# Innovation Cooperation and Foreign Ownership in the Czech Republic*

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*Abstract*

Innovation is essential for latecomer countries, such as the Czech Republic, to generate rapid productivity growth. Innovation cooperation can play an important role in facilitating this process, which requires agreements that extend across a wide range of partners both within the local economy and abroad. In this paper, we explore whether foreign subsidiaries are more or less likely to transfer technology to the local economy, correcting for firm size, age, industry, location, internal R&D activity, and other aspects of the innovative behaviour of enterprises. The analysis is based on firm-level data from the third Community Innovation Survey. Using a probit model, we find that international cooperative agreements are important for the Czech economy, but that foreign ownership does not facilitate knowledge spillovers to the local economy.

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# Innovation Cooperation and Foreign Ownership in the Czech Republic

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## *1. Introduction*

The creation, transfer and absorption of new knowledge are essential parts of innovation activity. Some of this knowledge comes from formal research and development (R&D) activity performed inside the enterprise, but it often comes from other activities that do not have any straightforward relation to R&D (OECD 1997). Much of the knowledge is obtained from external sources, which may include cooperative agreements with other enterprises or organizations, both at home or abroad (Nelson 1962, Richardson 1972 and Lundvall 1988). While the choice of partner depends on types of complementary resources firms seek to access and the knowledge available partners possess (Penrose 1959, Miotti and Sachwald 2003), the incidence of these arrangements illustrates the diversity of channels that are used to exploit technological opportunities (Baldwin and Hanel 2003). This diversity is essential for the innovation process and ultimately for economic growth (Nelson and Winter 1982).

Despite the large body of literature on the importance of technology transfer from parent firms to foreign-owned subsidiaries and knowledge spillovers to the local economy, there has been relatively little discussion on technology flows through cooperative agreements involved in these relationships. Studies using firm-level data, which regress total factor productivity on penetration of foreign-owned firms in the industry, typically find little evidence of technology spillovers due to foreign ownership (Görg and Greenaway 2002). This seems to be in line with the proposition that multinational corporations tend to limit spillovers of their knowledge base to non-affiliated firms to protect their ownership advantages (Dunning 1988 and Caves 1996). As they aim to exploit their superior knowledge base through direct investment abroad, they should be expected to channel knowledge from the parent to the local subsidiary, but protect it from spilling over to the host economy.

This is particularly important for new entrants into the European Union such as the Czech Republic, which have experienced sizeable inflows of foreign direct investment since the mid-1990s. The existing literature that relates directly to the Czech Republic suggests that spillovers to the local economy may have been even negative from 1992 to 1996 (Djankov and Hoekman 2000), although when R&D activity is included in the analysis, some technology transfer and spillovers are observed (Kinoshita 2001). A study by Damijan, et. al. (2003) confirmed that technology transfer may not have been very prevalent in the Czech Republic, but there was evidence that inter-industry relationships were important.

Indeed, the production function approach has little to say about specific mechanisms through which the knowledge spillovers proceed and about conditions supportive to the process. None of these studies examined the presence of cooperation arrangements in the Czech economy, which may indicate that the production function approach may not be adequately capturing the knowledge flows across firms. Without direct evidence on these mechanisms, we can hardly improve our understanding of the role foreign direct investment plays in international technology transfer and in turn in productivity growth in the host economies.

Empirical evidence from the Community Innovation Surveys triggered extensive analysis of R&D and innovation cooperation since the beginning of the nineties (Arora and Gambardella 1994, Colombo 1995, Veugelers 1997, Nooteboom 1999, Tether 2002, Miotti and Sachwald 2003, Becker and Dietz 2004 and Negassi 2004). But the literature on mechanisms of international technology transfer through foreign ownership remains small and limited to the analysis of Cassiman and Veugelers (2002) and Veugelers and Cassiman (2004). Using firm-level data from the innovation survey in Belgium as an example, these papers show that it is possible to measure knowledge spillovers directly instead of using more indirect measures as those used by the production function approach.

A recent study by Srholec (2005) focused directly on R&D activity of foreign affiliates in the Czech Republic. It is shown that foreign affiliates are less likely to engage in intramural R&D compared with domestic-owned firms. The paper also points to some differences in the effect of external R&D acquisition in foreign affiliates and domestic-owned firms. Although the external R&D sourcing appears to be strongly complementary to indigenous R&D in domestic-owned firms, only acquisition of R&D from laboratories and universities in the host country – indirectly indicated by innovation cooperation with relevant partners - seems to be complementary to intramural R&D in foreign affiliates, while sourcing of R&D from abroad does not appear to be relevant in this context.

This paper follows further in these veins by focusing directly on the effects of knowledge flows through innovation cooperation in the Czech Republic. We place particular emphasis on the role that foreign affiliates play in the transfer and absorption of new knowledge in this respect. We test whether foreign-owned firms are more likely to engage in innovation cooperation locally, after controlling for various complementary factors such as size, age, technological opportunities, regional differences, intramural research activity, openness to external sources of information, appropriability conditions or access to non-affiliated cooperation partners abroad.

To capture these knowledge flows we analyse large sample of manufacturing firms from the third Community Innovation Survey carried out in the Czech Republic in 2002 (the same dataset as in Chapter 6). Differences in the questionnaire and other considerations required us to further develop the model of Veugelers and Cassiman (2004). The paper primarily focused on market based (arms-length) transactions through the technology market such as licensing or R&D contracting – which can be viewed as channels of technology transfer very close to the market extreme on the hierarchy versus market continuum. In contrast, we focus on cooperative agreements for innovation, which are much broader means of inter-firm knowledge flows, defying the strong hierarchy and market dichotomy.

The paper is organized as follows. Section 2 briefly surveys the theoretical literature on knowledge flows through inter-firm cooperation. Section 3 describes the data used and the methodology underlying the Czech innovation survey. We then discuss the econometric approach and the results respectively in sections 4 and 5. Some concluding remarks follow in section 6.

### *2. Knowledge flows through inter-firm cooperation*

Firms have to decide on the most efficient combination of ways to organize their innovative efforts, either through internal R&D activity, arms-length acquisition of knowledge on markets for technology or most importantly through various types of organizational arrangements for inter-firm cooperation. It is well established in the literature that transactions involving exchange of knowledge suffer from fundamental market imperfections. Building partnerships with other organizations facilitates the knowledge flows and offers firms opportunities for resources sharing. Following the resources based theory of the firm coined by Penrose (1959) and its knowledge based extension proposed by Nonaka, Toyama and Nagata (2000), firms build on strategic capabilities, containing elements of tacit knowledge, which encourages the need to pool resources with other organizations in order to access knowledge complementary to their own knowledge base. Moreover, sharing of resources allows firms to rationalize innovation process through spread of high costs and risks involved in innovative activities, thereby permitting the exploitation of economies of scale and scope.

In contrast to perspectives of the transaction costs theory of the firm (Coase 1937, Williamson 1975), Richardson (1972) observed increasing trend in cooperative behaviour between firms and called for more balanced approach to the market versus hierarchy, in particular as long as innovation activity is concerned:

> "Firms are not islands but are linked together in patterns of co-operation and affiliation. Planned co-ordination does not stop at the frontiers of the individual firm but can be effected through co-operation between firms... inter-firm co-operation is concerned very often with the transfer, exchange or pooling of technology... new products also frequently require the co-operation of firms with different capabilities... it seems to me that we cannot hope to construct an adequate theory of industrial organisation, unless the elements of organisation, knowledge, experience and skills are brought back to the foreground of our vision." (Richardson 1972, pp. 888-895).

Building on evolutionary perspectives, the systemic nature of innovation process has been elaborated in the literature on innovation systems (Lundvall 1992, Nelson 1993 and Edquist 1997). The ability of firms to capitalize on external knowledge embedded in local social networks is seen as crucial for successful innovation process. Historical and geographical patterns shape innovation behaviour of firms because their context specific innovation capabilities evolve along path-dependent national and sectoral trajectories. Even if firms invest abroad, their knowledge base remains embedded in the local innovation systems (Pavitt and Patel 1999).

The evolutionary perspective suggests that multinational investment and international cooperation can not undermine the role of local innovation systems; in fact, the contrary is expected to be the outcome of globalization of innovation activities (Maskell and Malberg 1999). The deepening specialization of both firms and national economies within the production systems fragmented across the globe even more reinforces role of idiosyncratic strategic capabilities and the need to pool complementary resources for innovation. From this perspective, multinational investment and international innovation cooperation allows firms to tap into geography and history specific advantages embedded in the local innovation systems (Chesnais 1992 and Cantwell 1995). Firms that orchestrate localized learning with global networking should find themselves in a superior position to expand in the global markets.

Advantages of a strategic nature for motivation of firms to cooperate on innovation are emphasized in the literature on strategic alliances (Gulati 1998, Sachwald 1998, for overview see Miotti and Sachwald 2003). Innovation cooperation is viewed as an organization answer to increasing complexity of research, heightening global competition and rapid technology progress. Empirical evidence on strategic alliances broadly confirms the increasing trend of non-affiliated cooperation in technology development in the global economy (Hagedoorn 2002). The strategic incentive for firms to involve in network relations with non-affiliated partners is reciprocal access to knowledge - firms share their knowledge to acquire valuable knowledge in return. The partner has to offer knowledge superior to existing capabilities of the cooperating firm, which suggests that technology cooperation between locally and foreign-owned firms is by far less likely in countries in large distance from the technology frontier. Most of the low and middle income countries, such as the Czech Republic, might not have much technological knowledge superior to knowledge base existing in the developed world.

Following Lundvall (1988), the localized nature of interactive learning has been emphasized in the literature on regional innovation systems. The regional perspective highlights historically evolved relationships among the internal organization of firms and their connections to one another and to the social structures and institutions of their particular localities (Gertler 1993 and 2004, Maskel and Malmberg 1999, Saxenian 2000, Cook 2004 and Asheim and Gertler 2004). Cook (2004) proposes the term "collaborative manufacturing" to capture the tendency to see value chains as the principal driver of new, more collaborative relationships between customers and suppliers, which is increasingly important in industries with supply chains organized in value networks at a global scale. Gertler (2004) points to the fact that systems of innovation and production have become more social in nature as production systems are increasingly characterized by a more finely articulated social division of labour, achieved through the process of vertical disintegration of large firms and the growing use of various forms of outsourcing.

Our main matter of concern here is the choice between local and global partners for cooperation. Following the interaction learning perspective, it is likely that firms embedded in the local social environment will choose to cooperate with partners in their proximity. The theory predicts that firms will tend to choose local rather than foreign partners if there are partners with the needed complementary resources present in the local economy. Consequently, knowledge spillovers should be expected to be geographically bounded within a limited space over which interaction and communication is facilitated, search intensity is increased, and task coordination is enhanced (Feldman 2000). A lack of complementary resources locally, on the other hand, encourages firms to engage with foreign partners. As further argued by Lundvall (1988), organization proximity through foreign ownership may overcome geographical and cultural distance. Hence,foreign-owned firms should have easier access to cooperation partners abroad. the foreign-owned firms have an inherent advantage to access foreign sources of technological knowledge through other firms in the group and parents abroad.

Admittedly, for foreign-owned firms to be channels of international technology transfer, these firms need to source technology internationally and diffuse - intentionally or unintentionally - the foreign technological knowledge to the host economy. As already noted, however, foreign-owned firms can restrict their activities to application of technologies developed abroad and confine spilling of knowledge to the local economy. Foreign-owned firms can resemble "cathedrals in a desert", building on innovation capabilities of other affiliated firms concentrated in home locations of their parents abroad, while maintaining limited R&D and cooperation links in the host economy (Gertler, Wolfe and Garkut 2000 and Narula 2003). Indeed, this should be a serious matter of concern for countries behind the technology frontier, such as the Czech Republic, as shall be illuminated in the following.

## *3. The Data*

The empirical analysis in this paper is based on information at the firm level obtained from a compulsory survey conducted by the Czech Statistical Office. Firms were asked about their activities aimed at generating new product and process innovation over years 1999 to 2001. The survey was harmonized with the third Community Innovation Survey organized by Eurostat and follows the methodology of the Oslo manual (OECD, 1997). The questionnaire was sent to a representative sample of 5,829 Czech enterprises with more than 10 employees in both manufacturing and service industries. The response rate was 65% (3808 enterprises). About 38% of the respondents claimed to have introduced a new product or process during the period. Only the successful innovators were asked about details on their innovation activities, which imply that only the innovating companies can be included in the analysis. Moreover, the Czech business register allows us to detect foreign ownership only for non-financial and incorporated firms (about 85% of the respondents). Hence, we restricted our analysis to a sample of 729 innovating companies in manufacturing industry.

Besides information on size, age, ownership, industry and location of the firms, the data set provides direct and firm-specific evidence on internal R&D activity as a measure of local technology (and absorptive) capability; innovation cooperation as a channel of technology transfer within and across national borders; importance of external information sources for innovation as a measure of an ability to take advantage of pool of relevant external knowledge; the use of methods to protect intramural innovations and finally importance of various obstacles that hinder innovation activity of the firms in question (see Appendix 1 for overview of the variables).

We measure size of the company by the variable “SIZE”, which is number of employees (in logs). The variable AGE refers to the number of days since firm’s registration in the business register (also in logs). The binary variable “FOREIGN” takes the value of 1, when the firm is foreign-owned. The Czech business register defines foreign-owned firm as an enterprise with more than 50% share of non-residents in equity. The binary variable “R&Dinternal” takes the value of 1 for firms that indicated to be permanently engaged in intramural R&D.

The focal point of our analysis is cooperation as a means to obtain technology from abroad and the local economy. Innovation cooperation means active participation in joint R&D and other innovation projects with other organisations (either other enterprises or non-commercial institutions). Our measure of technology transfer within the national economy is a binary variable “COOPnational” with the value 1 for firms that reported having a partner for innovation cooperation in the Czech Republic. And the measure of access to global technology is a binary variable “COOPglobal” with value 1 for firms that reported having a partner for innovation cooperation abroad. Eight different types of partners for innovation cooperation were identified in the questionnaire: (1) internal to the enterprise group; (2) upstream suppliers; (3) downstream customers; (4) competitors; (5) consultants; (6) R&D laboratories; (7) universities; and (8) public or non-profit research institutes. It is important to note that we exclude cooperation with a partner internal to the enterprise group as we want to focus on external transfer to the firm. The reason for ignoring the internal partner is to avoid interaction with the "FOREIGN" variable as the foreign-owned firms are part of a foreign group by definition.

An important catalyst for external innovation cooperation is firm's awareness on a pool of knowledge available outside of its borders. The survey provides information on perceived importance of external information sources for innovation from other firms (suppliers, customers and competitors) and scientific institutions (universities and R&D laboratories). Firms were asked to give score on each of the five sources on a scale from 1 to 4. We rescaled the scores to a number between 0 (unimportant) and 1 (highly important). Factor analysis confirms that there is a difference between importance given to information from the other firms and from the scientific institutions (see Appendix 2 for results of the factor analysis). Hence the variable "INFOmarket" refers to the factor score identified primarily by the former, while the variable "INFOscience" refers to the factor score reflecting the latter sources of information.

Firms use various methods for controlling the amount of information that spills over its boundaries. Ability to appropriate intramural inventions and innovations gives a firm better position to capitalize not only on its own innovative activity but also on innovation cooperation. The survey allows us to detect whether the firms applied for a new patent over the period or had valid patents at the end of 2001. To measure the appropriability conditions we use the binary variable "PROTECT" with the value 1 if the firm reported having at least one valid patent or patent application.

A number of obstacles can hamper firm's innovation capabilities. The survey provides information on the following obstacles to innovation that are given by economic and other external factors to a firm: excessive perceived risks, innovation costs too high, lack of appropriate sources of finance, insufficient flexibility of regulations and finally lack of customers responsiveness to innovated products. Firms were asked to rate the importance of the obstacles on a scale from 1 to 4. Again, we rescaled the score to a number between 0 (unimportant) and 1 (highly important). Although each of the obstacles is expected to capture different factors hampering innovation activity, we detected, however, high correlation among all of them: factor analysis indicated only a single principal component across all of the obstacles. Hence, the variable "OBSTACLES" is estimate of the single factor score across the five obstacles to innovation (see Appendix 2 for results of the factor analysis).

**Table 1: Overview of the sample**

| | Total (N = 729) | Local-owned (N = 517) | Foreign-owned (N = 212) |
|---|---|---|---|
| Size and industry distribution: | | | |
| SIZE (average number of employees) | 512 | 434 | 701 |
| Age (average years since registration) | 8.7 | 8.9 | 8.4 |
| Share of firms engaged in: | | | |
| R&Dinternal | 48% | 49% | 45% |
| COOPnational or global | 37% | 36% | 39% |
| COOPnational | 32% | 33% | 31% |
| COOPglobal | 20% | 17% | 27% |
| COOPnational and global | 16% | 14% | 19% |
| COOPnational as % of COOPglobal | 77% | 81% | 70% |

Note: Due to missing answers for some question, the number of observations differs between the variables (the minimum number of available answers is 666 for innovation cooperation).

Finally, we control for differences in technology opportunities across industries and factors given by regional location of a firm. The industry-specific factors are captured by a set of industry dummies at 2-digit level of NACE (rev. 3) and the regional factors by dummy for location of the firm in Prague agglomeration and in other district with technical university (see Appendix 1 for further identification of the variables).

Table 1 presents descriptive overview of the sample. Nearly one third of the firms are in foreign ownership. Local-owned firms are on average almost half the size of foreign-owned firms, but not much difference appears to be in average age the firms. With regards to the sectoral distribution, foreign-owned firms are more concentrated in medium-high-tech and less represented in low-tech industries, but the difference is also small. In this respect, the sample is representative as these characteristics broadly correspond with a patterns showing up in comparative analyses of local and foreign-owned firms in the Czech manufacturing during the period.Nearly half of the firms were permanently engaged in internal R&D activities and more than a third of them had at least one cooperative agreement for innovation.1 32% of firms reported some form of innovation cooperation with another local partner and 20% of firms reported having a partner abroad. Consequently, only 16% of the firms had a partner both at home and abroad. There is not much difference between local and foreign-owned firms. A notable exception is that foreign-owned firms engage much more frequently into a global cooperative agreement than the locally owned firms.

[1] Note also that some of the innovating firms didn’t provide information on innovation cooperation, which restricts the sample to 666 observations in equations 2 and 3 – see below.

A key question for our thesis is whether there exists a link between the local and global cooperation. The table shows that despite the gap in the frequency of global cooperation, the incidence of simultaneous global and local cooperation is only slightly higher in the foreign-owned firms. It is interesting to see that firms cooperating globally have more than two times higher frequency of cooperating locally. Moreover, this holds even more for cooperation behaviour of local-owned firms as 81% of the local-owned firms that cooperate globally reported also having a local partner, as compared to an average of 77%. Surprisingly, even if the foreign-owned firms are much better connected to the global technological know-how, we do not observe significant difference along the ownership dimension for a wider diffusion of the globally acquired knowledge in the local economy.

These descriptive figures already indicate important patterns of innovation behaviour in the Czech manufacturing firms and also hint to some differences between local and foreign-owned firms. The observed differences in the cooperation behaviour, however, could be influenced by differences in size or sectoral distribution of firms and other factors. To control for impact of these factors, we investigate the issues in more depth in the following econometric analysis.

## *4. The Econometric Model*

A probit model is ideal for capturing information from the Czech innovation survey since the questionnaire asks whether the enterprise enters into a certain kind of cooperative agreement. In our example, the decision to carry out own R&D activity or enter into a cooperative arrangement corresponds to Y=1. This gives the probability that Y=1 is chosen conditional on the explanatory variables. The probit model is defined as

$$P(y=1|x) = \Phi(x\beta),$$

where $\Phi$ is the standard cumulative normal probability distribution and $\beta$ are unknown parameters. We use a maximum likelihood estimator because it is the most precise estimator when there are large samples such as in our case.

Following Veugelers and Cassiman (2004) we consider three direct influences that multinational corporations can have on the transfer of technology: (1) effects of foreign ownership on internal R&D activity; (2) importance of foreign-owned firms for international technology transfer, and (3) role of foreign ownership for local technology diffusion. We depart from their model, however, for two interrelated reasons. First, the questionnaire used for the third Community Innovation Survey included different questions about international technology transfer as compared with the first Community Innovation Survey. As a consequence, Veugelers and Cassiman (2004) focused primarily on arms-length transfer of technology through market transactions such as licensing or R&D contracting. We are mainly concerned with innovation cooperation, which is an inter-firm relation in the whole continuum between the both extremes of hierarchy versus market, which has become increasingly important in the knowledge-based economy of late nineties. Indeed, a purely “off-the shelf” purchase of technology is rather rare in reality as most of the knowledge transfer requires interaction (and cooperation) between users and producers of technology in one form or another (as argued by Lundvall 1988). Hence, the innovation cooperation covers much broader phenomena including some of the arms-length transactions on the technology market.

In our analysis we distinguish between cooperative agreements that involve the foreign parent and its Czech-owned subsidiary and those that involve the foreign-owned subsidiary and various partners outside of the firm’s global group. By contrast, Veugelers and Cassiman (2004) used measure of international technology transfer that does not allow for this distinction. In reality, technology transfer that includes the link between foreign parent and local subsidiary is highly related to the variable on foreign ownership, which can cause problems since foreign ownership is the key variable in the model. A large part of the international technology transfer can occur between the parent and subsidiary. The measure of global cooperation allows us to separate this kind of technology transfer and filter out the interaction between foreign ownership and cooperation with the foreign headquarters in our estimates.

To examine whether foreign-owned firms are more likely to cooperate in the local economy, we first explore which firm’s characteristics influence probability to engage in internal R&D activity and global cooperative agreements in equations (1) and (2). After controlling for these factors, we investigate the role of the foreign ownership on the local cooperation in equation (3).

Equation (1) captures the probability of carrying out internal R&D activity:

$$\text{(1)}\quad R\&Dinternal = a_m + b_m LN(size) + c_m LN(age) + d_m FOREIGN + e_m INDUSTRYdummies + f_m REGIONALdummies + e_{R\&Dinternal}$$

Explanatory variables include size (in logs), age (in logs), foreign ownership, the variable that captures obstacles to innovation and dummies that control for industry-specific technology opportunities (the OECD taxonomy). Large firms can enjoy economies of scale of various kinds. We expect that the probability of having in-house R&D activity (or at least one cooperative agreement) increase with the size of the firm. The size variable appears as a natural logarithm because we expect non-linearity to be involved in these relations. Since established firms are more likely to be engaged in R&D activity, we include the variable for age to capture maturity (life-cycle) of the firm. In the specific case of foreign affiliates, the age variable is also expected to at least partly control for a possible difference between recently established greenfield projects and (privatization) mergers and acquisitions. Again non-linearity is expected in the age variable, so it is used in logs. The variables for size and age are also included in the following specifications essentially for the same reasons as above.

Foreign ownership is essential to every equation. Here it captures strategy of multinational corporations with regards to internationalization of their R&D activities. Negative coefficient of the ownership variable would suggest that the foreign-owned firms are restricted to using technology developed by their parent multinationals abroad, while positive sign would suggest that foreign investment contribute to developing R&D capabilities in the host country. Recent empirical evidence suggests increasing trend in foreign direct investment in R&D activities (see Le Bas and Sierra 2002), but such investment tends to be concentrated mainly between countries with already highly developed technological capabilities (see Verspagen and Schoenmakers 2004). Since the Czech Republic is positioned at the middle of the technology ladder in a global comparison (see for example Chapter 3 of this thesis), our expectation of the impact of the foreign ownership on internal R&D activity is not clear-cut.

Equation (2) captures transfer of technology from abroad as a consequence of global cooperation:

(2) $COOPglobal = a_n + b_n LN(size) + c_n LN(age) + d_n FOREIGN + e_n INFOmarket + f_n INFOscience + g_n R\&Dinternal + h_n e_{R\&Dinternal} + i_n INDUSTRYdummies + i_n REGIONALdummies + e_{COOPglobal}$

Besides the size, foreign ownership and industry dummies, this equation includes the importance of external information sources for innovation, internal R&D activity and its residual from the previous equation as explanatory variables.2 As it is apparent from the descriptive overview, foreign ownership provides a key link to international cooperative agreements. Openness of a firm to external sources of technical knowledge is expected to serve as a catalyst of innovation cooperation. We also expect the internal R&D capability to be important in explaining the global cooperation activity. Following Cohen and Levinthal (1989 and 1990), internal R&D activity is not carried out solely to create new technology in-house but also to enhance capability of a firm to absorb technology from outside (and abroad). Internal R&D capability allows firms to scan external pools of knowledge and integrate it into its own R&D efforts. For example, internal R&D activity of foreign-owned firms can be directed towards adjustment of the parent's technology to the local factor endowments and customer's tastes, etc. (so-called asset exploiting versus asset augmenting foreign investment in R&D – see Patel and Vega 1999).

Equation (3) is central to our analysis as it is our direct measure of technology transfer through foreign ownership to the local economy in terms of cooperative arrangements with national firms and organizations:

(3) $COOPnational = a_p + b_pLP(size) + c_pLN(age) + d_pFOREIGN + e_pPROTECT + f_pCOOPglobal + g_pe_{COOPglobal} + h_pINDUSTRYdummies + g_pREGIONALdummies + \lambda_{INNOVheckman} + e_{COOPnational}$

Besides the size, foreign ownership and industry dummies, the explanatory variables include the appropriability conditions as well as global innovation cooperation and generalized residuals from the previous equation again. The focus here is on whether foreign-owned firms are more or less likely to transfer technology through innovation cooperation to the local economy, after correcting for the other determining factors (also from the previous equations through inclusion of the residuals). Foreign-owned firms that cooperate in the host economy provide an opportunity for the local firms to obtain technology from abroad. Since this opportunity implies that the foreign-owned firms have easier access to technology abroad, we also examine role of the global cooperation for explaining the probability that a firm will engage in local cooperative agreement. It will allow us to decide whether any effect of the

[2] Besides including independent variable of the preceding equations to the following ones, we also include the generalized residuals obtained from the preceding regression to correct for a possible common measurement error bias and other unmeasured commond determinants (see also Veugelers and Cassiman 2004). Such correlation could bias coefficient estimates in the equation (3), which is a key issue in the paper.

foreign ownership is due to easier access to international technological know-how for foreign-owned firms or rather due to the foreign ownership itself. Finally, protection of inventions through patenting can slow spillovers to the local economy, but it can also encourage firms to engage more actively in innovation cooperation.

The model was constructed so that each independent variable becomes a dependent variable in the subsequent equations. By the substituting, we can acquire a reduced form of the model as follows:

(4) $COOPnational = a_{mn} + b_{mn}LP(size) + c_{mn}LN(age) + c_{mn}FOREIGN + d_{mn}PROTECT + e_{mn}EXTinfo + f_{mn}OBSTACLES + g_{mn}INDUSTRYdummies + h_{mn}REGIONALdummies + + \lambda_{INNOVheckman} + e'_{COOPnational}$

The reduced form captures a total effect of foreign ownership on the local cooperation, while the previous equations can be used to disentangle direct and indirect effects of the foreign ownership as will be explained in a more detail in the following section.

## *5. The Results*

We estimate the probit model using the method of maximum likelihood. The regression coefficients estimate the influence of the independent variables on the probability that the firm engages in intramural R&D activity and cooperate globally or nationally. Since only the innovative firms give details on R&D activity and innovation cooperation in the innovation surveys estimation of the model can be influenced by a sample selection bias. We use a probit-specific Heckman's procedure to estimate the equations (3) and (4), which are central to the analysis. Similarly to Veugelers and Cassiman (2004) we correct for the possible selection bias only in the latter equations to keep the analysis tractable. The correction for sample selection on innovative firms can be identified by variables that are available for the total sample of firms, which answered the innovation survey. Besides the dummy for foreign ownership, therefore, we test whether the obstacles prevent firms from innovation and include the battery of industry dummies in the first equation. The Heckman's correction for innovation activity is well identified by these factors (see Appendix 3).

Table 2 summarizes the results. Foreign ownership is the main variable, which is significant in all estimates. Negative coefficient of the foreign ownership in both the equation (3) and the reduced form (4) suggests that foreign-owned firms are less likely to be a source of technology transfer through innovation cooperation to the local economy. On the other hand, there is strong evidence that cooperative arrangements with foreign partners are essential for technology transfer to the local economy regardless of the local or foreign ownership of the firms. This suggests that innovation cooperation with foreign partners may be a much more effective way to encourage international technological transfer than foreign direct investment.

It is confirmed that size of a firm matters for probability to engage in own R&D activity as well to cooperate for innovation at home and abroad. On the other hand the age of a firm does not seem to be very relevant in this context. The variable do not appear to be much significant in any of the estimates, though it came out close to be significant at 10% level in the equation for global cooperation. The industry dummies proved to be important for the internal R&D activity. The results suggest that firms from generally high-tech and medium-high-tech industries, such as machinery, transport equipment, electronics and chemicals, have significantly higher probability of conducting internal R&D activity. But the industry dummies do not matter for the innovation cooperation, whether national or global, with the only exception of firms in food and tobacco industry industries that are less likely to cooperate globally. A location in the capital of Prague seems to increase likelihood of firms to cooperate for innovation in the local environment. In fact, the dummy for Prague comes out with the highest magnitude of the coefficient in equations (3) and (4), which points to important agglomeration effects for likelihood to cooperate in the area. In contrast, a location of firms in other districts with technical university does not seem to matter.

The first regression shows that foreign-owned firms are significantly less likely to engage in their own R&D activity compared to local-owned firms. After correcting for impact of the other explanatory variables, our results suggest that having foreign-owners decreases probability to conduct in-house R&D activity by 33% in the Czech manufacturing. In other words, the reason why foreign-owned firms report only slightly lower R&D activity compared to their local-owned counterparts is largely due to their larger size, technological level of the industry and other factors.

**Table 2: Regressions results**

| *Dependent variables:* | (1)<br>R&D activity | (2)<br>Global cooperation | (3)<br>National cooperation | (4)<br>National cooperation (reduced) |
|---|---|---|---|---|
| Constant | -3.21 (3.75)*** | -4.63 (2.76)*** | -0.32 (0.32) | -1.07 (1.51) |
| Size (in logs) | 0.33 (7.22)*** | 0.29 (5.02)*** | 0.14 (3.04)*** | 0.16 (3.51)*** |
| Age (in logs) | 0.13 (1.35) | 0.21 (1.61) | -0.02 (0.26) | 0.06 (0.88) |
| Foreign-ownership | -0.33 (2.81)*** | 0.24 (1.82)* | -0.32 (2.94)*** | -0.16 (1.78)* |
| Information from market | .. | 0.11 (1.74)* | .. | 0.02 (0.48) |
| Information from science | .. | 0.09 (1.53) | .. | 0.22 (4.82)*** |
| Patent protection | .. | .. | 0.30 (2.51)** | 0.28 (2.75)*** |
| R&D activity | .. | 0.38 (2.84)*** | .. | .. |
| Residuals of eq. (1) | .. | 1.36 (0.38) | .. | .. |
| Global cooperation | .. | .. | 1.16 (6.72)*** | .. |
| Residuals of eq (2) | .. | .. | -1.42 (1.01) | .. |
| Food and tobacco (15, 16) | -0.29 (1.06) | -0.74 (1.95)* | -0.03 (0.11) | -0.32 (1.31) |
| Textiles, leather and footwear (17, 18, 19) | 0.31 (1.21) | 0.14 (0.37) | 0.17 (0.58) | 0.23 (1.02) |
| Wood, paper and printing (20, 21, 22) | -0.62 (1.99)** | -0.33 (0.82) | 0.33 (1.22) | 0.22 (0.90) |
| Chemical, rubber, plastics and fuel (23, 24 ,25) | 0.64 (2.56)** | -0.07 (0.19) | 0.19 (0.64) | 0.02 (0.08) |
| Non-metallic mineral products (26) | 0.11 (0.42) | -0.33 (0.89) | 0.04 (0.12) | -0.23 (0.92) |
| Basic and fabricated metal products (27, 28) | 0.15 (0.59) | -0.33 (0.89) | 0.19 (0.70) | 0.21 (0.93) |
| Machinery and equipment, n.e.c. (29) | 1.06 (4.17)*** | -0.36 (0.98) | 0.08 (0.25) | -0.12 (0.51) |
| Electronics (30, 31, 32, 33) | 0.53 (2.16)** | -0.17 (0.42) | -0.26 (0.91) | -0.30 (1.35) |
| Transport equipment (34, 35) | 0.58 (2.15)** | -0.02 (0.05) | 0.03 (0.11) | -0.11 (0.43) |
| Prague | 0.18 (0.97) | 0.25 (0.83) | 0.42 (2.39)** | 0.42 (2.92)*** |
| Other districts with technical university | 0.10 (0.77) | -0.04 (0.22) | 0.13 (1.15) | 0.07 (0.79) |
| Heckman's correction for innovative firms | .. | .. | -1.10 (3.61)*** | -1.35 (3.49)*** |
| Wald $\chi^2$ | 135.57 | 79.03 | 105.19 | 86.36 |
| Number of observations | 726 | 666 | 666 | 669 |

Note: Absolute value of robust z-statistics in brackets and ***,**, and * indicate significance at the 1, 5, and 10 percent level. Due to missing values for independent variables, the number of observations differs between the estimates.

The second equation confirms that own R&D activity improves absorptive capacity of a firm, which increases likelihood to engage in innovation cooperation abroad. Significant and positive coefficient for the ownership variable suggests that being part of the multinational company provides easier access to global cooperative agreements. This is also to be expected since foreign-owned firms can capitalize on global connections of their parent companies. The variable for importance of external information sources for innovation is included because it is presumed that firms will engage more frequently in innovation cooperation if they are more open to external environment. The coefficient comes out significant only for information from other firms, though the coefficient for information from scientific institutions is significant at 15% level. The results confirm that firms more opened to publicly available technological knowledge are more likely to engage in cooperative agreements.

The third equation shows that foreign-owned firms have much less interest to cooperate in the host economy in order to innovate compared to the their local-owned counterparts. Magnitude of the coefficient sends a clear message: all else equal, having foreign owners reduces the probability to have a local innovation partner by 32%. Furthermore, firms that cooperate globally are more likely to cooperate locally, which contrasts with the effect of foreign ownership. Finally, the appropriability conditions, measured by patenting track record of a firm, seem to matter for the cooperation with local partners.

Results of the reduced form of equation for national cooperation broadly confirm effects of the explanatory factors detected in the previous regressions.3 As suggested by Veugelers and Cassiman (2004), the reduced form provides a total effect of foreign ownership on local innovation cooperation, which can be decomposed into direct and indirect components by tracing the effects of foreign ownership through the other equations. The direct effect is obtained from the coefficient of the ownership variable in the third equation. The indirect effect is based on the fact that the foreing-owned firms are more likely to engage in global cooperation (the second equation), while at the same time having global partner for cooperation increases the probability to cooperate with a local partner (the third equation). We

[3] The main difference is in the external sources of information. It appears that opennes to information from scientific institutions matters for national cooperation, while importance given to information from other firms does not seem to matter. The results highlight the central role scientific institutions for facilitating local transfer of knowledge.

can also trace another indirect effect through the first equation as foreign-owned firms are less likely to engage in internal R&D activity. This affects the probability to involve – ceteris paribus - in innovation cooperation.

Table 3 provides overview of results for the ownership variable in terms of marginal probabilities of the explanatory variables. The total negative effect of foreign ownership on the probability of local innovation cooperation is a result of counterbalancing direct and indirect effects. In this case the variable for foreign ownership has opposite signs in the second and third equation. As a result, the direct effect is highly negative, while foreign-owned firms are more likely to cooperate globally implies a positive indirect effect. The indirect effect, however, is not strong enough to offset the direct effect, so that we observe the negative total effect of the foreign ownership. Moreover, we also observe negative indirect effect of foreign ownership through its impact on the likelihood of having internal R&D activity. Firms that engage in internal R&D activity proved to be more likely to have global partner for innovation cooperation. As foreign-owned firms are less likely to engage in internal R&D activity, it creates the other indirect effect on probability of innovation cooperation. Overall, foreign-owned firms - as compared to local-owned firms - are less likely to transfer technology through the innovation cooperation to the host economy. These results are robust across alternative specifications.

**Table 3: The direct and indirect effect of the foreign ownership on local cooperation**

| | | | |
|---|---|---|---|
| (a) | Marginal probability for the foreign ownership coefficient in eq (4) | -0.061* | (1.73) |
| (b) | Marginal probability for the foreign ownership coefficient in eq (3) | -0.124*** | (2.84) |
| (c) | Marginal probability for the global cooperation in eq (3) | 0.445*** | (5.57) |
| (d) | Marginal probability for the foreign ownership coefficient in eq (2) | 0.063* | (1.76) |
| (e) | Marginal probability for the R&D activity coefficient in eq (2) | 0.095*** | (2.87) |
| (f) | Marginal probability for the foreign ownership coefficient in eq (1) | -0.130*** | (2.87) |
| | Effects of the foreign ownership: | | |
| | Total effect = (a) | -0.061 | |
| | Direct effect = (b) | -0.124 | |
| | Indirect effect via eq (2) = (c) * (d) | 0.028 | |
| | Indirect effect via eq (1) = (e) * (f) | -0.012 | |

Note: Absolute value of robust z-statistics in brackets and ***,**, and * indicate significance at the 1, 5, and 10 percent level.

### *6. Concluding remarks*

Using firm level data from the firm Community Innovation Survey, the paper analysed differences in innovation activity and cooperation behaviour between foreign and domestic owned firms in the Czech Republic. A main conclusion from the study is that foreign-owned firms are more likely to cooperate globally but at the same time even less likely to cooperate locally. The results confirm that having easier access to global cooperation, foreign-owned firms tend to have lower incentives to cooperate in the host country, especially if the local environment does not provide attractive opportunities for innovation cooperation, which is generally the case of countries behind the technology frontier. On the other hand, our findings indicate that those locally-owned firms that cooperate globally are much more likely to have local cooperation partner. Our results broadly confirm the previous findings by Veugelers and Cassiman (2004) with the main exception that foreign-owned firms are even less likely than domestic-owned firms to engage in intramural R&D activities in the Czech manufacturing (see also Srholec 2005).

The main limitation of the study is that we can test only for occurrence of a cooperative agreement but not for the intensity or quality of the technology transfer involved. Further work should also analyze the impact of innovation cooperation on productivity growth. This requires integrating the innovation surveys data with economic results from the annual industrial surveys, which exists for the Czech Republic, but does not yet cover a reasonable period of time after the innovation survey. It may also be useful to analyze dynamic aspects of interplay between cooperative behaviour and other aspects of firm's innovation activity, something that may be possible in the near future as longitudinal data for innovation surveys in the Czech Republic become available

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## Appendix 1: Overview of the variables

### Firm specific variables:

| | |
|---|---|
| SIZE | Number of employees |
| AGE | Number of days since registration of the firm in the business register |
| FOREIGN | Binary variable with value 1 when the company is foreign-owned (more than 50% foreign ownership) |
| R&Dinternal | Binary variable with value 1 when the company has permanent intramural R&D activities |
| COOPnational | Binary variable with value 1 for innovative firms that have innovation cooperation with a non-affiliated partner in the Czech Republic (without other companies in the group) |
| COOPglobal | Binary variable with value 1 for innovative firms that have innovation cooperation with a non-affiliated partner abroad (without other companies in the group) |
| PROTECT | Binary variable with value 1 for companies that had valid patent or applied for a patent |
| OBSTACLES | Factors score on the following obstacles to innovation: excessive perceived risks; innovation costs too high; lack of appropriate sources of finance; insufficient flexibility of regulations and finally lack of customer's responsiveness to innovated products. The factor analysis estimate came out with a single principal factor with eigenvalue higher than one (see Appendix 2). The obstacles were on a scale from 0 (unimportant) to 1 (highly important). |
| INFOmarket and INFOscience | Factor scores on the following external sources of information: suppliers of equipment, materials, components or software; clients or customers; competitors and other enterprises from the same industry; universities or other higher education institutes and government or private non-profit research institutes (see Appendix 2 for identification of the variables). The variables were on a scale from 0 (unimportant) to 1 (highly important). |

### Industry dummies (NACE, rev. 3 codes):

| | *NACE, rev. 3 codes* |
|---|---|
| Food and tobacco | 15, 16 |
| Textiles, leather and footwear | 17, 18, 19 |
| Wood, paper and printing | 20, 21, 22 |
| Chemical, rubber, plastics and fuel | 23, 24 ,25 |
| Non-metallic mineral products | 26 |
| Basic and fabricated metal products | 27, 28 |
| Machinery and equipment, n.e.c. | 29 |
| Electronics | 30, 31, 32, 33 |
| Transport equipment | 34, 35 |

### Regional dummies

| | |
|---|---|
| Prague | The capital city (app. 10% of total population) |
| Other districts with technical university | NUTS4 with a technical university (except Prague) as follows: Brno, Ostrava, Plzen, Olomouc, Liberec, Hradec Kralove, Usti nad Labem, Ceske Budejovice, Pardubice, Zlin, Opava (besides the capital of Prague, there are 40 other districts in the Czech Republic) . |

## Appendix 2: Factor analysis on obstacles and information sources

*Results of the factor analysis on the obstacles to innovation (principal-component factors)*

| | Factor loadings |
|---|---|
| Excessive perceived economic risks | 0.82 |
| Innovation costs too high | 0.85 |
| Lack of appropriate sources of finance | 0.71 |
| Insufficient flexibility of regulations or standards | 0.71 |
| Lack of customer responsiveness to innovation | 0.69 |
| Eigenvalue | 2.87 |
| Proportion of the first factor in the sum across all eigenvalues | 0.58 |
| Number of observations | 1,594 |

Note: Only a single principal factor with eigenvalues higher than one was detected by the estimate.

*Results of the factor analysis on the sources of information (principal-component factors; orthogonal varimax rotation)*

| | Factor loadings | |
|---|---|---|
| | INFOmarket | INFOscience |
| Suppliers of equipment, materials, components or software | 0.52 | 0.31 |
| Clients or customers | 0.86 | 0.04 |
| Competitors and other enterprises from the same industry | 0.80 | 0.24 |
| Universities or other higher education institutes | 0.19 | 0.85 |
| Government or private non-profit research institutes | 0.07 | 0.88 |
| Eigenvalue | 1.68 | 1.66 |
| Proportion of the retained factors in the sum across all eigenvalues | 0.34 | 0.33 |
| Number of observations | 726 | |

Note: Only two principal factors with eigenvalue higher than one were detected by the estimate.

**Appendix 3: The first-step probit estimates for Heckman corrections**

| Dependent variable: | *Successful innovation* | |
|---|---|---|
| Estimate: | (3)<br>National cooperation | (4)<br>National cooperation (reduced) |
| Constant | -0.42 (3.22)*** | -0.42 (3.22)*** |
| Foreign ownership | 0.04 (0.55) | 0.04 (0.55) |
| Factor score on ext. obstacles | 0.19 (5.55)*** | 0.19 (5.51)*** |
| *Industry dummies (NACE, rev. 3 codes):* | | |
| Food and tobacco | 0.47 (2.62)*** | 0.48 (2.68)*** |
| Textiles, leather and footwear | -0.09 (0.59) | -0.09 (0.58) |
| Wood, paper and printing | -0.24 (1.42) | -0.24 (1.42) |
| Chemical, rubber, plastics and fuel | 0.47 (2.80)*** | 0.48 (2.86)*** |
| Non-metallic mineral products | 0.84 (4.51)*** | 0.84 (4.51)*** |
| Basic and fabricated metal products | -0.04 (0.28) | -0.03 (0.23) |
| Machinery and equipment, n.e.c. | 0.67 (3.93)*** | 0.67 (3.93)*** |
| Electronics | 0.51(3.17)*** | 0.51 (3.17)*** |
| Transport equipment | 0.63 (3.51)*** | 0.63 (3.51)*** |
| Wald $\chi^2$ | 145.32 | 144.98 |
| Number of observations | 1,505 | 1,508 |

Note: Absolute value of robust z-statistics in brackets; *, **, *** denote significance at the 10, 5 and 1 percent levels. The number of observations differs because three firms answered the question on cooperative behaviour but didn't provide information on R&D activity.