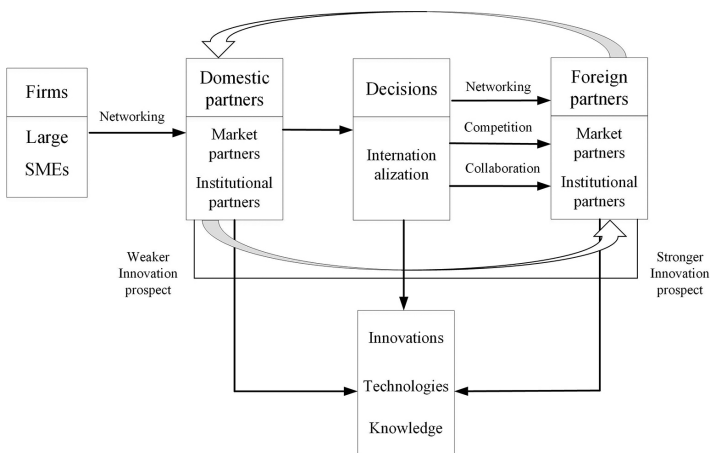

Figure 1. Proposed theoretical framework

The conceptual model shown in Figure 1 is employed in this paper to explain the linkage between how internationalizations affect different types of firm-level innovations and its related activities, which are moderated by different forms of collaboration arrangements. The theoretical framework was formulated based on the extant empirical reviews of literature on open innovations, internationalizations and networking for knowledge and innovations.

2. Variables description and measurements

To fulfil the aim of this study, we considered variables that have frequently been used to measure firm-level innovations. The definitions and measurements adopted in this paper are consistent with those used by the Eurostat Community Innovation (CIS) surveys measurements. We also believe that the concept of innovation is a multilevel phenomenon that needs to be understood from different levels or stages of its creation, firms, regions and international dimensions (Amoroso, 2017; Abbasi et al., 2019). Bearing in mind the multilevel nature of innovations, we considered firms at different levels of innovations and assessed the various factors influencing their R&D collaborations for innovations.

Dependent variables: First, we considered product innovations, this variable capture whether firms have generated or taken measures to change their product innovations. A dummy variable which takes the value 1 if the firm introduced to the market a new or significantly improved goods or services between 2012 and 2014, and 0 if not (Bianchi et al., 2016; Un & Rodríguez, 2018). The second dependent variable considered is process innovations, also a dichotomous variable with value of 1 signifying whether firms implemented a significantly improved production and distribution process and 0 for otherwise. The process innovation variable also consisted of whether firms undertook activities that significantly improve supporting activities such as planning, finance, recruitment, hiring, training, development that could positively impact firms' processes. The third dependent variable is Research and development (R&D). In accordance with the literature, we believe that engaging and investing in R&D, can be a catalyst to spur innovations. The R&D variable is also a dummy variable with a value of 1 when the firm undertook activities to generate novel knowledge capable of solving scientific problems and contributing to innovations and 0 if otherwise (Baumann & Kritikos, 2016). Lastly, we believe that external knowledge is vital for firms' innovations and its related activities. Firms that are too internally centred, cannot be innovative because they lack with regards to external knowledge which can impact its innovation activities. We therefore included the variable external knowledge, measured with whether firms acquired existing knowledge from other sources for the development of improved innovations. External knowledge has been described in the open innovation literature to be vital because it complements firms internal knowledge leading to innovations (Antonelli & Fassio, 2016). We believe that having access to external knowledge will improve innovations in the Czech manufacturing sector. This variable is also dichotomous, taking the value of 1 if the firms acquired new knowledge from external sources and 0 if otherwise.

Independent variables: The CIS consist of data on eight most important innovation partners locally and internationally. The independent variables included in the analysis consisted of these eight innovation collaboration partners from the Czech Republic, specifically we considered firms in the enterprise group, suppliers of equipment and other materials,

clients from the private sector, clients from the public sector, competitors from enterprise group, consultants, and knowledge institutional partners universities and other research organisations. And for the international innovation partners, we considered firms in the foreign enterprise group (mostly multinational subsidiaries), foreign suppliers of equipment and materials, clients from the foreign private sectors, clients from the foreign public sectors, foreign competitors, foreign consultants, foreign universities and foreign research organisations. All the independent variables are dummy variables that take the values of 1 when these firms collaborated with these local and foreign innovation partners, and 0 meaning there were no collaborations with these partners (Soh & Subramanian, 2014).

Control variables: We carefully considered some firm characteristics that have been widely used in open innovation literature which are capable of influencing firm's innovation performance and activities. We control for firm size, measured with the total number of employees employed between the years 2012 and 2014. This is because firms classified as large firms have ballooned possibilities of implementing or introducing new products and innovations in comparison with SMEs because they have the financial muscle and higher absorptive capacity to absorb and utilize new knowledge and technologies vital for innovations (Cohen & Levinthal, 1989). This imply that larger firms are more soaring to introduce a new product or process innovations. Secondarily, we control for firm's ownership, measured with whether the firm belongs to a multinational group or is locally owned. Numerous studies have concluded that foreign owned firm especially operating in low technology countries can transfer innovation form their parent companies (Srholec, 2005; Dachs & Peters, 2014). These vital variables were used in our empirical models.

3. Data and methodology

This section empirically test the relationship between the firm's participation in international markets, their collaborations with both domestic and foreign partners and firms' innovations. We sourced data from the current Eurostat Community Innovation Survey (CIS) conducted between 2012 and 2014. Numerous studies have used the CIS data to analyse firms' innovations (see Odei & Stejskal, 2018a). This truncated dataset provides comprehensive information on firm-level innovations across EU member states and they are usually conducted every two years interval. The CIS dataset provide information on the innovativeness on different categories of enterprises, their innovation activities, public support (funding) for innovations, and the expenditures these firms devote to innovation activities. This dataset provided information on firm's market orientations (participations in global markets), most essential domestic and foreign innovation partners as well as firm characteristics such as firm size and ownership. For the 2012–2014 CIS, a total of 5198 innovative firms in the Czech Republic took part in the survey (see profile of respondents in the descriptive statistics below). The analysis involved a final sample of 3069 firms in the manufacturing sector in the Czech Republic. The final sample consist of all innovative manufacturing industries (both large and SMEs) in the NACE classification 10–33 that carried out R&D activities in the period 2012–2014 in the Czech Republic. We built four models with four different measures of innovation to assess whether firm's partnership with most important domestic and foreign innovation partners affect their innovation kinds.

The probit model was employed for our empirical analysis due to the dichotomous nature of our dependent variables. In the first stage, the probit model helped us to estimate the likelihood that these variables will or not influence firms' innovations (product, process, R&D and external knowledge). The probit model assumes that there is a converse relationship in the standard normal distribution of probability and this relationship is modelled as a linear combination of the independent variables (Fox, 2015). We therefore assume that the association between firm's participation in international markets, collaborations with local and foreign innovation partners and firms' innovations (product, process, R&D and external knowledge acquisition) are all linear. Then in the second stage the treatment effect inverse-probability weighted regression-adjustment (IPWRA) estimator was used to find the additionality effect of how these selected variables will impact on firms' innovations of interest. The IPWRA allowed us to estimate the average causal effect of a dichotomous variable on an outcome variable of policy and scientific interest (firms innovations and its related activities). IPWRA estimators depend on weighted regression coefficients to calculate averages outcomes of predicted treatment-levels, where the weights represents the projected inverse likelihoods of treatment (Cattaneo, 2010). The doubly robust method combines both outcome regression model and average treatment scores. Using both the outcome regression and the IPWRA estimator enabled us to overcome selection biases from the confounding variable that might affect the results. The doubly robust IPWRA estimator fuses these two main approaches and at least one of the two models must be correctly indicated to achieve an unbiased effect estimator. This allowed us to consistently estimate the parameter estimator of interest by reducing residual biases i.e. the causal relationship between foreign market participations, R&D collaborators and firms innovation performances and activities.

4. Results and discussions

We begin the results discussion first by providing a brief information about the predictive powers of our models. The explanatory powers of our models as shown in Table 3 are 34%, 8%, 56% and 35% respectively for the different models. This means that the variance explained in the endogenous variables are somewhat average. Our models can therefore be said to have between substantial and moderate predictive accuracies respectively (Cohen, 1988). This doesn't take away the fact that they have statistically significant predictive powers.

The results of the descriptive statistics and variance inflation factor (VIF) of the variables used in the empirical analysis are displayed in Table 1. This table provides imperative information about the frequencies of the variables. The low means in the descriptive results show that firms in the Czech manufacturing sector do not engage in R&D collaboration with these important partners that can have significant influence on their ability to innovate. The results show that about 15% of these firms had introduced product innovations, while approximately 20% had implemented process innovations. So, we can conclude that majority of these firms are more process innovators than product innovators. The results also show that majority of these firms didn't carry out research and development activities, just 10% invested in R&D and its related activities. It can also be seen that a little of these firms acquired external

Table 1. Descriptive statistics and variance inflation factors (source: own calculations)

Variables	Mean	SD	Variance inflation factor (VIF)			
			Product innov.	Process innov.	R&D	Ext. know
Product innovations	0.152	0.359	–	–	–	–
Process innovations	0.196	0.397	–	–	–	–
R&D	0.102	0.303	–	–	–	–
External knowledge	0.025	0.157	–	–	–	–
European markets	0.244	0.429	1.05	1.11	1.09	1.09
Non-EU markets	0.119	0.324	1.13	1.15	1.12	1.17
Local enterprise group	0.011	0.110	1.07	1.10	1.08	1.16
Local suppliers of equipment	0.036	0.186	1.04	1.21	1.18	1.33
Local clients private sector	0.015	0.123	1.03	1.21	1.11	1.33
Local clients public sector	0.005	0.070	1.08	1.08	1.05	1.17
Local competitors	0.004	0.064	1.07	1.16	1.06	1.21
Local consultants	0.018	0.133	1.08	1.21	1.13	1.32
Local universities	0.034	0.182	1.07	1.22	1.05	1.36
Local research institutions	0.015	0.120	1.08	1.19	1.05	1.27
Foreign enterprise group	0.027	0.162	1.15	1.24	1.27	1.33
Foreign suppliers of equipment	0.029	0.167	1.22	1.30	1.28	1.43
Foreign client private sector	0.014	0.119	1.04	1.15	1.09	1.30
Foreign clients public sector	0.001	0.035	1.00	1.02	1.05	1.11
Foreign competitors	0.003	0.055	1.04	1.10	1.04	1.17
Foreign consultants	0.007	0.084	1.05	1.13	1.07	1.19
Foreign universities	0.004	0.065	1.08	1.11	1.04	1.16
Foreign research institutions	0.003	0.051	1.11	1.11	1.00	1.15
Size (%) (large, SMEs)	22.8%, 77.2%		1.09	1.14	1.12	1.16
Ownership (%) (local, foreign)	11.8%, 24.2%		1.09	1.12	1.11	1.15

Note: Where SD-standard deviations, R&D-research and development, Ext. know-external knowledge.

knowledge i.e. approximately 3%. Also, roughly 24% of these firms exported to the European markets, with just 12% selling in other non-EU markets. Cumulatively, we can conclude that 36% of firms in the Czech Republic participated in international markets by exporting. Additionally, for local innovation collaborating partners, suppliers of equipment and materials and universities were preferred for collaborations (4% and 3% respectively). Also, just 2% of these firms used the services of Czech consultants and collaborated with research organizations from the Czech Republic. The foreign innovative partners dominantly used were also suppliers of equipment and materials 3%, followed by the foreign enterprise group also 3%. Only 1% of these firms collaborated with clients and customers from the foreign private sectors.

The results on firm characteristics also show that 22.8% of these firms can be classified as large firms while majority 77.2% are Small and Medium-scale Enterprises (SMEs). Similarly,

Table 2. Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
Product innovations (1)	1																					
Process innovations (2)	0.370	1																				
External knowledge (3)	0.323	0.186	1																			
R&D (4)	0.509	0.279	0.406	1																		
European markets (5)	0.452	0.170	0.254	0.376	1																	
Other markets (6)	0.453	0.216	0.277	0.415	0.611	1																
Local ent. Group (7)	0.234	0.160	0.146	0.259	0.177	0.216	1															
Local sup. Of equip (8)	0.378	0.240	0.261	0.454	0.303	0.321	0.366	1														
Local client private (9)	0.257	0.157	0.193	0.305	0.197	0.227	0.293	0.417	1													
Local client public (10)	0.144	0.095	0.157	0.184	0.120	0.138	0.191	0.237	0.308	1												
Local competitors (11)	0.138	0.062	0.097	0.159	0.102	0.118	0.147	0.215	0.364	0.263	1											
Local consultants (12)	0.292	0.182	0.237	0.396	0.229	0.270	0.327	0.442	0.369	0.248	0.195	1										
Local universities (13)	0.397	0.233	0.228	0.529	0.306	0.378	0.345	0.468	0.376	0.227	0.212	0.510	1									
Local research inst (14)	0.259	0.155	0.182	0.384	0.199	0.266	0.284	0.371	0.347	0.291	0.261	0.454	0.502	1								
Foreign ent. Group (15)	0.341	0.209	0.212	0.359	0.278	0.290	0.233	0.361	0.187	0.133	0.042	0.291	0.298	0.176	1							
Foreign sup of equ (16)	0.345	0.230	0.225	0.410	0.285	0.311	0.320	0.561	0.318	0.212	0.162	0.432	0.446	0.317	0.532	1						
Foreign clients pub (17)	0.082	0.062	0.074	0.086	0.054	0.094	0.111	0.128	0.149	0.313	0.047	0.090	0.097	0.101	0.130	0.107	1					
Foreign clients pri. (18)	0.273	0.158	0.212	0.304	0.207	0.256	0.219	0.294	0.482	0.200	0.205	0.326	0.353	0.244	0.312	0.444	0.207	1				
Foreign consultant (19)	0.190	0.117	0.191	0.279	0.147	0.191	0.214	0.225	0.220	0.086	0.075	0.385	0.296	0.205	0.297	0.356	0.109	0.259	1			
Foreign competitor (20)	0.114	0.067	0.141	0.182	0.093	0.138	0.156	0.159	0.202	0.194	0.396	0.126	0.229	0.224	0.101	0.204	0.055	0.175	0.136	1		
Foreign universities (21)	0.149	0.094	0.085	0.215	0.111	0.162	0.161	0.194	0.196	0.067	0.126	0.192	0.301	0.285	0.186	0.250	0.095	0.202	0.272	0.179	1	
Foreign research insti. (22)	0.109	0.077	0.127	0.189	0.080	0.126	0.111	0.104	0.150	0.088	0.130	0.153	0.213	0.225	0.150	0.234	0.060	0.208	0.299	0.191	0.390	1

11.8% of these firms are locally owned by Czechs, while 24.4% are multinational firms (64% missing data). The largest composition of firms in the Czech manufacturing sector are those that manufacture basic metals consisting of about 4.5%, followed by firms that manufacture rubber & plastic products (3.3%), machinery & equipment repairs (3.3%), manufacture of machinery & equipment (2.2%), transport equipment (2%), textile manufacturing constitute about (1.6%). The mean results show that the extent of innovations, and innovations collaborations are lower in the Czech Republic. Lastly, we measured the correlations between the constructs with the Variance Inflation Factor (VIF) and the correlation matrix. The results in Table 1 and 2 show that the correlations between the dependent and explanatory variables are very low. The results mean that our statistical measurement model was not affected by potential multicollinearity issues because our variance inflation factor (VIF) for the variables were all below the 3.3 tolerance threshold (Kock, 2015). This is also supported by the low coefficients in the correlation matrix.

The regression coefficients and their corresponding p-values of the four specifications of the probit models (for the probability of firms to internationalize and collaborate for their innovations) are presented in Table 3. The results in Table 3 show that there is a positive relationship between firms' participation in international markets and all measures of innovations considered in this paper. This means that our hypothesis 1 is confirmed and supported. All measures of innovations and its related activities are positively influenced by firms' participations (extent of internationalizations) in both European and other non-EU markets.

Table 3. Probit regression analysis results (source: own calculations)

Variables		Product innovation	Process innovation	R&D	External knowledge
Internationalization	European markets	0.221*** (0.068)	0.121* (0.071)	0.310*** (0.075)	0.248* (0.114)
	World markets	0.449*** (0.062)	0.288*** (0.063)	0.525*** (0.063)	0.375*** (0.085)
Domestic innovation partners	Domestic enterprise group	0.237 (0.216)	0.346* (0.160)	0.156 (0.195)	−0.174 (0.173)
	Domestic suppliers of equipment	0.713*** (0.123)	0.522*** (0.102)	0.548*** (0.117)	0.417*** (0.119)
	Domestic client (private sector)	0.354* (0.205)	0.248 (0.155)	0.269 (0.191)	0.020 (0.171)
	Domestic clients (public sector)	−0.064 (0.341)	0.199 (0.249)	0.689* (0.365)	0.272 (0.254)
	Domestic competitors	0.538 (0.388)	−0.243 (0.269)	−0.225 (0.350)	−0.255 (0.306)
	Domestic consultants	0.235 (0.203)	0.069 (0.144)	0.021 (0.183)	0.269* (0.153)
	Domestic universities	0.834*** (0.132)	0.453*** (0.106)	1.237*** (0.129)	0.012 (0.128)
	Domestic research institutions	0.388* (0.222)	0.057 (0.156)	0.713*** (0.234)	0.105 (0.165)

End of Table 3

Variables		Product innovation	Process innovation	R&D	External knowledge
Foreign innovation partners	Foreign enterprise group	1.004*** (0.146)	0.534*** (0.117)	0.433*** (0.132)	0.232* (0.135)
	Foreign suppliers of equipment	−0.146 (0.156)	0.253* (0.124)	0.109 (0.145)	−0.145 (0.143)
	Foreign client private sector	1.205*** (0.270)	0.088 (0.152)	0.531** (0.190)	0.338* (0.164)
	Foreign clients public sector	6.382 (0.000)	0.559 (0.582)	−0.275 (0.647)	−29.121 (0.000)
	Foreign competitors	−0.113 (0.436)	−0.223 (0.306)	0.153 (0.455)	0.373 (0.306)
	Foreign consultants	0.496 (0.350)	−0.104 (0.210)	0.009 (0.277)	0.349* (0.206)
	Foreign universities	0.715 (0.620)	−0.027 (0.273)	−0.226 (0.398)	−0.599* (0.300)
	Foreign research institutions	−0.408 (0.560)	0.339 (0.357)	6.512 (0.000)	0.391 (0.329)
Control variables	Large firms	0.523*** (0.085)	0.479*** (0.085)	0.459*** (0.088)	0.155 (0.117)
	SMEs	0.381*** (0.067)	0.319*** (0.069)	0.370*** (0.070)	0.102 (0.100)
	Domestic owned firms	0.396** (0.152)	0.157 (0.145)	0.429** (0.152)	0.373* (0.189)
	Foreign owned firms	0.178 (0.139)	0.061 (0.132)	0.025 (0.137)	0.248 (0.174)
	Constant	1.501*** (0.151)	1.402*** (0.146)	1.727*** (0.153)	2.236*** (0.205)
	Pseudo R^2	0.336	0.086	0.556	0.350
	Observations	3069	3069	3069	3069

Note: Robust standard errors in parentheses. Significance levels: ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

Our results imply that firms' increase the probabilities of improving their product and process innovations, R&D and external knowledge acquisitions when they participate in foreign markets. This is because these international markets are characterised by intense competitions which doubles as a medium for firms to gain knowledge. When firms compete with other firms from around the world, it forces them to adopt modern and cost cutting methods and techniques of production. Firms participation and competition with other firms can enable them to introduce newly developed goods and services from market leaders. They can also learn and inquire into market research and emulate at home to improve their channels of production and distribution. Since the Czech Republic is still undergoing its transition to market economies, it can boost its innovative capabilities by learning from other advanced technological countries and this can help to improve innovation. Exporting to international markets also has a positive ramification on firms acquisition of external knowledge. They

are highly probable to gain this international knowledge from foreign innovative partners such as universities, clients and customers, and other firms in the foreign enterprise group (Pietrobelli & Rabellotti, 2011). Our result echoes the findings of other related researches that concluded that innovations search influences firms to internationalize through exporting to benefit from advanced knowledge and technologies prevailing in foreign countries (Gërguri-Rashiti et al., 2017).

With regards to firms' collaborations for innovations, the results show that our hypothesis 2a is confirmed but only for process innovations, there is a positive and statistically significant relationship between firms' partnership with other firms in the local enterprise group and process innovations. Firms process innovations are highly probable to influence their collaborations with other firms in domestic enterprise group. When firms collaborate with other partners in the domestic enterprise group, they stand a skyrocketing chance to implement noticeable improved production and distribution processes. This is because the enterprises group has a diversified decision-making structure which can impact on their production, sales, profits and distribution activities. The enterprise group can also be an avenue for firms to improve upon their logistics and distribution of goods and services, so firms' interactions will mean they can be assured of improved ways of transporting goods to final customers. Conversely, our hypothesis 2b is also confirmed and supported for all measures of innovations considered in this paper. We find that there is a positive and statistically significant relationship between the foreign enterprise group and product, process innovations, R&D and external knowledge. This means that these measures of innovations and its related activities (product and process innovations, R&D and external knowledge) stimulates the propensities of firms to collaborate with partners in the foreign enterprise group. After these firms have internationalized and entered into foreign markets, their innovations can induce them to collaborate with foreign partners in the enterprise group. This can be attributed to the fact that the foreign enterprise group has advanced innovation potentials, technology base and knowledge centres that these firms can tap into to induce their innovations (Piperopoulos et al., 2018). Our results corroborate the findings of similar studies conducted in Hungary and the Czech Republic that concluded that innovations drive firms to collaborate with R&D partners both domestically and internationally (Odei & Stejskal, 2019).

Hypothesis 3a was confirmed. Our result show that there is a positive and statistically significant relationship between firms' collaborations with domestic suppliers of equipment and all measures of innovations considered in this paper. This result means that suppliers of equipment are likely to exert great and valuable contributions to new product and process development. They can also provide firms with knowledge and equipment needed to carry out their research and development activities. As external partners, they can also contribute to firm's external knowledge accumulations as they provide access to external knowledge that complements firm's internal knowledge base. This external knowledge can influence firm's product and process innovations, R&D and in tandem serve as an external source of knowledge (Ayala et al., 2017). However, our hypothesis 3b was also partially confirmed but only for process innovations. It was rejected for product innovations, R&D and external knowledge acquisitions. It can also be seen that there is a positive relationship between firms' collaborations with foreign suppliers of equipment and process innovations. Our result signifies

that firms process innovations increases the probabilities of these firms to collaborate with suppliers of equipment from foreign countries when they take the decisions to internationalize. When these firms collaborate with foreign suppliers, they can benefit from advanced technologies that they can employ to boost their production and distributions (Hsieh et al., 2018). Foreign suppliers were not likely to contribute to stimulating firms product innovations probably due to the fact that these suppliers do not spent much time with these firms to engage them on how their equipment should be used to influence their production processes. This result is consistent with the conclusions reached by a related study conducted in other transition countries by Pilav-Velić and Marjanovic (2016).

Our results also show that there is a positive correlation between firms' partnership with clients and customers from both the public and private sector and firms product innovations and R&D. These results confirm our hypothesis 4a. The result means that product innovations and R&D prospects is highly significant to stimulate firms to collaborate with clients and customers in the Czech Republic. This result is in line with similar studies conducted in CEE countries by Prokop et al. (2019). This is because firms' interactions with their clients and customers and exchange knowledge and information which can be incorporated in firm's production decisions. Clients can also influence the production process by letting producers know their tastes and preferences and their choice of packaging of goods and services. At the polar end, our hypothesis 4b was also supported. Our results prove that products innovations, R&D and external knowledge acquisitions are all highly likely to improve when firms internationalize and interact with other firms. These innovations and related activities can be highly moderated when these firms collaborate with clients and customers from the foreign private sector. Their probable influence was so strong on product innovations as can be seen with the highest coefficient (1.205). Firms interacting with foreign clients raises the propensity to improve their production, logistical and delivery methods due to the consumers having variety to choose from. When this is compromised, then consumers will shift to other producers with better quality alternatives. Our results corroborate other similar studies that all proved that firms' innovations improve with the extent of firms' internationalizations and possible collaborations with foreign partners such as clients and customers (Gkypali et al., 2018).

Hypotheses 5a and 5b are rejected. Our results show that there is no statistical relationship between firms' partnership with both local and foreign competitors and innovations. So, firms' product and process innovations, R&D and external knowledge acquisition didn't spur their probable collaborations or coexistence with their market rivals. Our result is quite surprising especially with competitions from foreign competitors. Firms innovations have been proven to induce their collaborations with other partners to improve their competitive advantages. Competitive pressure especially from foreign competitors are known to spur innovations in low technological endowed countries. However, our results have proven contrary. Our finding is contrary to the findings of a similar studies in the Czech manufacturing sector by Prokop et al. (2019). Our hypothesis 6a and 6b are supported for product and process innovations, and R&D but its rejected for external knowledge acquisitions. There is also a positive and significant impact of firm's partnerships with local consultants and external knowledge acquisitions. These results all show that innovations can push firms to collaborate

with these partners. And, after they have taken the decision to internationalize, their quest for innovations propels them to partner with these foreign partners to better their innovations and its related activities. This confirms the hypothesis that these firms are probable to gain expert advice and external knowledge when they partner consultants. This confirms the numerous researches that have confirmed that consultants can be relied on for external knowledge and information about customers' taste and preferences (Martinez et al., 2016).

Our empirical model results also provide evidence that there is a positive impact between firms' innovations and their collaborations with domestic knowledge centres (universities and other public research centres). The results show that firms' product and process innovations and R&D are probable to compel firms to collaborate with domestic universities. In addition, product innovations and R&D needs are highly likely to contribute to their partnerships with other domestic research organizations. This means that our hypothesis 7a is supported for product and process innovations, and R&D, but rejected for external knowledge acquisitions. This implies that knowledge from the research conducted in these knowledge centres can increase the propensity of influencing product and process innovations, R&D and external knowledge. Firms could rely on these institutions when they want to implement a significantly improved goods and services. These knowledge hubs can also be the birthplaces of R&D that can have tremendous impacts on firms' innovations (Odei & Stejskal, 2018b). However, our hypothesis 7b is rejected for product and process innovations, R&D and external knowledge. We found that acquisition of external knowledge rather reduces the probability that these firms will collaborate with foreign knowledge centres (universities). After these firms have internationalized, they are not probable to collaborate with foreign universities. Firms product and process innovations, R&D potentials and external knowledge acquisitions are not likely to contribute to influencing their collaborations with foreign knowledge partners (universities). These innovations are not likely to improve with the extent of internationalizations and the possible collaborations with foreign universities. This is highly probably due to the continues improvement of education in the Czech Republic, they provide the knowledge and research needs of these industries so there is therefore no need for them to fall on foreign universities for knowledge and innovations (Stejskal & Hajek, 2015; Odei & Stejskal, 2019).

We controlled for firms' characteristics and its potential impact on innovations. Our results show that firm size has a positive effect on product and process innovations and R&D. Firms classified as large firms and SMEs were more probable to be product and process innovators conducting research and development. They have the financial endowment to embark on R&D to influence their products and process developments. However, we find that these firms were not likely to acquire external knowledge. They depend only on internal knowledge from their internal boundaries, meaning they didn't have any external collaborations for external knowledge and innovations. Our results also demonstrated that ownership had a strong correlation with product innovations, R&D and external knowledge. This was particularly true for firms that are domestic owned. They were highly probably to generate product innovations, conduct research and development and acquire external knowledge. Contrary, our results also pointed out that foreign owned forms (multinationals) were not product and process innovators and were no probable to conduct and engage in R&D and didn't acquire external knowledge by collaborating. These conclusions are consistent with the literature

on firm characteristics as well as product and process innovations (Un & Rodríguez, 2018).

While the probit regression model is an unbiased estimator, it can be adversely affected by the presence of confounding variables in the model leading to incorrect estimations of causal treatment effects (Gore & Reynolds, 2012). The presence of confounding problem results in biased and inconsistent estimates, that might reduce the effect of firm's internationalizations and R&D collaborations on innovations and its related activities. Moreover, firms' internationalizations and their R&D collaborations can also be affected by measurement errors due to differences in responses provided by different firms that undertook the survey within countries during the stipulated time periods. Additionally, the other covariates may also be contaminated with measurement errors. Therefore, we anticipate that the zero responses provided by firms that didn't internationalize and engage in R&D collaborations can affect the overall influences of those firms that participated in international markets and collaborated leading to selection bias. To correct for the issues of confounding and selection bias arising from the dichotomous outcomes (1 = yes and 0 = no), the treatment effect' inverse-probability weighted regression-adjustment (IPWRA) was used. This helped to eliminate the bias estimates by adjusting for all confounding factors by determining their various significances based on their average results (Abadie et al., 2004). The IPWRA estimator uses the weighted regression coefficients to estimate averages of treatment-level expected outcomes, with the weights being the estimated inverse probabilities of the treatment. The IPWRA analysis allowed us to determine the additionality effect of firm's internationalization and their collaborations with various R&D partners on firms' innovations and its related activities.

We modelled our outcome variables as measures of firms' innovations and its related activities, while the treatment dependent variables were exporting to foreign markets and R&D collaborators. The results of the Average Treatment Effects (ATE) of the population are presented in Table 4 below. For our model with product innovations, the iprwa results show significant and positive coefficients for 11 variables namely foreign market competitions, domestic suppliers of equipment, domestic clients from private sector, domestic clients from the public sector, domestic competitors, domestic consultants, domestic universities, domestic research institutions, foreign enterprise group foreign suppliers of equipment and foreign consultants. The results show that firms' product, were highly probable to be influenced more by domestic collaborations rather than foreign collaborations. Except for the collaborations with domestic partners in the enterprise group, product innovations were all highly likely to be influenced by other domestic R&D collaborators. On the hand, on average product innovations were not influenced by the extent of internationalizations and collaborations. The foreign partners that mattered for product innovations were the enterprise group, consultants and suppliers of equipment. The results mean that on average, these firms benefit more with regards to product innovations when they internationalize and interact with these partners. Firms that internationalized and participated in foreign markets are 21 percentage point more probable to increase their product innovations than those firms with just domestic market focus. Through foreign markets these Czech firms face intense competitions and that compels them to learn to innovate. They can acquire new skills and technologies that might influence their production process. Our result is akin to other extensive studies conducted in 14 transition countries across Europe where the results show a positive significant impact of

foreign market participation impact on firm's product innovation activities (Gërguri-Rashiti et al., 2017). The result has shown that product innovations significantly improves with the extent of internationalization which is moderated by firms' collaborations with foreign consultants. Among all these covariates, foreign consultants demonstrated to have the highest average effect on product innovations. On average, firms' product innovations increase by 49 percentage points when they internationalize and engage foreign consultants. Our ATE results imply that firms that collaborated with foreign consultants are highly probable to improve their product innovations twice as compared to those that didn't engage them. Consultants from strong innovative countries for instance can transfer their expert advice to firms in the Czech manufacturing sector and this can have adverse effect on their innovations. A study by Boermans and Roelfsema (2015) in 10 transition countries in Eastern Europe and Central Asia also confirmed our results that external consultants especially from abroad are more probable to help firms improve their product innovations.

In the second model with process innovations, the ipwra results show 11 covariates with positive coefficients. We have argued in the theoretical section that foreign markets, domestic and foreign R&D partners are likely to stimulate process innovations within firms all other things being equal. Our ATE results show that firms process innovations soars with the extent of internationalizations (export). Firms that internationalize are more likely to improve their process innovations on average by 14 percentage points better than firms that do not participate in international markets. So, when firms decide not to export, they are not exposed to any foreign competitions and this is likely to reduce their process innovations by 76 percentage point. The ATE also show that process innovations were significantly influenced by both domestic and foreign collaborators. The results show that process innovations were increased on average by 28 percentage point when firms collaborated with domestic suppliers. Domestic suppliers can increase the probability of increasing process innovations. The literature also confirmed that clients and customers can improve process innovations. Our results show that they are likely to boost process innovations on average by 26 and 19 percentage points respectively. As confirmed by the literature, knowledge institutions contribute to stimulating firm-level innovations. Knowledge institutions such as universities and other research organizations also increase the probabilities of improving process innovations on average by 21 and 15 percentage points in comparison with firms that didn't collaborate with these knowledge hubs. Recent studies in the Czech Republic by Hájek and Stejskal (2018) confirmed the importance of these knowledge institutions in the creation of firm-level innovation. Among the domestic collaborators, suppliers of equipment demonstrated to have the highest average effect on process innovations (0.275). The ATE results also show that internationalized firms' process innovations are likely to be spurred on average terms when they collaborate with five collaborators. Among the foreign collaborators, the ATE results show that on average firms' cooperation within their enterprise group increase the prospects of process innovations by 31 percentage points and their collaborations with foreign suppliers of equipment by 33 percentage points. Foreign clients by 34 percentage points than firms that didn't engage these vital collaborators. The highest ATE results of foreign suppliers of equipment demonstrate that they can increase the probabilities of helping to transfer existing technologies from strong innovator countries to the Czech Republic. Finally, using foreign

consultants and foreign universities could also increase the propensities of helping firms to improve their industrial process on average by 27 and 33 percentage points better than firms that didn't engage these partners.

The results in Table 4 also show that on average, firms' internationalizations are probable to improve research and development, but on average this is just a little over 10 percentage points. This result shows that R&D influences firms to internationalize. This has been confirmed by a related study in Croatia by (Dabić et al., 2012). R&D activities also influence

Table 4. Average impacts of inverse-probability-weighted regression adjustments
(source: own calculations)

	Variables	Product innovations	Process innovations	R&D	External knowledge
Domestic innovation partners	Foreign markets	0.212*** (0.025)	0.140*** (0.023)	0.097*** (0.019)	–
	Domestic enterprise group	−0.012 (0.029)	0.043 (0.029)	−0.012 (0.020)	−0.022 (0.015)
	Domestic suppliers of equipment	0.333*** (0.047)	0.275*** (0.047)	0.260*** (0.046)	0.076** (0.030)
	Domestic clients (private sector)	0.383*** (0.085)	0.260*** (0.081)	0.174* (0.076)	0.041 (0.046)
	Domestic clients (public sector)	0.373*** (0.117)	0.155 (0.141)	0.207 (0.143)	–
	Domestic competitors	0.446*** (0.105)	−0.049 (0.134)	0.203 (0.152)	0.032 (0.071)
	Domestic consultants	0.402*** (0.065)	0.189** (0.080)	0.118 (0.076)	0.038 (0.050)
	Domestic universities	0.405*** (0.039)	0.205*** (0.043)	0.330*** (0.045)	0.038 (0.027)
	Domestic research institutions	0.345*** (0.089)	0.148* (0.082)	0.311*** (0.090)	−0.018 (0.030)
Foreign innovation partners	Foreign enterprise group	0.415*** (0.050)	0.312*** (0.055)	0.175*** (0.008)	0.072 (0.032)
	Foreign suppliers of equipment	0.330*** (0.065)	0.383*** (0.063)	0.167** (0.061)	−0.004 (0.028)
	Foreign client private sector	–	0.344*** (0.095)	0.224* (0.102)	0.083 (0.070)
	Foreign competitors	0.193 (0.174)	0.146 (0.189)	0.156 (0.185)	0.213 (0.146)
	Foreign consultants	0.490*** (0.062)	0.265* (0.118)	0.398** (0.142)	0.304* (0.133)
	Foreign universities	–	0.329* (0.190)	0.373* (0.175)	-0.059* (0.026)
	Foreign research institutions	–	–	−0.026 (0.137)	–
	Observations	3069	3069	3069	3069

Note: Robust standard errors in parentheses. Significance levels: ***P < 0.01, **P < 0.05, *P < 0.1.

firms to collaborate with domestically with five partners. Domestic suppliers of equipment also are likely to increase R&D among these firms by 26 percentage points than firms that didn't engage these partners. The ATE results also show that domestic knowledge institutions significantly improve R&D. On average firms that collaborated with domestic universities and other research public research organizations are probable to boost their R&D potentials by 33 percentage points and 31 percentage points more than firms without any engagements with these knowledge institutions. Domestic universities and other research organizations significantly impacted on firms R&D capabilities as seen with the highest ATE results respectively. Among the foreign partners, the results show that the quest to engage in R&D was likely to influence firms to partner with five foreign partners. The constant interactions with other firms in the foreign enterprise group could increase the prospects of R&D by 18 percentage points, foreign suppliers could also probably help boost R&D by 17 percentage points. Foreign private sector clients by 22 percentage points. The ATE results again show that foreign consultants can significantly improve firms R&D potentials by 40 percentage points, and foreign universities by 37 percentage points. Our results confirm and buttress the findings of previous studies outlined in the literature section.

Finally, the literature has confirmed that external knowledge can influence firms' decisions to internationalize and collaborate with other vital partners that matters. Foreign market participations, local and foreign R&D partners as important source of firm's knowledge that can help to boost innovations. But our results proved contrary, external knowledge was not a predictor of firms' decisions to participate in foreign markets. Among all the local R&D collaborators, only suppliers of equipment had a probable significant impact on firms' external knowledge. For these firms, their collaborations with local suppliers increase the probability of contributing to their external knowledge component on average by just 8 percentage points. Meaning that firms that didn't engage suppliers of equipment could decrease their external knowledge potential by 92 percentage points. The results also show that, foreign consultants are the greatest conduits through which these firms could have access to external knowledge for their innovation needs. On average, firms that collaborated with these foreign consultants are probable to increase their exogenous knowledge stock to about 30 percentage points more than those firms that didn't use them.

Surprisingly, our ATE results demonstrate that firms that collaborations with foreign universities rather decrease the probability to acquire external knowledge on average by 6 percentage points. This means that for these firms that collaborated with foreign universities, there was no additionality effect of this collaborations on their external knowledge acquisitions which subsequently stimulate innovations. This might be to the fact that these firms have low absorptive capacities and may not be able to assimilate external knowledge especially from foreign universities. A study by Stejskal and Hajek (2015) in the Czech high-tech industrial sector and Pavlínek (2017) in the automobile sector all supports our claim that the manufacturing sector is characterized with low absorptive capacities that makes them unable to absorb and use external knowledge. So long as no remedies are found to correct this problem, these firms won't be able to utilize external expertise and know-how from the domestic and foreign sources and will continuously wallop in lower levels of innovation.

Conclusions

The central focus of this paper was to explore the linkages between firms' competitions in foreign markets, and how their interactions with both local and foreign innovation collaborators stimulate their innovations. Building on the open innovation, internationalization and networking models for innovations, we aimed to know whether firms' innovations search influence them to internationalize and network with both local and foreign collaborators. Our empirical analysis involved two different model specifications built on the probit regression model and treatment effects' inverse-probability weighted regression-adjustment (IPWRA) estimator. Using the doubly robust estimation method, the treatment parameter of interest are reliably predicted if when one of the models is correctly specified. The results of the descriptive statistics showed that innovations and R&D collaborations are very low in the Czech Republic. These low levels of R&D collaborations in transition CEE countries have been supported by numerous recent studies (see Lewandowska et al., 2016; Hájek & Stejskal, 2018). Albeit the level of R&D synergies and innovation are low as shown by the descriptive statistics, the transition process has increased firms' extent of internationalizations and participation in innovations networks domestically and internationally. The results of our empirical analysis have shown that there is a strong and positive relationship between these firms' foreign markets participations and their product and process innovations, research and development and these markets also were avenues for these firms to acquire external know-how that can be highly beneficial for their innovations. This means that firms' innovations influence them to internationalize and interact to acquire new knowledge and advanced technologies that can increase their innovation performances. Our results also showed that the domestic innovation partner that mattered most for these firms' innovations are suppliers of equipment and materials. They positively influenced all four measures of innovations considered in our analysis. Domestic universities also play a very significant influence on firms' product, process and R&D activities. This means that their research and development activities and their faculty and student transfer knowledge to industries to stimulate innovations. Our results also proved that research organizations also had a positive impact on these firm's product innovations and R&D activities. Interestingly we also found that external know-how is highly probable to influence firms to collaborate with domestic consultants. Firms innovations didn't significantly influence their decisions to collaborate with local competitors in the same sector. On the other hand, our results also demonstrated that innovations were highly probable to impacted when they collaborate with foreign partners in the foreign enterprise group. They influenced all dimensions of firm's innovations measures considered in this paper. Their greatest influence was on product innovations, as can be seen with the highest coefficient among the other innovation measures. We also conclude that clients and customers from the foreign private sector are very influential on these firm's product innovations, R&D and they also serve as a vital source of external know-how for these firms. External knowledge was significantly and positively influenced by firms' collaborations with foreign consultants. Surprising our results showed that foreign universities rather had a negative impact on firms' external knowledge acquisition meaning that these firms were not probable to collaborate with foreign universities for external knowledge.

Lastly, our results for the effects of control variables also showed that large firms were highly likely to introduce new products and process as well as conduct R&D activities this is consistent with the literature. SMEs were also highly probable to be product and process innovators and were highly likely to conduct and engage in R&D related activities. Similarly, locally owned firms were more likely to be innovative than foreign owned or multinational firms. We conclude that both size and ownership didn't have any significant impact on firm's external knowledge acquisitions.

The estimated treatment effects of firms participating in foreign markets and probable collaborations with domestic and foreign partners are also shown to be different for firms. The percentage gains in product innovations on average were higher for firms that responded yes. We summarise the results as firms increase their product innovations on average percentage points (21%) when they participate in international markets. They also improve their product innovations on average points when they collaborate with local partners such as suppliers of equipment, clients and customers from both the public and private sectors, competitors, consultants, universities and other research organizations. Foreign partners that could increase the probabilities of impacting product innovations on average percentage points are partners in the enterprise group and consultants. Foreign consultants demonstrated to increase firms product innovations on average by 50%. For firms process innovations, the ATE results show that firms gain when they export to foreign markets. For firms that participated in foreign markets it increased their process innovations by 14%. On average local partners that could increase the probabilities of firms process innovations are suppliers of equipment could increase process innovations by 28%, local clients by 26%, consultants 19%, local universities 21%, other local research organizations 15%. The results also show that foreign partners such as those in the enterprise group on average could increase process innovations by 31%, suppliers of equipment 38%, clients from the private sector by 34%, consultants 27% and universities by 33%. For R&D, it is estimated that foreign markets contributed to its increase by just 10%, local suppliers by 26%, clients from the private sector by 17%. On average local universities had the highest contributions to firms R&D (33%) and other local research organizations by 31%. Foreign partners that on average contribute to increase R&D were the enterprise group (18%), suppliers of equipment (17%), foreign consultants (40%) and foreign universities (37%). Finally, for external knowledge, the ATE results show that, firms collaborations with local suppliers of equipment on average contributed to their external knowledge stock by 8%. Finally, the results show that firms collaborations with foreign consultants could increase external knowledge on average by 30%.

Contributions to theory and practice

The results of our analysis have implications for understanding how firm-level innovations can achieved and studied especially in transition countries. The empirical results suggest that firms cannot achieve innovations domestically and with only domestic partners but instead they need to consider tapping into knowledge and technologies emanating from foreign countries if they want to introduce new products and services effectively and efficiently. We have controverted and showed empirically that firms' decisions to internationalize affect dif-

ferent measures of innovation and its related activities, which are all moderated by the different types of collaborations arrangements. Firms innovations soars when they collaborate with domestic and foreign partners when they internationalize. This result contributes to the extant recent studies that shows the impact of foreign and local collaborators propensity to stimulate firm's product, process, R&D and external knowledge.

This research study simultaneously defined and tested empirically a theoretical model that combines the domestic and international open innovation milieu focused with its focus on networking for knowledge and innovations. This model significantly contributes to existing open innovation and networking literature. To the best of our knowledge this is the first research study focusing on how firms interactions in both domestic and international innovation milieu in a transition economy i.e. the Czech Republic. We have demonstrated that firms collaborations with both domestic and foreign partners produces additionality effects on firm-level innovations and its related activities. We therefore offer useful insights into how firms in transition economies can increase their innovations by collaborating with foreign partners to complement their domestic knowledge deficits to improve their innovation performance and its related activities.

Innovations represents one of the best means firms can rely on to stay productive and competitive especially for firms in transition economies with weak innovation potentials. Our results agree with the literature that firms internationalizations and networking with other partners has additionality effect on innovations. It is therefore imperative for firm managers and researchers to harness the potential of networking with both domestic and foreign partners for innovation. This article has proven that foreign partners significantly impact on firm-level innovations, when firms collaborate with them. Firm managers in the Czech Republic need to take advantage of the opening up process to utilize innovations from countries with strong innovations to augment their weak innovation prospects.

Another imperative policy implication for industrial managers in the Czech Republic is that they need to realize that they cannot achieve efficient innovations by focusing just on the Czech local market and collaborating with only Czech innovation partners. Instead they need to take bold decisions to internationalize and orient themselves to foreign markets as well as invest and forge long-term partnerships with foreign collaborators such as those in the foreign enterprise groups, clients and customers and engage the services of foreign consultants. Foreign consultants can help in the transfer of knowledge and expertise from their innovations advanced countries to the Czech Republic. When these measures are undertaken, then there will be the continuous and uninterrupted flow of knowledge and know-how and its subsequent spill over effects.

This study has limitations that can be overcome in further studies. We didn't include in our analysis other measures of innovations such as organizational and market innovations. This deliberate omission means that we cannot conclude that foreign and local partners influence general innovations in the Czech Republic. We therefore recommend further studies to consider these other types of innovations. Finally, this study can be extrapolated in other countries using different samples and methods to capture the differences in business ecosystems and innovation policies.

Funding

Author contributions

SAO and JS contributed equally to prepare this manuscript.

Disclosure statement

The authors do not have any conflict of professional, financial and personal interests relating to the research described in this paper.

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