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## Innovation Cooperation and Innovation Activity of Slovenian Enterprises

**Working Paper** no. 6/2007, vol. XVI

**Abstract:** In this paper the authors explore the importance of innovation cooperation for innovation activity in general and that of Slovenian enterprises (what kind of innovation cooperation is the most "productive" for innovation activity, and whether the location and foreign ownership of innovation cooperation matters). They give underlying reasons for the proliferation of innovation cooperation, review the literature on the determinants of a firm's innovation activity, with particular attention given to innovation cooperation and the determinants of innovation cooperation. They also identify the determinants of the innovation activity of Slovenian firms and explore the effect of innovation cooperation.

**Key words:** innovation cooperation, innovation activity, foreign ownership, innovation partner, R&D, Slovenia

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Working Paper: Innovation Cooperation and Innovation Activity of Slovenian Enterprises
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Language Editor: Dean J. DeVos

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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, what kind of innovation cooperation is the most "productive" for innovation activities, and whether the location and foreign ownership of innovation cooperation matters. Probit estimations confirmed external innovation cooperation as one of the most important incentives for innovation activity, after R&D spending. However, a significant influence was only confirmed for domestic and not for international innovation cooperation in general. 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. The impact of innovation cooperation differs by distance; the contribution of EU partners to innovation activity was the highest (higher then that of domestic partners), while partners from other locations may even decrease the probability of innovation.


**Povzetek**

V literaturi je inovacijsko sodelovanje pomembna determinanta inovacijske aktivnosti, produktivnosti in rasti podjetij in je postalo predmet intenzivnih raziskav. V delovnem zvezku obravnavamo pomen inovacijskega sodelovanja za inovacijsko aktivnost slovenskih podjetij: katera vrsta inovacijskega sodelovanja je najbolj »produktivna« za inovacijsko aktivnost in ali sta lokacija partnerjev in tuje lastništvo podjetij pomembni za inovacijsko sodelovanje. Probit ocene potrjujejo, da je zunanje inovacijsko sodelovanje, takoj za lastnimi R&R izdatki, najpomembnejša spodbuda za inovacijsko aktivnost podjetij. Vendar se značilen vpliv potrjuje le pri domačem, ne pa tudi pri mednarodnem inovacijskem sodelovanju na splošno. Učinkovitost se spreminja tudi glede na vrsto partnerjev; medtem ko se z medpodjetniškim inovacijskim sodelovanjem verjetnost inoviranja vidno povečuje, to ne velja za sodelovanje z univerzami in R&R instituti. Vpliv inovacijskega sodelovanja se spreminja tudi glede na razdaljo med partnerji; pri mednarodnem sodelovanju so k inovacijski aktivnosti največ (več kot domači partnerji) prispevali partnerji iz EU, medtem ko sodelovanje s partnerji z drugih lokacij lahko celo zmanjša verjetnost inoviranja.

# 1 INTRODUCTION

Innovation cooperation has become an increasingly prominent feature of firms' innovation activity. 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). 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, etc.).

In terms of organisational modes, innovation cooperation varies from 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).

The objective of the paper is to look at the innovation cooperation of Slovenian enterprises, and some of its specific aspects, as a determinant of their innovation activity. Firstly, we explore the types and characteristics of innovation cooperation (the types of cooperation, the enterprises and partners involved, the location of innovation partners, the relation of innovation cooperation to R&D spending) by descriptive statistics, and, secondly, we estimate the contribution of innovation cooperation to innovation activity. We look at the determinants of a firm's probability of innovation, such as own R&D, size, and export orientation, industry characteristics, foreign ownership and we pay special attention to the role of innovation cooperation. 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).

Our analysis is based on firm-level data from the Community Innovation Survey for Slovenia in the period 2000-2002. This determines our analytical possibilities as far as various organisational modes of innovation cooperation are concerned in the following way: (i) by identifying a firm as being a subsidiary of a foreign parent, we capture the impact of the hierarchical (equity) type of innovation cooperation, (ii) by identifying a firm as having "any cooperation arrangements on innovation activities with other enterprises or institutions,"[1] we capture the impact of all of a firm's other equity and/or non-equity contractual agreements on innovation cooperation, (iii) by calculating vertical and horizontal innovation spillovers, we also capture inter-firm informal-non-contractual innovation cooperation. The specific value added of this exercise is that in the model we differentiate between the effects of innovation cooperation according to types of cooperation, i.e. between

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[1] Definition used in the Community Innovation Survey, where the term other enterprises comprises other enterprises within the enterprise group, suppliers, clients or customers, competitors, and other firms from the same industry, and consultants, while the term other institutions comprises commercial laboratories/R&D enterprises, universities, and government or private non-profit research institutes.

domestic and international cooperation, between cooperation with enterprises and with R&D institutions, and according to proximity, between cooperation with partners from Slovenia, the EU and the CEEC. Thus, we explore the importance of innovation cooperation for innovation, what kind of innovation cooperation is the most "productive" for innovation activity, and whether the location and foreign ownership of innovation cooperation matter.

The underlying reasons for the proliferation of innovation cooperation are discussed in the next section. Section Three reviews the literature on the determinants of a firm's innovation activity, paying particular attention to innovation cooperation, and on the determinants of innovation cooperation. Section Four provides a descriptive analysis of the innovation cooperation and innovation activity of Slovenian firms and Section Five identifies the determinants of the innovation activity of Slovenian firms and explores the effects of innovation cooperation. Section Six concludes the Working Paper.

**2 REASONS FOR THE 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 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)[2]. 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 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 shows the dominance of national and, to a lesser extent, EU partners in innovation cooperation[3] (Commission of the European Communities, 2005). 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).

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 and 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, to which one should add 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 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

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[2] 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).

[3] 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%.

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 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 THE DETERMINANTS OF A FIRM'S INNOVATION ACTIVITY AND THE DETERMINANTS OF A FIRM'S INNOVATION COOPERATION**

This section first of all reviews the determinants of a firm's probability to innovate, followed by the determinants of a firm's decision to engage in innovation cooperation.


**3.1 Standard explanatory variables 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, and market position (export orientation), industry characteristics, ownership structure, multinationality, public subsidies, and external knowledge acquisition in its various forms[4].

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 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-

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[4] 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.

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).

### 3.2 The impact of innovation cooperation on firms' own R&D and innovation activity

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[5]. 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).

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[6].

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[5] 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.

[6] 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 type of partners in innovation cooperation and its impact on innovation activity has many aspects. 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).

The determinants of innovation cooperation are of a firm- and industry-specific character. Apart from that, country characteristics also may have an impact on the intensity of innovation cooperation. According to Narula (2003: 148), the propensity of firms of a given nationality 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.

There are important differences among individual industries as far as the intensity of innovation cooperation is concerned. 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). This is no surprise since empirical studies 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.[7] 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.

Own R&D activity is crucial in order for a firm 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; Kremp and Mairesse, 2004;

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[7] 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).

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)[8]. This supports the absorption capacity view of in-house research (Veugelers and Cassiman, 1999). A firm's absorption capacity is definitely crucial to ensuring a positive impact of innovation networking on a firm's innovation output. 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 appropriability 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 strength of the appropriability regime, i.e. 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).

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[8] 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.

## 4 THE INNOVATION COOPERATION AND INNOVATION ACTIVITY OF SLOVENIAN ENTERPRISES – A DESCRIPTIVE ANALYSIS

External knowledge spillovers have already been identified as an important innovation incentive (Damijan et al., 2006) in the case of Slovenia. Besides own R&D, which proved to be the most important determinant of firms' innovation activity, FDI (foreign direct investment) and R&D subsidies (domestic and international) were also found to be an important innovation incentive. This section further explores the importance of innovation determinants and focuses on external innovation cooperation[9] as an incentive to innovation activity.

Data on external innovation cooperation are only available from two CIS surveys from 2000 to 2002.[10] This limits the use of econometric models and excludes the possibilities of panel research. Formal modes of innovation cooperation include (i) internal innovation cooperation (within the group, intra-firm innovation cooperation)[11] and (ii) external innovation cooperation, which can be further divided into cooperation with firms (inter-firm: customers, suppliers, competitors, consultants, other firms) and with research institutes (including commercial labs and R&D institutes, universities, and public or private non-profit R&D institutes).

However, foreign-owned innovative firms much more frequently use innovation cooperation than domestic innovative firms (see Table 1). This is especially so for internal, intra-firm innovation cooperation, which was only reported by foreign-owned firms. For foreign owned firms, intra-firm innovation cooperation is much more frequent than external innovation cooperation. In 2002, 91.7% of innovative foreign-owned firms reported internal innovation cooperation, compared to 46.4% that reported external innovation cooperation.

**Table 1: Innovation activity and innovation cooperation of innovative Slovenian firms by type of ownership, 2000-2002**

| | No. of surveyed firms | Fraction of innovative firms in all surveyed firms (%) | Fraction of innovative firms involved in intra-firm innovation cooperation[*] (%) | Fraction of innovative firms involved in external innovation cooperation (%) |
|---|---|---|---|---|
| **All firms** | | | | |
| **2000** | 2,518 | 21.2 | 27.9 | 65.8 |
| **2002** | 2,564 | 20.6 | 33.3 | 44.5 |
| **Domestic** | | | | |
| **2000** | 1,923 | 17.5 | 0.0 | 64.9 |
| **2002** | 1,935 | 17.3 | 0.0 | 43.4 |
| **Foreign** | | | | |
| **2000** | 595 | 32.9 | 76.1 | 67.4 |
| **2002** | 629 | 30.5 | 91.7 | 46.4 |

Notes: [*] all firms that reported this variable are foreign-owned; in a pooled sample (2000 plus 2002), 80% of foreign owned firms declared their firms to be a part of a group of firms (subsidiaries).
Source: Statistical Office of Slovenia; own calculations.

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[9] Formal innovation cooperation monitored by the survey and informal-non-contractual innovation cooperation captured by calculating vertical and horizontal innovation spillovers are analysed.

[10] Almost 3,000 firms were targeted by a compulsory survey that resulted in a more than 80% response. In the 2000 survey, companies with 10 or more employees were surveyed, while in 2002 the lower boundary was 5 or more employees. In spite of this, the number of surveyed firms did not increase considerably. This may, however, explain the lower share of innovative firms in the 2002 as compared to 2000 survey (see Table 1). Namely, the fraction of innovative firms is much lower among smaller firms than among medium and especially large firms (see Damijan et al., 2006).

[11] Since domestic firms have not reported any intra-firm innovation cooperation, we only test for external innovation cooperation in the model.

Innovative firms widely use various types of external innovation cooperation. In a pooled sample (2000 plus 2002), 53.8% of innovative firms used at least one form of external innovation cooperation.[12] External innovation cooperation is more used by foreign-owned than domestic firms. Yet the share of innovative firms involved in external innovation cooperation decreased sharply from 2000 to 2002. The fall was slightly greater among domestic compared to foreign-owned firms. This may suggest a rationalization of innovation cooperation strategy.

The average R&D intensity of Slovenian firms (measured by the ratio of R&D expenditures to sales) increased in the period 2000-2002 (see Table 2). This was due to the increased R&D intensity of foreign-owned firms, while the R&D intensity of domestic firms decreased. External innovation cooperation brings changes in R&D spending in terms of volume and growth. Innovative firms involved in external innovation cooperation have higher average R&D spending and their average R&D expenditures per sales further increased in the studied period. The average increase, again, was only found in foreign-owned firms, while domestic external cooperative innovators decreased their R&D expenditures per sales. Foreign-owned innovative firms with external innovation cooperation almost doubled their R&D expenditures to sales, from 4.5% in 2000 to as much as 8.6% in 2002. It is also worth noting that innovative foreign-owned firms with external innovation cooperation exhibit much higher R&D intensity than those with intra-firm innovation cooperation. It seems that foreign firms with more transfer of technology from other parts of the parent firm need less in-house R&D efforts than others.

**Table 2: R&D-to-Sales ratio of innovative Slovenian firms by type of ownership, 2000-2002, in %**

| | Innovative firms | Innovative firms with intra-firm innovation cooperation | Innovative firms with external innovation cooperation | Innovative firms without external innovation cooperation | Non-Innovative firms |
|---|---|---|---|---|---|
| **All firms** | | | | | |
| **2000** | 6.0 | 3.3 | 6.5 | 6.0 | 0.021 |
| **2002** | 6.5 | 7.0 | 6.9 | 6.0 | 0.015 |
| **Domestic** | | | | | |
| **2000** | 7.1 | 0.0 | 7.6 | 6.9 | 0.023 |
| **2002** | 6.4 | 0.0 | 5.8 | 6.8 | 0.004 |
| **Foreign** | | | | | |
| **2000** | 4.1 | 3.3 | 4.5 | 4,2 | 0.012 |
| **2002** | 6.6 | 7.0 | 8.6 | 4,8 | 0.055 |

Source: Statistical Office of Slovenia; own calculations.

External innovation cooperation is mostly concentrated on one partner, yet a clear tendency towards the diversification of innovation partnerships is noticed from 2000 to 2002. The average number of external partnerships by firms increased from 2.4 to 2.9 (see Table 3). In 2000, more than 40% of firms involved in external innovation cooperation had only one partner, while there were only 25% of such firms in 2002. The percentage of firms with two external partners increased from 21% to 25%, with three partners from 16% to 18%, with four partners from 6% to 10%, etc. According to descriptive statistics, a higher number of external innovation partners does not seem to increase a firm's R&D expenditures. An initial increase in the number of

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[12] The Slovenian innovation survey also reports on the innovation cooperation of non-innovative firms. As expected, innovative firms exhibit much more intensive innovation cooperation than non-innovative firms. In 2002, only 1.3% of non-innovative firms reported having external innovation cooperation.

partners (up to four) might increase R&D expenditures, while further new partnerships caused no predictable increase in R&D spending (see Table A.1 in the Appendix).

Most external innovation cooperation takes place among firms, while cooperation with institutes is much less frequent (see Table 3). However, from 2000 to 2002, the frequency of innovation cooperation with research institutes strongly increased (from 49.3% to 62.0%), while the overall frequency of inter-firm innovation cooperation remained almost unchanged. At present, the frequency of inter-firm innovation cooperation is almost the same in domestic and foreign-owned firms (at approximately 88%), while cooperation with research institutes is more frequent in the case of foreign-owned firms (more than 64%) than in domestic firms (less than 61%). Compared to domestic firms, foreign-owned firms are much more frequently involved in simultaneous inter-firm cooperation and cooperation with research institutes. The majority of firms involved in innovation cooperation with research institutes is also involved in inter-firm cooperation, while the opposite only holds for 2002. It seems that more and more firms involved in inter-firm innovation cooperation found research institutes to be a useful complement.

**Table 3: Types of external innovation cooperation of innovative Slovenian firms**

|  | Cooperation with firms | | Cooperation with research institutes | | Cooperation with firms & research institutes | | Average no. of external innovation partnerships per firm |
|---|---|---|---|---|---|---|---|
|  | % of firms | R&D/sales, in % | % of firms | R&D/sales, in % | % of firms | R&D/sales, in % |  |
| **All firms** | | | | | | | |
| **2000** | 87.8 | 6.7 | 49.3 | 5.1 | 40.7 | 5.2 | 2.4 |
| **2002** | 88.6 | 7.0 | 62.0 | 8.7 | 57.1 | 9.5 | 2.9 |
| **Domestic** | | | | | | | |
| **2000** | 85.6 | 8.1 | 48.1 | 4.9 | 39.4 | 5.6 | 2.3 |
| **2002** | 88.7 | 5.8 | 60.7 | 6.1 | 47.4 | 6.2 | 2.9 |
| **Foreign** | | | | | | | |
| **2000** | 91.6 | 4.4 | 51.4 | 5.5 | 42.9 | 4.7 | 2.6 |
| **2002** | 88.4 | 9.0 | 64.2 | 13.8 | 59.5 | 15.5 | 2.9 |

Source: Statistical Office of Slovenia; own calculations.

In 2002, foreign-owned firms with external innovation cooperation showed a ratio of R&D expenditures to sales that was on average twice as high as for comparable domestic firms (which is also seen in Table 3). This was the opposite of the situation in 2000, and was a result of a considerable increase of the R&D expenditures of foreign-owned firms in 2000-2002. By far the highest increase (from 4.7% in 2000 to 15.5% in 2002) was noticed regarding foreign-owned firms cooperating simultaneously with firms and institutes. The situation with regard to domestic firms is quite different. Overall, they increased R&D expenditures to sales much less than foreign-owned firms; those cooperating with firms even decreased average R&D expenditures to sales. Regardless of the ownership type, cooperation with research institutes is related to higher average R&D expenditures to sales than cooperation with firms indicating more demanding innovation projects. While the number of external partners reveals no upward pressure on R&D intensity, a combination of different types of external innovation cooperation does. Firms involved in both main types of external innovation cooperation have the highest average R&D expenditures in sales, regardless of the ownership.

A closer inspection of inter-firm innovation cooperation (see Table 4) reveals that the most important is cooperation with buyer (customer) and supplier firms; for domestic firms, buyers are by far the most important innovation cooperation partner, while for foreign-owned firms, buyers and suppliers are similarly important partners. Half of the firms cooperate also with other firms (not related to direct business activity) and more

than 40% with consultants. Both innovation cooperation with other (not directly related) firms and consulting firms is more wide spread among domestic than foreign-owned firms. As expected, the least developed area is cooperation with competitors. These figures demonstrate that foreign-owned firms tend to concentrate inter-firm innovation cooperation relatively more on vertical business relationships with customers and suppliers, while domestic firms concentrate relatively more on other firms and consultants.

**Table 4: External inter-firm innovation cooperation of innovative Slovenian firms by types of cooperating firms**

| | No. of firms with external inter-firm cooperations | of which | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | With other firms | | With customers | | With suppliers | | With competitors | | With consultants | |
| | | % | R&D/ sales, in % | % | R&D/ sales, in % | % | R&D/ sales, in % | % | R&D/ sales, in % | % | R&D/ sales, in % |
| **All firms** | | | | | | | | | | | |
| **2000** | 257 | 23.0 | 3.5 | 73.2 | 7.5 | 62.3 | 5.7 | 19.8 | 7.2 | 45.1 | 5.0 |
| **2002** | 217 | 50.7 | 7.7 | 64.1 | 7.5 | 56.7 | 7.4 | 16.6 | 6.6 | 41.9 | 7.7 |
| **Domestic** | | | | | | | | | | | |
| **2000** | 160 | 0.0 | 0.0 | 76.3 | 9.5 | 55.6 | 6.9 | 22.5 | 8.4 | 47.5 | 5.9 |
| **2002** | 133 | 53.4 | 5.9 | 62.4 | 6.1 | 51.9 | 4.9 | 18.0 | 7.6 | 42.9 | 6.6 |
| **Foreign** | | | | | | | | | | | |
| **2000** | 97 | 60.8 | 3.5 | 68.0 | 3.8 | 73.2 | 4.2 | 15.5 | 4.3 | 41.2 | 3.5 |
| **2002** | 84 | 46.4 | 11.0 | 66.7 | 9.5 | 64.3 | 10.6 | 14.3 | 4.6 | 40.5 | 9.4 |

Source: Statistical Office of Slovenia; own calculations.

The ratio of average R&D expenditures to sales further confirms the above findings. For domestic firms, average R&D expenditures to sales is the highest for the group of firms cooperating with competitors and consultants. For foreign-owned firms, R&D expenditures are the highest for the group of firms cooperating with suppliers and buyers. This suggests a more target-oriented and consistent innovation strategy of foreign affiliates. Also and contrary to domestic firms, foreign-owned firms increased average R&D expenditures regardless of the type of partner; domestic firms increased average R&D spending only in the group cooperating with consulting firms.

The frequency of innovation cooperation with R&D institutions (commercial laboratories, R&D firms, universities, and state or private non-profit institutes) decreased on average in the examined period among domestic as well as foreign-owned firms (see Table 5). Commercial sources are used relatively more by foreign-owned firms, while domestic firms are more prone to innovation cooperation with universities and non-profit institutes. For domestic firms, R&D expenditures are the highest in innovation cooperation with non-profit institutes, while the average R&D spending of foreign-owned firms is the highest in cooperation with universities and commercial R&D firms.

There are on average three- to four-times more innovative firms among the medium-sized firms than among small firms, while among large firms the share of innovative firms is five- to six-times higher than among small firms (see Table 6). Foreign-owned firms, especially if they are of medium or large size, are more likely to be innovative than firms with domestic owners. Similar holds true for innovation cooperation that increases with firm size; medium sized firms cooperate more than small firms, and large firms cooperate more than medium firms. Foreign-owned firms are more likely to be involved in innovation cooperation in every size group. Also, the highest average number of external cooperation partners was found for large firms. However, there is no

very clear pattern of differences in the average number of external cooperation partners by size and by ownership.

**Table 5: External innovation cooperation of innovative Slovenian firms with R&D institutions**

| | No. of firms cooperating with any R&D institutions | of which | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | | With commercial labs and R&D firms | | With universities | | With public or private non-profit institutes | |
| | | % | R&D/ sales, in % | % | R&D/ sales, in % | % | R&D/ sales, in % |
| **All firms** | | | | | | | |
| **2000** | 142 | 52.8 | 6.1 | 88.7 | 6.1 | 59.2 | 6.8 |
| **2002** | 152 | 39.5 | 6.9 | 72.4 | 8.4 | 50.0 | 6.5 |
| **Domestic** | | | | | | | |
| **2000** | 90 | 46.7 | 7.4 | 82.2 | 7.6 | 61.1 | 8.1 |
| **2002** | 80 | 40.0 | 6.2 | 80.0 | 6.2 | 56.3 | 6.5 |
| **Foreign** | | | | | | | |
| **2000** | 52 | 63.5 | 4.4 | 100.0 | 3.9 | 55.8 | 4.3 |
| **2002** | 61 | 45.9 | 7.6 | 75.4 | 11.6 | 50.8 | 6.3 |

Source: Statistical Office of Slovenia; own calculations.

**Table 6: External innovation cooperation by size and ownership type of innovative Slovenian firms**

| | Fraction of innovative firms in all firms surveyed, % | | Fraction of cooperating firms, % | | Average number of cooperation partners by cooperating firm | |
| --- | --- | --- | --- | --- | --- | --- |
| | **Domestic** | **Foreign** | **Domestic** | **Foreign** | **Domestic** | **Foreign** |
| **Small** | | | | | | |
| **2000** | 11.4 | 14.7 | 5.6 | 7.9 | 2.1 | 2.4 |
| **2002** | 12.4 | 11.7 | 4.0 | 5.0 | 2.6 | 2.3 |
| **Medium** | | | | | | |
| **2000** | 26.3 | 40.9 | 13.3 | 17.7 | 2.3 | 2.2 |
| **2002** | 24.9 | 36.9 | 14.0 | 13.1 | 3.2 | 2.6 |
| **Large** | | | | | | |
| **2000** | 54.2 | 60.0 | 32.5 | 34.8 | 2.8 | 2.8 |
| **2002** | 54.3 | 61.1 | 26.7 | 37.3 | 2.7 | 3.8 |

Source: Statistical Office of Slovenia; own calculations.

The distribution of firms involved in innovation cooperation classified by technological intensity[13] (see Table 7) reveals that firms in the medium-high technology sectors, such as electrical appliances, automotive production, machinery and chemical production, are the most active in innovation cooperation. In foreign-owned firms this is followed by high and low technology industries, while in domestic firms, surprisingly, in low technology industries. Foreign-owned firms are more involved in innovation cooperation in all four technological intensity groups. In the 2000-2002 period, foreign-owned firms radically increased the frequency of innovation cooperation in high technology industries and considerably decreased the frequency of cooperation in medium-high technology industries, while the situation with domestic firms was quite the opposite.

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[13] Individual sectors are classified into four groups according to technological intensity (low technology, medium-low technology, medium-high technology, and high technology) according to OECD methodology (see OECD, 2005: 181-184).

**Table 7: External innovation cooperation by technological intensity of innovative Slovenian firms**

| | Fraction of innovative firms in all firms surveyed, % | | Fraction of cooperating firms, % | | Average number of cooperation partners by cooperating firm | |
|---|---|---|---|---|---|---|
| | Domestic | Foreign | Domestic | Foreign | Domestic | Foreign |
| **Low tech** | | | | | | |
| **2000** | 15.6 | 39.1 | 7.1 | 19.6 | 3.1 | 3.1 |
| **2002** | 14.8 | 40.1 | 6.5 | 17.0 | 3.7 | 3.7 |
| **Medium-low tech** | | | | | | |
| **2000** | 11.0 | 20.7 | 9.6 | 8.2 | 3.5 | 3.8 |
| **2002** | 10.7 | 18.8 | 4.3 | 6.4 | 3.4 | 3.5 |
| **Medium-high tech** | | | | | | |
| **2000** | 30.6 | 47.6 | 12.2 | 30.1 | 3 | 3.4 |
| **2002** | 34.2 | 39.6 | 14.0 | 23.8 | 3.5 | 3.9 |
| **High tech** | | | | | | |
| **2000** | 25.4 | 42.2 | 17.4 | 2.2 | 3.5 | 3.6 |
| **2002** | 26.1 | 35.5 | 1.2 | 21.5 | 3.6 | 3.5 |

Source: Statistical Office of Slovenia; own calculations.

As regards the geographical origin of innovation cooperation partners, domestic partners are more frequent than international partners (see Table 8 and Table A.2 in the Appendix). More than 60% of all the firms with external innovation cooperation in 2000 cooperated with domestic partners. Domestic cooperation expanded faster than international cooperation. The majority of those that have international innovation cooperation are also involved in some kind of domestic innovation cooperation. International innovation cooperation or a combination of both is more typical for foreign-owned than for domestic firms.

**Table 8: The geographical breakdown of external innovation cooperation (%)***

| | Domestic (Slovenia) | International | Domestic & international | EU-15 & EFTA countries | New EU members | USA | Japan | other |
|---|---|---|---|---|---|---|---|---|
| **All firms** | | | | | | | | |
| **2000** | 44.2 | 29.9 | 20.7 | 23.1 | 5.1 | 2.7 | 1.0 | 0.7 |
| **2002** | 63.3 | 40.0 | 31.4 | 33.1 | 5.7 | 2.9 | 1.2 | 1.6 |
| **Domestic** | | | | | | | | |
| **2000** | 43.9 | 27.8 | 19.8 | 20.9 | 4.8 | 1.1 | 1.1 | 1.1 |
| **2002** | 61.3 | 35.3 | 28.0 | 29.3 | 6.0 | 1.3 | 0.7 | 1.3 |
| **Foreign** | | | | | | | | |
| **2000** | 44.9 | 33.6 | 22.4 | 27.1 | 5.6 | 5.6 | 0.9 | 1.9 |
| **2002** | 66.3 | 47.4 | 36.8 | 38.9 | 5.3 | 5.3 | 2.1 | 1.1 |

Note: * The sum of the percentages of firms involved in domestic and international innovation partnership may exceed 100, as firms may be involved in both.
Source: Statistical Office of Slovenia; own calculations.

A more detailed analysis of innovation cooperation revealed that international cooperation is mostly related to customers and suppliers. For this type of cooperation, international cooperation is more important than domestic, as a majority of those that cooperate with buyers and suppliers use international partners. Universities, commercial and non-profit R&D firms, consultants, and other firms are, on the other hand, more frequently found in the domestic environment.

International innovation cooperation partners are most frequently found in EU & EFTA countries (see also Table A.2 in the Appendix). Cooperation with partners from EU candidates is mostly concentrated on

relationships with buyers and suppliers. Distance reduces the variety of innovation cooperation; in more distant markets (USA, Japan, etc.) innovation cooperation is mainly concentrated on buyers and suppliers.

The organization of a firm's own R&D department is usually treated as a proxy for the firm's absorption capacity regarding innovation cooperation. The majority of innovative Slovenian firms involved in external innovation cooperation have their own R&D department (see Table 9). The percentage of firms with active external innovation cooperation with their own R&D department increased from 2000 to 2002, and among domestic firms even more than among foreign-owned firms. Own R&D activity is predominantly organized on a regular basis.

**Table 9: The own R&D activity of innovative Slovenian firms with external innovation cooperation**

|  | Firms with own R&D activity organized | | Firms with own R&D organized as % of cooperating firms |
| --- | --- | --- | --- |
|  | Regular R&D (%) | Periodical R&D (%) | |
| **All firms** | | | |
| **2000** | 64.8 | 35.2 | 70.7 |
| **2002** | 65.6 | 34.4 | 72.8 |
| **Domestic** | | | |
| **2000** | 64.8 | 35.2 | 69.5 |
| **2002** | 62.5 | 37.5 | 93.7 |
| **Foreign** | | | |
| **2000** | 64.7 | 35.3 | 72.7 |
| **2002** | 71.2 | 28.8 | 88.9 |

Source: Statistical Office of Slovenia; own calculations.

All variables explored in the descriptive analysis have been further tested as determinants of innovation activity.

## 5 DETERMINANTS OF THE INNOVATION ACTIVITY OF SLOVENIAN FIRMS – THE IMPORTANCE OF INNOVATION COOPERATION

Previous research on Slovenian firms (Damijan et al., 2006) confirmed the importance of a number of standard explanatory determinants of firms' innovation activity. It was demonstrated that the innovation activity of firms is persistent over time (firms that were innovative two years ago are also more likely to be presently innovative), 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. Surprisingly, innovative firms do not seem to be more productive in terms of value added per employee (expressed in terms of the individual sector average). The role of innovation cooperation, which is the subject of this paper, has not been tested so far.

In order 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 control variables contained in $\mathbf{M}_{it}$ are those explored in the descriptive analysis and some control variables, that is, a dummy for past innovation activity (lagged one period, that is, two years), firm size (number of employees), firm relative productivity (the firm's value added per employee relative to the average productivity of the particular sector), capital intensity, share of R&D expenditures in total sales, organization of own R&D activity, export propensity, and a dummy for foreign ownership, as well as variables for the importance of external innovation cooperation (differentiated between domestic and international, according to type and distance of the partner). The dummy for foreign ownership can also be considered a proxy for intra-firm innovation cooperation.[14] The model also includes horizontal and vertical spillovers from the innovation activity of other firms. They indicate the level of informal inter-firm innovation cooperation. Horizontal spillovers are measured by the number of innovations realised in the same sector. Vertical spillovers are calculated as the number of innovations conducted in a related sector multiplied by the respective input-output coefficient, where the latter reflects the strength of the input – output relationship between the sectors. In other words, the more interlinked both sectors are through bilateral supply and demand links, and the higher the innovation activity in both sectors, the larger is the scope for positive vertical knowledge spillovers between both sectors. The model also takes into account the technological intensity of the sectors in which the firm operates. It is expected that firms operating in 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.

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[14] As intra-firm innovation cooperation is fully accounted for by foreign-owned firms, and no firms with intra-firm innovation cooperation were observed among domestic firms, this variable could not be applied in a probit model (see also Table 1). Further research should include the foreign subsidiaries of domestic enterprises in order to measure the impact of intra-firm innovation adequately.

**Table 10: Firms' probability to innovate\* in Slovenia, 2000-2002 (probit models)**

| Y= innovative firms | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | z | Coef. | z | Coef. | z | Coef. | z |
| **R&D/Sales** | **43.020** | **9.66** | **48.152** | **10.73** | **41.801** | **8.96** | **41.874** | **8.98** |
| **Own R&D activity** | **1.213** | **12.38** | **1.336** | **13.9** | **1.229** | **12.16** | **1.246** | **12.32** |
| **Innovative $_{t-2}$** | **0.417** | **3.3** | **0.371** | **2.97** | **0.407** | **3.14** | **0.405** | **3.12** |
| **Size** | **0.340** | **3.98** | **0.365** | **4.4** | **0.374** | **4.31** | **0.366** | **4.18** |
| IFDI | -0.059 | -0.51 | -0.064 | -0.56 | -0.089 | -0.75 | -0.090 | -0.74 |
| Skill | 0.000 | 0.18 | 0.000 | 0.46 | 0.000 | 0.06 | 0.000 | 0.38 |
| VA/emp | 0.000 | -0.67 | 0.000 | -0.5 | 0.000 | -0.81 | 0.000 | -1.2 |
| Capital intensity | 0.000 | 0.86 | 0.000 | 0.75 | 0.000 | 0.86 | 0.000 | 0.73 |
| EXPORT/ Sales | 0.250 | 1.47 | 0.298 | 1.8 | 0.323 | 1.86 | 0.284 | 1.61 |
| **Hs_inov** | **0.009** | **2.04** | **0.010** | **2.49** | **0.009** | **1.93** | **0.010** | **2.19** |
| Vs_inov | 0.003 | 0.3 | 0.004 | 0.46 | 0.001 | 0.15 | 0.004 | 0.38 |
| **External innovation cooperation** | **1.640** | **7.99** | | | | | | |
| **Domestic cooperation** | | | **1.487** | **4.84** | | | | |
| International cooperation | | | 0.771 | 1.76 | | | | |
| Cooperation with R&D institutions | | | | | 0.113 | 0.6 | | |
| Cooperation with firms | | | | | **1.567** | **6.6** | | |
| **Cooperation in Slovenia** | | | | | | | **0.840** | **5.46** |
| **Cooperation in the EU** | | | | | | | **2.727** | **3.35** |
| **Cooperation in CEEC** | | | | | | | **-2.259** | **-4.06** |
| ML tech | -0.036 | -0.19 | -0.054 | -0.29 | 0.026 | 0.13 | -0.023 | -0.12 |
| MH tech | -0.237 | -1.15 | -0.344 | -1.7 | -0.191 | -0.91 | -0.192 | -0.91 |
| H tech | -0.257 | -1.08 | -0.277 | -1.2 | -0.166 | -0.69 | -0.194 | -0.8 |
| Constant | -2.493 | -9.95 | -2.587 | -10.6 | -2.573 | -9.97 | -2.590 | -10.03 |
| Number of obs. | 1972 | | 1972 | | 1972 | | 1923 | |
| LR chi2(15) | 1887.03 | | 1860.64 | | 1860.64 | | 1805.94 | |
| Prob > chi2 | 0 | | 0 | | 0 | | 0 | |
| Pseudo R2 | 0.743 | | 0.733 | | 0.733 | | 0.742 | |

Notes: * Product and process innovations are treated equally; significant coefficients are bolded; Model 1, 2, 3 - innovation cooperation by various types of partners included as dummies; Model 4 - variables indicating innovation cooperation by regions are not dummies, but also include a number of different types of partners; cooperation in the USA, Japan, and other regions were dropped out of the model due to multicollinearity (USA, Japan) or perfect prediction (EU, other).
Source: Statistical Office of Slovenia; own calculations.

Results of four separate probit estimations based on bi-annual data for manufacturing and non-manufacturing firms in Slovenia in the period 2000-2002 are given in Table 10. The results confirm that innovation cooperation is, next to R&D spending, the most important incentive for innovation activity. In all models a significant impact on innovation activity was robustly indicated also for firms' own organization of R&D activity, previous innovation activity, and firm size. Foreign ownership, along with skill intensity, export intensity, labour productivity, and capital intensity, was not confirmed as a significant incentive. The lack of a significant impact of foreign ownership may 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). Sectoral technological intensity has also not proved as significant determinant of innovation activity. Inter-firm

informal non-contractual cooperation captured by innovation spillovers was only confirmed for horizontal spillovers.

Yet the location and type of innovation cooperation partner matter. A significant influence of innovation cooperation has only been confirmed for domestic but not for international cooperation. The efficiency of innovation cooperation varies also according to the type of partners; while inter-firm innovation cooperation significantly increases the probability of innovation, this was not found for universities and (commercial or non-profit) R&D institutes. The impact of innovation cooperation next differs by distance; although domestic innovation cooperation was found to be more important than international cooperation in general, the highest contribution to innovation activity was found for innovation cooperation with EU partners (higher than for domestic Slovenian partners), while innovation cooperation with Central and Eastern European partners significantly decreased a firm's probability of innovation.

# 6 CONCLUSIONS

Innovation cooperation is an important determinant of innovation activity. A descriptive analysis demonstrates that foreign-owned firms involved in innovation cooperation increase R&D spending in sales, while the opposite was found for domestic firms. Foreign-owned firms are more involved in innovation cooperation in terms of the number and variety of innovation partners. Due to a lower initial level, domestic firms have made larger increases in the frequency of innovation cooperation (with faster growth of inter-firm cooperation, in 2002 the level was already the same as for foreign-owned firms). In spite of differences identified by the descriptive analysis, foreign ownership was not found to be a significant determinant of innovation activity, along with capital intensity, productivity, and skill intensity in the probit models. The lack of a significant impact of foreign ownership also brought into question the relevance of intra-firm innovation cooperation in foreign affiliates.

Using firm-level data on innovation activity, combined with firm-level financial data and firm-level data on foreign versus domestic ownership for a large sample of Slovenian enterprises in the period 2000-2002, we arrived at several interesting findings. First, probit estimates revealed that overall innovation cooperation is, next to R&D spending, the most important incentive for innovation activity. Yet, secondly, a significant influence was confirmed only for domestic but not for international innovation cooperation. Thirdly, the efficiency varies also according to the type of partners; while inter-firm innovation cooperation significantly increases the probability of innovation, this was not found for universities and (commercial or non-profit) R&D institutes. Fourthly, the impact of innovation cooperation differs by distance; EU partners were found to be an important and significant incentive for innovation activity, while others may even decrease the probability of innovation. Fifthly, horizontal innovation spillovers, as a proxy for informal innovation cooperation, also seem to be positive and significant for firms' innovation activity. This is not so for vertical innovation spillovers.

These results should stimulate further research that would explore the impact of international innovation cooperation in greater detail. The impact of foreign ownership (foreign affiliates) should be explored along with domestic multinational firms (based domestically). Such extension of the research would also enable greater insight into intra-firm innovation cooperation. Especially for firms coming from countries that lag behind in R&D spending and national innovation systems, this information is essential for building an optimal innovation behaviour strategy. Other possible directions for future research include the impact of firm size on innovation cooperation, and 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.

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**APPENDIX**

**Table A.1: Firms with external innovation cooperation by number of external partners and R&D expenditures per sales**

| No. of external partners | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| **All firms** | | | | | | | | | |
| Number | 2000 | 124 | 62 | 47 | 19 | 22 | 6 | 12 | 2 |
| | 2002 | 62 | 62 | 43 | 25 | 21 | 19 | 7 | 6 |
| % of firms cooperating with | 2000 | 42.2 | 21.1 | 16.0 | 6.5 | 7.5 | 2.0 | 4.1 | 0.7 |
| no. of partners | 2002 | 25.3 | 25.3 | 17.6 | 10.2 | 8.6 | 7.8 | 2.9 | 2.4 |
| R&D/sales (%) | 2000 | 7.1 | 5.3 | 5.5 | 7.4 | 4.8 | 3.7 | 13.2 | 3.2 |
| | 2002 | 4.8 | 5.2 | 5.2 | 17.7 | 8.2 | 4.4 | 4.7 | 4.5 |
| **Domestic firms** | | | | | | | | | |
| Number | 2000 | 84 | 39 | 27 | 12 | 12 | 4 | 9 | 0 |
| | 2002 | 42 | 38 | 23 | 18 | 12 | 10 | 4 | 3 |
| % of firms cooperating with | 2000 | 44.9 | 20.9 | 14.4 | 6.4 | 6.4 | 2.1 | 4.8 | 0 |
| no. of partners | 2002 | 28.0 | 25.3 | 15.3 | 12.0 | 8.0 | 6.7 | 2.7 | 2.0 |
| R&D/sales (%) | 2000 | 7.9 | 6.5 | 6.4 | 7.1 | 5 | 5 | 14.6 | 0 |
| | 2002 | 4.3 | 5.9 | 5.6 | 5.7 | 6.9 | 9.3 | 6.4 | 2.7 |
| **Foreign firms** | | | | | | | | | |
| Number | 2000 | 40 | 23 | 20 | 7 | 10 | 2 | 3 | 2 |
| | 2002 | 20 | 24 | 20 | 7 | 9 | 9 | 3 | 3 |
| % of firms cooperating with | 2000 | 37.4 | 21.5 | 18.7 | 6.5 | 9.3 | 1.9 | 2.8 | 1.9 |
| no. of partners | 2002 | 18.7 | 22.4 | 18.7 | 6.5 | 8.4 | 8.4 | 2.8 | 2.8 |
| R&D/sales (%) | 2000 | 5.2 | 3.3 | 4.3 | 6.9 | 4.5 | 1.2 | 3.8 | 3.2 |
| | 2002 | 5.7 | 3.9 | 4.8 | 48.4 | 9.9 | 5.1 | 2.3 | 6.3 |

Source: Statistical Office of Slovenia; own calculations.

**Table A.2: External innovation cooperation by regions and type of partner, number**

| Partner type | Domestic (Slovenia) | | EU & EFTA countries | | New EU members/CEEC | | USA | | Japan | | Other | | Total International | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2002 | 2000 | 2002 | 2000 | 2002 | 2000 | 2002 | 2000 | 2002 | 2000 | 2002 | 2000 | 2002 |
| Other firms | 30 | 91 | 40 | 41 | 3 | 9 | 7 | 6 | 2 | 1 | 1 | 4 | 53 | 61 |
| Customers | 121 | 79 | 109 | 90 | 25 | 20 | 15 | 19 | 6 | 5 | 10 | 5 | 165 | 139 |
| Suppliers | 102 | 85 | 91 | 80 | 19 | 16 | 10 | 5 | 3 | 5 | 6 | 6 | 129 | 112 |
| Competitors | 32 | 22 | 31 | 19 | 6 | 2 | 2 | 2 | 0 | 0 | 1 | 1 | 40 | 24 |
| Consultants | 95 | 79 | 34 | 29 | 5 | 2 | 4 | 4 | 0 | 0 | 1 | 1 | 44 | 36 |
| Commercial labs and R&D firms | 62 | 48 | 22 | 21 | 3 | 3 | 4 | 6 | 1 | 0 | 1 | 2 | 31 | 32 |
| Universities | 124 | 109 | 12 | 14 | 7 | 6 | 1 | 0 | 1 | 0 | 0 | 0 | 21 | 20 |
| Public/private non-profit R&D institutes | 81 | 73 | 11 | 9 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 14 | 11 |

Source: Statistical Office of Slovenia; own calculations.