Innovation Cooperation and Innovation activity: The impact on the case of Slovenian Enterprises

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Abstract

Innovation cooperation has been recognised as an important determinant of enterprises' innovation activity, productivity, and growth, and has recently become the subject of intensive research. We explore the importance of innovation cooperation for the innovation activity of Slovenian enterprises, and identify what kind of innovation cooperation is the most "productive" for innovation activities. Probit estimations confirmed external innovation cooperation as one of the most important incentives for innovation activity, next to R&D spending. Significant influence is confirmed for domestic and for international innovation cooperation, though domestic cooperation recently more likely brings results. The efficiency varies also by type of partners; while inter-firm innovation cooperation significantly increases the probability of innovation, this was not found regarding cooperation with universities and R&D institutes. Innovation cooperation strategy The strategy of innovation cooperation should thus not exclude internationalization, and involve not only related enterprises, but also buyers and suppliers, from both domestic and international markets. All other types of innovation partners, especially public institutions need careful management..

Key words: innovation cooperation, innovation activity, foreign direct investment, innovation partner, R&D, Slovenia.

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1 INTRODUCTION

Innovation cooperation has become an increasingly prominent feature of firms' innovation activity and growth. Once more a provisional or transitional step, recent studies suggest that innovation cooperation is now a core component of corporate strategy (Powell and Grodal, 2005: 57). The increasing internationalization of innovation activity, growing innovation networks, co-creation and open innovation has recently made it the subject of intensive research. Literature documenting the increasing relevance, diversity, and benefits of innovation cooperation for the innovation activity of firms is ample and leaves no room for doubt (Veugelers, 1997; Veugelers and Cassiman, 1999; Hagedoorn, 2001; Hagedoorn and Duysters, 2002; Narula, 2003; Powell and Grodal, 2005; Commission of the European Communities, 2005, Bughin, Chui and Johnson, 2008 etc.). Still, most of companies conduct innovation inside the organization and focused on closely managed internal sources.

In terms of organisational modes, innovation cooperation varies from intra-firm, wholly-owned subsidiaries with full internalisation of transaction, across various types of equity and non-equity agreements, to spot market transactions, where independent firms engage in arms-length transactions (Narula, 2003: 135-137). One may also add informal non-contractual innovation cooperation, such as common membership in a professional or trade association, participation in ad hoc industry committees, or executive education programs, conferences, personal mobility, common educational backgrounds, etc. (Powell and Grodal, 2005: 60, 70). The distinction of organisational modes of innovation cooperation is important, since they have a different impact on participating firms' innovation activity. For instance, weak ties serve more as bridges to novel information where there is a rapid exchange, while strong ties are useful for social control and the exchange of tacit knowledge (Powell and Grodal, 2005: 69).

Innovation behaviour of enterprises recognised as global market leaders in their niche (such as Google, Apple, IBM, LEGO) suggest that successful innovation companies pursue a multitude of strategies for innovation activity, yet innovation cooperation outside firms is identified as one of the most efficient mechanisms/tools. Cooperation with related enterprises and internalization of innovation activity as “traditional” practice in innovation has proved insufficient for maintaining the market leader position. Extension to external sources (innovation cooperation with non related partners outside the company) is expected to foster innovation activity by increasing both the volume and merchandising of ideas. Growing internationalization and extension from national to international partners is as well expected to foster innovation.

The aim of the paper is to estimate the relevance of innovation cooperation of Slovenian enterprises[4], and some of its specific aspects, as a determinant of their innovation activity. The difference between intra-firm and inter-firm innovation cooperation, national and international innovation cooperation, profit and non-profit organizations cooperation is studied as well as the impact of geographical proximity of innovation partner. Firstly, we explore innovation cooperation by descriptive statistics and look at the extend of innovation cooperation in general, observe the use of external and international partners involved in international cooperation and discover what kind of partners are most frequently included in innovation cooperation. Secondly, we estimate the efficiency of innovation cooperation (in general and by particular types of cooperation). We look at the determinants of a firm's innovation activity, such as own R&D, size, technological characteristics of industry, internationalization of firms (through export orientation, foreign ownership, and direct investment abroad) and pay special attention to the role of innovation cooperation. The relevance of selected determinants and the change in the probability to innovate due to innovation cooperation is estimated by probit models. The motivation for the exercise is that research on the relationship between innovation cooperation and innovation activity is a relatively recent area of inquiry, with limited direct empirical evidence (Powell and Grodal, 2005: 58). Though identified as important, the efficiency of practices for fostering innovation activity is rarely measured.

The article is structured into five sections. Introduction is followed discussion about the reasons and determinants of innovation activity and innovation cooperation. Section four highlights the estimated impact of innovation cooperation on innovation activity by type partners and section five concludes.

2 THE REASONS FOR PROLIFERATION OF INNOVATION COOPERATION

Although R&D continues to be highly centralised and internalised, and tends to remain at home (Narula, 2003; Cantwell and Molero, 2003), innovation cooperation has proliferated in the last 25 years. R&D partnerships were relatively rare until the end of the 1970s, when there was a first sudden increase in annually formed partnerships from less than 50 to about 100. By the end of the 1980s the number had increased to about 500. In the 1990s there were no further increases in the number of annually formed R&D partnerships (MERIT-CATI database; see Hagedoorn, 2001). The increase in R&D partnerships has been accompanied by changes in their organisational forms. There was a strong increase in the structural share of non-equity R&D partnerships from about 20% at the beginning of 1970s to more than 90% in 1998 (Hagedoorn, 2001; Narula 2003)[5]. In spite of the booming literature on the internationalisation of R&D (see, for instance, Cantwell and Molero, 2003; Narula, 2003; UNCTAD, 2005, etc.), and the increasing number and intensity of

[4] The fourth Community Innovation Survey (CIS 4) identified Slovenia, beside Finland and Lithuania, as a country with the highest level of innovation cooperation.

[5] The choice of organisational form is determined by the technological characteristics of an industry; equity agreements are preferred in relatively mature industries while non-equity ones are more common in high-tech industries (Hagedoorn and Narula 1996).

international innovation cooperations, the share of international partnerships in newly established R&D partnerships in the 1970s and 1980s oscillated between 60% and 80%, decreasing to about 50% by the end of 1990s (Hagedoorn 2001). The Community Innovation Survey (CIS) shows the dominance of national and, to a lesser extent, EU partners in innovation cooperation[6] (Commission of the European Communities, 2005, 2007). This reflects the importance of close geographic proximity for selecting partners for innovation cooperation. The data also reveal sector and country differences in the extent of international innovation cooperation. Medium-tech industries and small countries tend to engage in more international alliances than high- and low-tech sectors and large countries (Hagedoorn, 2001; Narula, 2003, Commission of the European Communities, 2005, 2007). Fourth Community Innovation Survey highlight that the highest levels of innovation cooperation were found small European countries that do not have the highest, but medium levels in innovation activity in general.

What are the reasons for the proliferation of inter-firm innovation cooperation and what are the underlying theoretical explanations for the process? Growing innovation cooperation has been closely related to the process of globalisation, the convergence of consumer preferences, the pace and scope of technological change, the increasing similarity of technologies across countries and the cross-fertilisation of technology between sectors, leading to increasing costs and risks associated with innovation (Narula, 2003; Veugelers, 1997). There are cost-economising (lowering and/or sharing the costs of R&D activities) and strategic reasons (increasing flexibility and lowering risk, seeking complementary assets) for the proliferation of innovation cooperation, including the reduction of transaction costs (new space-shrinking technologies, harmonisation of regulations, liberalisation) and some game-theoretic considerations (follow-my-leader strategy, to increase trust in partners) (Hagedoorn, 2001; Narula, 2003). Based on a broad survey of the literature, Hagedoorn (2001: 4) lists the following specific motives for R&D and innovation partnering: the need to monitor and engage in the cross-fertilisation of technological disciplines, the search for technological synergies, achieving economies of scale and scope in R&D, the need to incorporate complementary technologies, jointly coping with R&D uncertainty, sharing the costs of R&D projects, capturing a partner's tacit knowledge, and shortening the innovation cycle.

The underlying theories explaining innovation cooperation are, on the one hand, the transaction costs/internalisation perspective (cost minimisation strategy) and, on the other hand, the organisational capability and technology-based view of the firm (enhancing the value of the firm). Based on recent theoretical studies, Narula (2003) proposes that the innovation cooperation phenomenon is best explained by an organisational-learning framework. The key issue has to do with the explanatory mechanisms related to the firm's choices between internal R&D activities and external sources of R&D, innovation, and technology (Veugelers, 1997; Veugelers and Cassiman, 1999; Sanna-Randaccio and Veugelers, 2003; Petit and Sanna-Randaccio, 2000). Namely, innovation cooperation is nothing other than but one of the external sources of technology, the

[6] In the 1998-2000 Survey (CIS III) in the manufacturing sector national partners were involved in 82% of innovation cooperations, EU partners in 41%, US partners in 12% and Japanese partners in 6%.

others being the acquisition of new personnel or equipment, the licensing of external technology, the outsourcing of R&D to other firms or research institutions, cooperative agreements between firms or other research institutions, and absorbing freely available information (spillovers) (Veugelers and Cassiman, 1999: 65-68). The existing literature on internal, in-house R&D vs. external R&D sourcing has been concentrated on the choice between the two, 'make' or 'buy', options while it is, in fact, the complementarity of the two, and not substitution between the two, which is more in line with the actual situation (Veugelers, 1997; Veugelers and Cassiman, 1999). This points to the issues of the optimal integration of external knowledge and the adequate absorption capacity of firms using external R&D sourcing. Own R&D activities are needed to efficiently use the external sources of knowledge (Veugelers and Cassiman, 1999; Mowery and Rosenberg, 1989; Cohen and Levinthal, 1990). Moreover, external linkages facilitate innovation, and at the same time, innovative outputs attract further collaborative ties (Powell and Grodal, 2005: 67-68).

3 DETERMINANTS OF INNOVATION ACTIVITY AND INNOVATION COOPERATION

Among standard explanatory factors of a firm's innovation activity own R&D is the crucial determinant of a firm's innovation activity/capacity and of its capacity to absorb external knowledge (Cohen and Levinthal, 1989). Own R&D directly expands a firm's technology level by new innovations and increases a firm's ability to identify, assimilate, and exploit outside knowledge. The theoretical foundations for the above are supplied by the literature on endogenous innovation and growth (see, for instance, Aghion and Howitt, 1992; 1998; Grossman and Helpman, 1991; Romer, 1990). Other standard explanatory variables of a firm's innovation activity identified by the existing literature include a firm's size, diversification, internationalisation and market position (export intensity, foreign direct investment and direct investment abroad), industry characteristics, ownership structure, public subsidies, and external knowledge acquisition in its various forms[7].

Veugelers and Cassiman (1999: 65-66) provide an overview of studies on the subject. As far as size is concerned, the results suggest that the relationship between innovativeness and size is positive, but not necessarily linear, and it depends on industry characteristics. Industry characteristics are another determinant of a firm's innovation activity in the sense that high-tech industries exhibit higher innovation activity. The industry variable captures several dimensions, i.e. the scope for future demand, opportunities for technological innovations, and the cumulativeness of knowledge, indicating to what extent current innovation further build on previous R&D. The model of Veugelers and Cassiman (1999: 70-75) confirms the predictions of

[7] Various authors include other variables as well. For instance, Veugelers and Cassiman (1999) include approbriability conditions and obstacles to innovation. They claim that the absence of a need to innovate is an important determinant of the non-innovative character of firms. On the other hand, high perceived risks and costs of innovation and low appropriability of results do not necessarily discourage innovation, but rather determine how innovation is organized.

the literature; large and more export oriented firms in high tech industries are more likely to innovate.

The fact that a firm is an MNE (multinational enterprise) or a non-MNE obviously has an impact on its innovation strategy. In view of the increasing importance of global sourcing for innovation, multinationality may be expected to have a positive impact on a parent company's innovation activity. Parent MNEs more often tend to integrate their subsidiaries in their innovation strategies and a major challenge for an MNE is to find an organisational system that is capable of transferring know-how across units and locations, allowing locally generated know-how to be used throughout the multinational organisation (Sanna-Randaccio and Veugelers, 2003: 17-18).

The mirror picture of the above is whether a firm is a foreign subsidiary or not. There is ample literature on the positive impact of technology transfer from parent companies to local subsidiaries on the latter's productivity growth (see for example, Haddad and Harrison, 1993; Blomström and Sjöholm, 1999; Aitken and Harrison, 1999; Girma et al., 2001; Barry et al., 2002; Damijan et al., 2003, etc.), but there are not many studies which directly analyse the impact of foreign ownership on a subsidiary's innovation activity. Cantwell and Molero (2003: 5-7) claim that there is little evidence of any great difference in the innovation behaviour of foreign-owned compared to domestically-owned firms. The difference between the two groups is more a result of structural differences, such as a larger average size of foreign subsidiaries and their higher participation in high-tech sectors (Molero and Heys, 2002). Still, as claimed above, the innovation strategies of MNEs are changing, as is the impact of their innovation activities on host countries. More innovation-active foreign subsidiaries will tend to source more know-how from local sources and, at the same time, will become more interesting vehicles for technology diffusion into the local economy. But this may lead to a situation where valuable know-how leaves the country, while the subsidiary R&D remains too dependent on the assimilation of know-how developed elsewhere in the parent company (Sanna-Randaccio and Veugelers, 2003: 17-18).

Empirical research on the impact of innovation cooperation on a firm's innovation activity is relatively scarce, but the existing evidence clearly finds a strong positive relationship between innovation networking and innovation output[8]. It is, however, not only true that innovation cooperation stimulates a firm's internal R&D and innovation activity, but also vice versa, a firm's internal R&D and innovation activity stimulates its engagement in innovation cooperation (Powell and Grodal, 2005; Veugelers, 1997; Veugelers and Cassiman, 1999). This also points to the importance of absorptive capacity. R&D cooperation has a significant positive effect on own R&D only if the companies have sufficient absorptive capacity (Veugelers, 1997).

[8] See Powell and Grodal (2005: 65-68) for an extensive overview of the studies claiming that innovation networking has a positive impact on a firm's innovation activity. See also Darby et al. (2003) for the positive impact of innovation cooperation on patenting by US firms, Kremp and Mairesse (2004) for the positive impact of French firms' alliances for knowledge acquisition on their innovation intensity, and Adams and Mircea (2004) for the positive impact of research joint ventures on increasing innovation.

The impact of innovation cooperation on a firm's innovation activity is related to both the pattern of collaborative relationships and the type of partners (Vinding, 2002). As far as the former is concerned, the literature distinguishes between formal and informal, strong and weak, and direct and indirect innovation cooperation. The empirical evidence suggests that formal, strong, direct ties have a stronger impact on firms' innovation activity than informal, weak, and indirect ties (Powell and Grodal, 2005: 68-69; Godoe, 2000; Ahuja, 2000). However, informal ties also have another effect, i.e. they exhibit a positive influence on the facilitating of formal ties (see Powell and Grodal, 2005, for an overview of the relevant literature).

The concept of informal innovation cooperation is very near to the concept of knowledge spillover. Here one should distinguish between the effect of knowledge spillovers on a firm's innovation output and on a firm's own R&D. Knowledge spillovers are a consequence of the public-good nature of R&D output, which prevents firms from fully internalising the benefits of own R&D, but at the same time enables other firms to appropriate some of these benefits (see, for instance, Arrow, 1962; Nelson, 1959). Knowledge spillovers, therefore, have a positive impact on the recipient firm's innovation activity. The situation is not equally clear as far as the impact of knowledge spillovers on a firm's own R&D is concerned. The literature on knowledge spillovers states that external R&D typically substitutes for own R&D in the recipient firm and reduces own R&D by the sending firm, which cannot fully internalise all benefits from its investment. Veugelers (1997), however, list a number of situations in which spillovers enhance a firm's own R&D[9].

Not only the type of partnership but also the type of partner impact innovation cooperation and innovation activity. Partners may differ by position in value chainand/or geographical proximity/location. Cantwell and Molero (2003) relate the intensity of the innovation cooperation of foreign subsidiaries with host economy firms to the type of subsidiary. Competence-creating subsidiaries tend to be more integrated into local innovation networks than competence-exploiting subsidiaries. This is because the ability of the competence-creating subsidiaries to fulfil their role depends on their embeddedness in local networks with other firms and other institutions. According to Vinding (2002), domestic partners in networks have a greater positive impact on innovative performance than foreign partners. This is in line with the idea that the extent of interaction between the technological activities of firms tends to rise as geographical distance falls (Cantwell and Molero 2003). Other partner-specific characteristics of innovation cooperation, as documented in the literature, include that a diversity of network ties has a positive influence on firms' innovation activity, that firms with a central location within networks generate more innovative output (Powell et al., 1999), and that alliances with direct competitors have a negative effect on innovation (Baum et al., 2000).

[9] A market enhancement or cost reducing effect should stimulate own R&D, firms may respond to spillovers by cooperating on R&D, thereby internalising technology flows; the need to increase the absorption capacity for spillovers may also increase own R&D efforts.

The determinants of innovation cooperation are of a firm- , industry- and also **country specific** character. According to Narula (2003: 148), the propensity of firms to engage in innovation cooperation varies according to the characteristics of the country. This is because small and technologically less advanced countries tend to be focused in fewer sectors than large countries. Crowley (2004: 5) shows that innovation-active firms from new member states more frequently engage in innovation cooperation than those from the EU-15. The smaller average country size of new member states could be one of the explanatory factors. Fourth Community Innovation Survey highlight that the highest levels of innovation cooperation were found by small European countries that do not have the highest, but medium levels in innovation activity in general Commission of the European Communities, 2005, 2007). Country specific factors of innovation cooperation are yet to explore, but the weight of external factors of firms' innovation activity was tested. Sternberg and Ardt (2001, pp. 367) confirmed the impact of country characteristics such as size, national innovation systems and policies, but found internal firm-level determinants of innovation activity as more relevant as external environment.

Differences the intensity of innovation cooperation is also identified by **industries**. For Narula (2003), differences in technology partnering are an industry-specific phenomenon. Innovation cooperation is more intensive in technologically more intensive industries with rapid technological progress (Powell and Grodal, 2005; Kremp and Mairesse, 2004). Earlier empirical studies also share the common view that internal R&D intensity and technological sophistication are positively correlated with both the number and intensity of innovation cooperation (Veugelers, 1997; Veugelers and Cassiman, 1999; Freeman, 1991; Hagedoorn, 1995).

The relevant literature suggests a number of **firm-specific characteristics** which co-determine the intensity of a firm's innovation cooperation, the most important being firm **size** and **R&D intensity**. Crowley (2004: 4) shows that the frequency of innovation cooperation increases with company size. Large firms are more frequently engaged in innovation cooperation than medium-sized firms, and medium-sized firms more frequently than small firms.[10] This is in line with the findings of Narula (2003), Veugelers and Cassiman (1999), and Kremp and Mairesse (2004). On the other hand, Sarkar et al. (2001) claim that younger and smaller firms derive more value from network linkages than larger firms, presumably because smaller companies view the technological landscape as more uncertain.

Firm's **own R&D activity** is crucial to enter into innovation cooperation and to benefit from that cooperation. That is why own R&D activity is positively correlated with the intensity of networking (Freeman, 1991; Hagedoorn, 1995; Veugelers, 1997; Veugelers and Cassiman, 1999;

[10] An interesting finding coming out of the Community Innovation Survey is that innovation-active firms from the new member states are on average much keener to enter into innovation cooperation than firms from the EU-15. The difference is especially high in small- and medium-sized firms (Crowley, 2004: 4).

Kremp and Mairesse, 2004; Powell and Grodal, 2005). Own R&D positively affects a firm's ability to exploit the opportunities arising from innovation cooperation (Cohen and Levinthal, 1990; Powel et al., 1996; Veugelers and Cassiman, 1999)[11]. This supports the absorption capacity view of in-house research (Veugelers and Cassiman, 1999). As stated by Powell et al. (1996), the rate of the acquisition of skills and resources externally is closely linked to the generation of expertise internally.

Other determinants of innovation cooperation includes appropriate conditions, a firm's internal organisation and management methods, the use of the Internet and ICT (information-communication technology) for acquiring and sharing information. The decision to acquire technology externally is negatively affected by the effectiveness of different mechanisms for the protection of technology. Internal organizational resistance to externally induced change is another factor, which may lead to less external technology sourcing (Veugelers and Cassiman, 1999). Apart from that, managing acquisitions of external knowledge is a far from simple task and suitable organizational structures and incentive schemes need to be devised in order to stimulate external learning (Veugelers, 1997). Firms which use a variety of knowledge management practices are keener on entering into innovation cooperation (Kremp and Mairesse, 2004). The frequency of innovation cooperation also increases with the use of the Internet and ICT for acquiring and sharing information (Kremp and Mairesse, 2004).

4 THE RELEVANCE OF INNOVATION COOPERATION IN INNOVATION ACTIVITY

The aims of this section are to evaluate the scope, relevance and efficiency of innovation cooperation and examine whether the type and location of partner involved in innovation cooperation matters. The focus of the research is the enterprise level effect of various types of innovation cooperation on innovation activity.[12] Is the impact of intra-firm cooperation more important than external innovation cooperation? Is domestic innovation cooperation as productive as cooperation with international partners? What is the difference between public and private partners involved in innovation cooperation? What kinds of partners are most frequently included in innovation cooperation and which are the most efficient in innovation activity?

[11] Kremp and Mairesse (2004), Ahuja (2000), Stuart (2000), and Powell and Grodal (2005) also mention a firm's level of innovativity and patenting intensity as being positively correlated with innovation cooperation. According to Powell and Grodal (2005), firms with many prior patents are more likely to form alliances than firms lacking patents. This suggests a recursive process of innovation and growth in which innovation cooperation plays a central role.

[12] Other possible directions for future research include the impact of various policy measures on innovation activity and cooperation. In Slovenia, most of these measures (clusters, technological networks and platforms, centres of excellence) are in particular directed towards stimulating innovation cooperation. It would be interesting to see whether all these measures have had any impact on strengthening innovation cooperation among firms.

The data set used combines three different firm-level data sources: Community Innovation Surveys conducted by Slovenian Statistical Office from 1996 to 2004 financial statements collected by Agency of the Republic of Slovenia for Public Legal Records and Related Services (AJPES) and information on FDI status (parent company or foreign affiliate) provided by Bank of Slovenia. With one of the highest average level of innovation cooperation among EU countries and below EU average level in innovation activity in general the case of Slovenia is particularly appropriate for examination. With 27% share of enterprises with innovation activity Slovenia lags much behind EU27 average (42%) innovation activity. According to latest survey only Slovakia, Malta, Hungary, Romania and Bulgaria have lower share of innovative enterprises. Among innovative enterprises there is 47% of firms involved in innovation cooperation, while only 26% of European (EU"/) innovative enterprises use innovation cooperation (Table 1).

Table 1: Innovation activity and innovation cooperation of Slovenian firms

			% of all inovative enterpises					
				Co-operation partners				
	YEAR	Enterprises with innovation activity (%)	all types of innovation cooperation	supplie rs	customers/ clients	Compe- titors	Univer- sities	government or public institutes
Slove- nija	2000	22	74	29	34	9	20	15
	2002	21	46	21	40	25	5	5
	2004	27	47	38	33	20	19	13
EU27	2004	42	26	17	14	10	9	6

Source: Statistical Office of the Republic of Slovenia. Eurostat.

Data on innovation cooperation are available from four CIS surveys from 1996, 2000, 2002 and 2004.[13] Formal modes of innovation cooperation include (i) internal innovation cooperation (within the group, intra-firm innovation cooperation) and (ii) external innovation cooperation, which can be further divided into cooperation with firms (inter-firm: customers, suppliers, competitors, consultants, commercial labs and R&D institutes) and with public research institutes (including universities, and public or private non-profit R&D institutes). Cooperation partners are further examined by geographical location partners and differentiation between domestic, European, USA and other partners is possible (table 2). Innovation cooperation with domestic partners is more frequent than international cooperation and the extent of international cooperation falls with the distance. The share of enterprises involved in innovation cooperation, either

[13] In the 1998 sutvey the question on innovation cooperation was left out in Slovenia.

domestic or international, is larger among manufacturing than services enterprises (regardless of enterprise size). The share of enterprises in innovation cooperation also falls with size; large enterprises more likely cooperate in innovation than small and medium size enterprises.

Table 2: innovation cooperation partners by location 2002-2004

	% in innovation cooperation	location of innovation partner		
		Slovenia	other Europe	USA and rest of the world
Total	47.2	43	33	10
small	38.3	36	23	4
medium	52.2	46	38	10
large	65.6	61	53	25
Manufacturing	52.1	47	38	10
small	44.3	41	27	2
medium	53.1	48	42	10
large	66.2	63	58	28
Services	34.6	34	20	10
small	27.7	28	18	9
medium	44.7	45	19	10
large	57.7	54	39	15

Source: Statistical Office of the Republic of Slovenia.

Previous empirical research of firms' innovation activity on the sample of Slovenian enterprises confirmed the importance of a number of standard explanatory determinants (Damijan et al., 2006). It was demonstrated that the innovation activity of enterprises is persistent over time (firms that were innovative two years ago were also more likely to be innovative in the studies period), and that innovative firms are likely to be larger in terms of employment and to invest much more in R&D. At the same time, innovative firms are also more inclined to export and are more likely foreign-owned. Jaklič (2006) confirmed innovation activity as one of the key firm specific assets for creation of multinational enterprises as one of the most important determinant of direct investment abroad, but the opposite impact has not been examined. This study expands the number of determinants of innovation activity to examine the role of both inward and outward foreign investment and pay special attention to innovation cooperation, and its varieties.

To reveal the importance of individual factors on firms' innovation activity, we estimate the probability $INOV_{it}$ [0, 1] that a firm *i* in period *t* will innovate:

$$\Pr(INOV_{it} = 1 | \mathbf{M}_{it}) = G(\omega \mathbf{M}_{it}),$$

where $\mathbf{M}_{it}$ is a matrix of the operational characteristics of firms. We assume that errors are IID distributed and have an independent extreme-value distribution. The dependent variable $INOV_{it}$ is equal to 1 if a firm has made any innovation of products (services) or production processes in period t, and 0 otherwise. The variables contained in $\mathbf{M}_{it}$ include explanatory firms' characteristics discussed in previous chapter and some control variables, that is:

- firm size (number of employees),
- capital intensity (capital per employee),
- skill intensity (wages per employee)
- relative productivity (the firm's value added per employee relative to the average productivity of the particular sector (three digit level), "rval"),
- technological intensity (on the industry level)
- the share of R&D expenditures in total sales (R&D intensity),
- the size of R&D department (R&D staff),
- a dummy for past innovation activity (lagged one period, that is, two years, innovative t-2),
- export propensity (export revenues in total revenues),
- a dummy for foreign ownership (foreign affiliate, inward foreign direct investment, IFDI),
- dummy for direct investment abroad (parent enterprise, outward foreign direct investment, OFDI)
- as well as variables for the importance of external innovation cooperation, that is further differentiated:
- between internal (intra-firm) and external cooperation
- between domestic and international,
- according to the type of partner or geographical distance of the partner.

Foreign direct investment (FDI), as an indicator of internationalization level can also be considered a proxy for international intra-firm innovation cooperation. The model also takes into account the technological intensity of the sectors in which the firm operates. OECD classification (NACE Rev. 1.1.) of technology and knowledge intensive sector is used (high technology, medium high, medium-low, and low technology for manufacturing and knowledge intensive and less knowledge intensive for services[14]). The hypothesis is that enterprises operating in

[14] Two digit NACE is ussed for aggregation.

technologically more sophisticated sectors will have a higher probability of innovation in order to remain competitive or to increase their technological competitive advantage over competitors. Due to a short and non-balanced panel, we used a pooled sample and did not include the time dummies. Probit models that reveal the significance of particular determinant are followed by estimations of the efficiency of particular determinant, measured by dprobit models. dF/dx measures discrete change of dummy variable from 0 to 1 at average value of x.

Results of six separate probit estimations based on bi-annual data for manufacturing and non-manufacturing enterprises in Slovenia in the period 1996-2004 are given in Table 3. The average effect of innovation cooperation is estimated in Table 4. Probit models confirm that innovation cooperation as one of the most important and significant incentive for innovation activity. The other statistically significant determinants were R&D intensity, R&D staff, innovation activity in the past, and direct investment abroad (outward FDI).. Foreign ownership (inward FDI), along with firm size, skill intensity, export intensity, labour productivity, and capital intensity, is not confirmed as a significant predictor of innovation activity. Industrial technological intensity has also not proved as significant determinant of innovation activity.

Being within a group of multinational enterprise (MNE) per se does not predict innovation activity. Parent firms and foreign affiliates differ in innovation capacity. While the direct investment abroad significantly increase probability to innovate, the lack of a significant impact of foreign ownership point to the low importance of intra-firm innovation cooperation for the innovation activity of foreign affiliates or suggest the type of foreign subsidiaries, which are rarely competence centres or innovation units, as also confirmed by other studies on foreign subsidiaries in Slovenia (Majcen et al., 2005). These findings indicate that innovation base and innovation strategy is still prevailingly related to parent enterprise and internationalization of innovation activity through FDI is unbalanced. Being a foreign affiliate does not directly influence innovation activity, though international relations with customers and suppliers are more likely. Direct investments abroad on the other hand directly enhance innovation activity. As highlighted in case studies and interviews with innovative enterprises proximity to customers and competitors that often evolve into cooperation is the most efficient stimulation for innovation.

Yet the location and type of innovation cooperation partner matter. Not all innovation partnerships bring significant results to innovation activity and even if the impact is significant the estimated magnitude of effect of innovation cooperation on innovation activity varies a lot between different types of innovation cooperation. Company involved in innovation cooperation in general has only 3% higher probability to innovate (Table 4). This indicates hurdles in innovation cooperation. Problems accompanying innovation cooperation such as governance and leadership of partners, motivation and coordination of activities, protection of intellectual property and cost sharing may prevail over the benefits in volume and speed of merchandising the ideas.

Table 3: Determinants of innovation activity

	Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**		**Model 6**	
	Coef.	z	Coef.	z	Coef.	z	Coef.	z	Coef.	z	Coef.	z
R&D intensity	**61.000**	11.7	**61.222**	11.7	**60.968**	11.6	**61.408**	11.7	**61.631**	11.7	**66.686**	12.1
R&D staf	**0.1055**	6.14	**0.1054**	6.15	**0.11**	6.32	**0.1056**	6.1	**0.1141**	6.56	**0.1101**	6.33
Innovative t-2	**0.3739**	2.89	**0.3733**	2.9	**0.374**	2.9	**0.3838**	3.0	**0.3776**	2.91	**0.3879**	2.89
Size	0	-	0	-	0	-	0.0000	-0.2	0.0001	0.92	0.0002	1.4
Skill intensity	0.0001	0.84	0.0001	0.76	0	0.77	0.0001	0.6	0.0001	0.65	0.0001	0.65
Capital intensity	0	-0.4	0	-	0	-	0.0000	-0.4	0	0.61	0	0.67
Export int.	0.16	0.85	0.1464	0.78	0.149	0.79	0.1539	0.8	0.1539	0.81	0.2165	1.11
OFDI	**0.3547**	2.63	**0.3334**	2.47	**0.332**	2.45	**0.3479**	2.5	**0.3512**	2.59	**0.3764**	2.71
IFDI	-	-	-	-	-0.209	-	-	-1.3	-	-	-	-
Rval	0.0203	0.26	0	0.47	0	0.46	0.0000	0.5	0	0.26	0	0.09
Cooperation total	**2.1417**	11										
cooperation domestic			**1.5892**	7.36	**1.58**	7.3						
cooperation international			**1.8191**	5.15								
cooperation EU					**1.787**	5.02						
Inter-firm coop.							**1.9242**	9.1				
Intra-firm coop.							**2.0975**	3.1				
Private cooperation									**2.171**	9.64		
Public cooperation									0.0262	0.08		
Suppliers											**1.4464**	3.28
Buyers											**2.1506**	4.46
Universities											-	-
Public institutes											0.6142	1.27
Commercial institutes											-	-0.5
Intra-firm cooperation											**2.2755**	3.47
HItech	-	-	-	-	-0.201	-	-	-0.5	-0.266	-	-	-
MHItech	0.3012	1.01	0.3023	1.02	0.299	1.01	0.2991	1.0	0.2016	0.7	0.2729	0.88
MLOWtech	0.2564	0.88	0.2716	0.94	0.267	0.92	0.2623	0.9	0.1935	0.7	0.3151	1.05
LOWtech	0.2279	0.8	0.2524	0.89	0.25	0.88	0.2311	0.8	0.1561	0.57	0.2185	0.74
KNOWintserv	-	-	-	-	-0.116	-	-	-0.3	-	-	-	-
LESSKNOWserv	-	-	-0.1	-	-0.101	-	-	-0.5	-	-	-	-0.6
constant	-	-	-	-	-2.079	-	-	-6.7	-	-	-	-
number of obs.	1982		1892		1930		1948		1956		1784	
LR chi 2 (17)	1947.9		1945.3		1833.6		1883.2		1897.3		1528.2	
Prob > chi2	0		0		0		0.0000		0		0	
Pseudo R2	0.7582		0.7572		0.746		0.7542		0.7546		0.7233	

Notes: * Product and process innovations are treated equally; significant coefficients are bolded; Model 1, 2, 3 - innovation cooperation by all various types of partners included as dummies; Model 4 - variables indicating innovation cooperation by regions are dummies, cooperation in the USA, Japan, and other regions were dropped out of the model due to perfect prediction (taken either separately or together in the variable cooperation with rest of the world), In Model 5 variables for innovation cooperation with competitors and consultants were dropped out due to multicolinearity or perfect predictability.

Source: Statistical Office of Slovenia; own calculations.

Table 4: The efficiency of innovation cooperation

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	dF/dx	z	dF/dx	z	dF/dx	z	dF/dx	z	dF/dx	z	dF/dx	
R&D intensity	**1.583**	11.74	1.224	11.72	6.372	1.17E+01	1.488	1.17E+01	1.165	11.75	10.899	12.14
R&D staf	**0.003**	6.13	0.002	6.15	0.011	6.32E+00	0.003	6.11E+00	0.002	6.56	0.018	6.33
Innovative t-2	0.008	2.9	0.006	2.9	0.035	2.90E+00	0.008	2.95E+00	0.006	2.91	0.056	2.89
Size	0.000	-0.23	0.000	-0.12	0.000	-0.15	0.000	-0.16	0.000	0.92	0.000	1.4
Skill intensity	0.000	0.7	0.000	0.76	0.000	0.77	0.000	0.64	0.000	0.65	0.000	0.65
Capital intensity	0.000	-0.51	0.000	-0.21	0.000	-0.21	0.000	-0.36	0.000	0.61	0.000	6.70E-01
Export int.	0.004	0.85	0.003	0.78	0.016	7.90E-01	0.004	8.10E-01	0.003	0.81	0.035	1.11E+00
OFDI	**0.007**	2.63	**0.005**	2.47	**0.030**	2.45	**0.007**	2.54	**0.005**	2.59	**0.053**	2.71E+00
IFDI	-0.005	-1.09	-0.005	-1.29	-0.024	-1.31	-0.006	-1.34	-0.004	-1.14	-0.039	-1.33
Rval	0.000	0.43	0.000	0.47	0.000	0.46	0.000	0.48	0.000	0.26	0.000	0.09
Cooperation total	**0.031**	11.01										
cooperation domestic			**0.016**	7.36	**0.085**	7.3						
cooperation international			**0.014**	5.15								
cooperation EU					**0.075**	5.02						
Inter firm coop.							**0.023**	9.05				
Intra firm coop.							**0.013**	3.12				
Private cooperation									**0.020**	9.64		
Public cooperation									0.000	0.08		
Suppliers											**0.101**	3.28
Buyers											**0.113**	4.46E+00
Universities											-0.105	-1.05
Public institutes											0.067	1.27
Commercial institutes											-0.056	-0.5
Intra-firm cooperation											**0.105**	3.47
HItech	0.006	-0.51	-0.005	-0.53	-0.024	-0.53	-0.006	-0.51	-0.007	-0.71	-0.034	-0.48
MHItech	0.006	1	0.005	1.02	0.026	1.01	0.006	1	0.003	0.7	0.039	0.88
MLOWtech	0.006	0.88	0.004	0.94	0.024	0.92	0.005	0.9	0.003	0.7	0.045	1.05
LOWtech	0.005	0.83	0.004	0.89	0.023	0.88	0.005	0.81	0.003	0.57	0.033	0.74
KNOWintserv	-0.003	-0.36	-0.002	-0.35	-0.013	-0.37	-0.003	-0.34	-0.005	-0.69	-0.014	-0.26
LESSKNOWserv	-0.004	-0.43	-0.002	-0.35	-0.011	-0.35	-0.004	-0.5	-0.005	-0.86	-0.032	-0.6
obs. P	0.351		0.351		0.334		0.340		0.343		0.279	
pred. P (at x-bar)	0.990		0.993		0.949		0.991		0.993		0.909	
no of observ.	1982		1982		1930		1948		1956		1784.000	
Psevdo R2	0.7582		0.7572		0.746		0.7542		0.7546		0.723	

Notes: dprobit estimates: *) dF/dx is for discrete change of dummy variable from 0 to 1; z and P>|z| correspond to the test of the underlying coefficient being 0. Significant coefficients are bolded. Source: own calculations.

Still innovation cooperation is found as on of the most effective incentive. In enterprises expand innovation cooperation to non-related enterprise they significantly icrease the probability to innovatie. The average effect of external innovation cooperation is twice as large as the effect intra-firm cooperation. A significant influence of innovation cooperation is confirmed for both domestic and for international innovation cooperation. Innovation cooperation stimulates innovation activity whether the partner(s) come from domestic country or from Europe, however the effect of domestic cooperation is slightly higher (Table 4). Change in the probability to innovate if the case of domestic innovation cooperation is one percentage point higher compared to international innovation cooperation. In model 3, innovation cooperation with partners from USA or the rest of the world (formed as separate variable) is dropped out of the model, since innovation cooperation with so distant partner(s) is perfect predictor of innovation activity. Though rare and in spite of the largest geographical distance (Table 2) such type of innovation cooperation is normally carefully managed and brings results.

The efficiency of innovation cooperation varies also according to the type of partners. While intra-firm and inter-firm innovation cooperation (private enterprises) significantly increases the probability of innovation, this was not found for universities and public and non-profit R&D institutes (Table 3, Table 4). Though frequently used, public organizations are identified as less efficient partners and no significant impact to innovation activity is found, which suggest possible improvements in innovation cooperation behavior. Case studies and interviews revealed longer process and lower level of commercialization compared to inter-enterprise innovation cooperation. The relevance of inter-firm cooperation varies further. Buyers, suppliers and related firms (intra-firm cooperation) prove as the most productive partners in innovation cooperation. Not only that these type of partners are the only partners where significant impact is found, the effect of buyer or supplier innovation cooperation (10 and 11 percentage points increase of probability to innovate, respectively) is much larger than the effect of innovation cooperation in general (Table 4). Related firms as well are reliable innovation partners and increase the probability to inovate by 10.5 percentage points. High significance and large effect of intra-firm innovation cooperation is in line with the results of FDI variables and confirms the importance of transaction costs and internalization in innovation behavior.

4 **CONCLUSIONS**

Most of Slovenian firms are still focused on internal sources of innovation and poorly exploit ideas and incentives from external environment, though the level of innovation cooperation is among the highest in Europe. As the investment in R&D remains below European average the slow increase in the share of innovation activity in Slovenia is more likely the result of better use of external incentives to innovation capacity. The study identified innovation cooperation as one of key and efficient element for increasing innovation capacity. Countries and firms that lag behind in innovation activity should not neglect this option within their innovation behavior strategy.

Innovation cooperation was next to R&D intensity, R&D personnel, innovation activity in the past and outward investment abroad identified as significantly relevant predictor of innovation activity. Innovation cooperation is found as significant regardless of geographical location, both domestic and international cooperation are important, though the relevance differ by location and domestic cooperation currently brings higher result. The impact differs also by type of partners; while intra-firm and inter-firm innovation cooperation significantly increases the probability of innovation (with buyers and suppliers as the most efficient partners in innovation cooperation), this was not found regarding cooperation with public institutions such as universities and R&D institutes. Since one fifth of innovative enterprises cooperate with public institutes and universities better governance and management to increase its efficiency is suggested.

The impact of innovation cooperation is significant, yet the estimated magnitude of effect on innovation activity varies by different types of partners. This indicates hurdles in innovation cooperation that may originate from various reasons. Problems accompanying innovation cooperation such as governance and leadership of partners, motivation and coordination of activities, protection of intellectual property and cost sharing may prevail over the benefits in volume and speed of merchandising the ideas. All those problems are quite similar to those identified at outsourcing and off-shoring. Greater involvement in international value chains is expected to increase capacities for inter-firm cooperation and consequently also innovation cooperation. The strategy of innovation cooperation should thus not exclude internationalization, and involve not only related enterprises, but also buyers and suppliers, from both domestic and international markets. All other types of innovation partners, especially public institutions need careful management.

As a reliable tool for achieving innovation result, the potential of innovation cooperation may be better exploited and leaves room for better governance. It is an efficient option for enhancing innovation activity especially for firms coming from countries that lag behind in R&D spending and face less developed national innovation systems. These results may stimulate further research that would explore determinants and impact of international innovation cooperation in greater detail. Knowing firm level determinants, obstacles and effects of innovation cooperation would help recognize the most frequent risks and built more efficient innovation strategies. External (outside enterprise) determinants to innovation cooperation are also worth to explore to adjust policy measures. Cross country analysis would indicate whether the use and efficiency of innovation cooperation and external sources is related to the country characteristics such country size, national innovation systems, average level of innovation activity, internationalization and environmental factors. International fragmentation of production and slicing value chains is expected to increase external learning and international cooperation. As innovation cooperation and paradigms like open source platforms demonstrate as efficient patterns and reliable tools for achieving innovation results and sunk cost is realistic alternative, innovation policy should not only closely trace the effects but also set the in time incentives.

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