SCIENCE-INDUSTRY COOPERATION IN SLOVENIA: DETERMINANTS OF SUCCESS

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ABSTRACT: *Paper analyses barriers to science-industry cooperation in Slovenia through three detailed case studies. Each case tackles both sides, industry (firms) and science (university/ research institute). Case studies confirm our assumption that it is the lack of companies with in-house R&D activities which is the main structural deficit for more science-industry cooperation. Strengthening of firms' in-house R&D departments and staff, and clustering of firms around the most propulsive ones is the precondition for more science-industry cooperation. Successful science-industry cooperation can only be developed gradually, most often on the basis of previous personal contacts between main actors on both sides. Case studies reflect no impact of the intermediary institutions on science-industry cooperation.*

Keywords: *science-industry cooperation, Slovenia, case studies*

JEL Classification: O32, O33, O38

1. INTRODUCTION

Science-industry cooperation, i.e. cooperation between universities and government or public research institutes (public research organisations - PROs), on one side, and firms, on the other, has attracted considerable attention in the literature as well as in the policy discussions[3]. From firms' perspective, it is a part of a broader process of innovation cooperation as an increasingly prominent feature of firms' innovation activity. Conceptually – Narula (2003) within the industrial organisation network, Chesbrough (2006) within the Open Innovation Paradigm, Cohen and Levinthal (1989, 1990) and Mowery and Rosenberg (1989 - the key issue of innovation cooperation has to do with explanatory mechanisms related to firms' in-house R&D versus external sourcing of knowledge, innovation cooperation being one mode of external sourcing. The literature points to the complementarity of internal, in-house R&D and external knowledge sourcing, i.e. to the optimal integration of external knowledge into internal R&D of (Radnor, 1991; Veugelers and Cassiman, 1999; Criscuolo and Narula, 2008).

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3 As found by Izsak, Markianidu and Radošević (2013:17) in the EU Report on Decade of innovation Policy, »during the course of 2000s, the "mantra" of innovation policies has been to foster industry science links with diverse efforts being made to gear research towards business…«

Along these lines empirical research on the impact of innovation cooperation on firm's innovation capacity, as a rule, finds a strong positive relationship between innovation networking and innovation output (see, for instance Cohen and Levinthal, 1989, 1990; Mowery and Rosenberg, 1989; Veugelers, 1997; Veugelers and Cassiman, 1999; Belderbos *et al*., 2004a; Kremp and Mairesse, 2004; Arvanitis and Bolli, 2009 etc.). Empirical studies specifically dealing with science-industry cooperation say that for firms cooperation with PROs may be as useful, sometimes even more, than cooperation with other firms (Arvanitis and Bolli, 2009; Belderbos *et al*., 2004b; Guliani and Arza, 2009; Bercovitz and Feldman, 2007). Still, science-industry cooperation does not seem to be among the most frequent or the most important types of firms' innovation cooperation.

In 2010, the share of Slovenian innovative firms engaged in innovation cooperation with universities was 49.1% and of those engaged in cooperation with government or public research institutes 31.9%.[4] This qualifies science-industry cooperation as less frequent type of innovation cooperation (see table in Appendix 1), in spite of the fact that the promotion of industry- science cooperation has been high on the innovation policy agenda. The situation in EU27 is similar and even at a lower level. It also seems that firms on average treat science-industry cooperation as less important than innovation cooperation with other partners. Only 16% of Slovenian firms with innovation cooperation claim that cooperation with universities is the most valuable to them while the corresponding share for cooperation with government or public research institutes is even lower, i.e. 10.3%.[5]

The objective of this paper is to analyse science-industry cooperation in Slovenia, more precisely to look at the motivation behind cooperation, to identify problems and obstacles on one and the other side, as well as in innovation policy and institutional framework. Finally, we suggest what should be done at science, business and government level to intensify the science-industry cooperation with the ambition to achieve long-term growth based on innovation. In an environment of a small transition country, where in comparison to the bigger, more developed economies, limited R&D resources are available, it is imperative that cooperation of all existing scientific potential is stimulated. Of the countries that have joined EU in 2004-2007, Slovenia was the first transition country, which managed to join the group of *innovation followers* according to the IUS (EC, 2011). Also, according to World Economic Forum (WEF), only Slovenia is classified as a country in the innovation-driven stage of growth (WEF, 2007) of the 27 CEE/CIS countries ranked. Yet, the degree of cooperation between the public science sector and business R&D has been identified as one of the weaker elements of the country's innovation system by OECD (2011), ERAC (2010) as well as national evaluations (RISS, 2011) and thus a focus of several policy actions. The experience of Slovenia can therefore be of relevance to other smaller, research & innovation less intensive countries.

Based on the relevant theoretical considerations and existing empirical evidence we will test the hypotheses that frequency and extent of science industry cooperation depends

4 This has been quite an increase from 2004-2006 CIS data, when the corresponding shares were 19.4% and 13.2% respectively, as well as from 2006-2008 CIS, when the shares were added.

5 For 20.5% of firms performing innovation cooperation, the most valuable is innovation cooperation with suppliers, for 18.6% with clients or customers, for 9.6% with other firms within the group and for 9.2% with the competitors.

on: (i) the extent and nature of firms' in-house R&D and innovation activity, which also determine their absorption capacity, (ii) the existence of quality research and scientific productivity in PROs, critical mass of knowledge in specific areas of expertise, and on motivation of researchers, (iii) the development of a portfolio of intermediary institutions and their quality, and on (iv) the adequacy of national policy and institutional framework, supporting science industry cooperation.

The analysis is based on the three detailed case studies of science industry cooperation[6]. Each case is approached from both sides, i.e. concepts, motivation, problems, barriers etc. in individual cases are analysed from the perspective of firms and of the university/research institute. To the best of our knowledge this is the first such analysis for the transition countries of Central and Eastern European (CEE) countries and its conclusions may be of relevance for other small transition economies with a similar R&D potential.

The interviews convey two main messages. The first is that it is the lack of companies with in-house R&D activities which is the main structural deficit for more intensive science-industry cooperation. Strengthening of firms' in-house R&D departments and staff, and clustering of firms around the most propulsive ones is the precondition and possibly most effective measure for more science-industry cooperation. The second is that there are no fast breakthroughs in science-industry cooperation; successful cooperation can only be developed gradually, from specific small initial tasks to a more comprehensive collaboration. Also, case studies reflect no impact of the intermediary institutions on science-industry cooperation.

The paper is structured as follows. Introduction is followed by a short overview of theoretical considerations and empirical evidence on science industry cooperation in section two. Section three presents the cases, where each case first presents main features, motivation and development of innovation, then determinants and problems of cooperation. Section four concludes with suggestions of the measures for strengthening innovation capacity and science industry cooperation.

2. THEORETICAL CONSIDERATIONS AND EMPIRICAL EVIDENCE

Among the most prominent theoretical concepts of science industry cooperation is the so called Triple Helix Model by Etzkowitz and Leydesdorff (1997), and Viale and Etzkowitz (2010) which points to the new relationships between business, university and government, and claims that academia should be closely integrated with the industrial world (Eun *et al.*, 2006). Yet we also have a different view of the New Economics of Science (Dasgupta and David, 1994) and some others (Mowery and Sampat, 2004; Lundvall, 2002) who are concerned by a too close integration of science into industry and opt for a proper division of labour between the two. The latter view is based on the recognition

6 Several other research projects have been implemented by the authors, where industry-science R&D cooperation has been analysed- from the perspective of public R&D organisations (Mali et al, 2004), analysis based on case studies of 22 export-oriented R&D intensive companies (Bučar, 2010), analysis of intermediary organisations and innovation policy measures (Jaklič et al, 2012), etc. The outcomes of these led to the approach applied in this paper: simultaneous analysis of three cases of R&D cooperation from the perspective of PRO as well as of the enterprise.

that science and industry are two distinctively organized and functionally differentiated spheres (Dasgupta and David, 1994), and that norms of science and industry differ very much. In this paper, we take a more pragmatic perspective of context-specific perspective of science-industry relationship developed by Eun *et al*. (2006) in which the relationship depends on country specific economic conditions and where the basic determinants of relationship are internal resources of university, absorptive capacity of industrial firms and existence of intermediary institutions.

2.1. Science-industry cooperation: firms' view

Existing studies identify one or more of the following benefits of science-industry collaboration for firms: (i) access to state-of-the art knowledge and information, (ii) developing new products/processes, (iii) maintaining relationship with university researchers, (iv) access to students as potential employees, (v) increased patenting (Lee, 2000; Venniker and Jongbloed, 2002; Belderbos *et al*., 2004a). For CEE countries, Radošević (2011:373) also cites that universities and research institutes provide access to equipment to test the raw materials and finished products' quality.

List of factors that determine the motivation of firms for science industry cooperation is quite long, far the most often quoted being in-house R&D and absorption capacity, appropriability conditions and the nature of firm's R&D and innovation activity. *Firms' in-house R&D and their absorption capacity in general* – denoted by own R&D, level of technology, human capital - is definitely the main determinant which increases firms' propensity for R&D cooperation with universities (Arvanitis and Bolli, 2009; Giuliani and Arza, 2009; Kodama, 2008; Bercovitz and Feldman, 2007).

Nature of firm's in-house R&D and innovation activity is the next determinant of its cooperation with university. Firms that are more engaged in basic exploratory research, have higher knowledge base and introduce more advanced innovations tend to cooperate with universities (see Bercovitz and Feldman, 2007; Giuliani and Arza, 2009). For Bolli and Woerter (2011) firms' university cooperation corresponds to product innovation and hence quality competition, while cooperation with competitors lead to process innovations and therefore relates to price competition.

A number of other firm- related factors are also claimed to have the impact on cooperation with universities, i.e. firm's size, firm's propensity to innovation cooperation as such and its openness to external environment in general, extent of public funding, industry specific characteristics, individual characteristics of the researchers involved, and institutional environment in which knowledge is produced and used (Arvanitis and Bolli, 2009; Cassiman and Veugelers, 2002; Veugelers and Cassiman, 2005). Extent of public funding or joint participation of universities and firms in national R&D projects have proved to be another factor in favour of more science industry cooperation (Arvanitis and Bolli, 2009; Jensen *et al*., 2010).

2.2. Science-industry cooperation: science's view

Universities may benefit from collaboration with industry in several ways: (i) getting access to additional research funding, (ii) additional equipment and facilities, (iii) additional information and data, (iv) increased number of publications and innovations, (v) better insights into their own research and access to new research problems, (vi) channel for knowledge transfer, (vii) improved quality of teaching and providing students with insights in industry research, (viii) securing funds and improved job opportunities for their students (Lee, 2000; Venniker and Jongbloed, 2002).

Quality of university research, motivation of academic researchers and intermediating mechanisms are the main determinants of science- industry cooperation on university side. Empirical evidence suggests a positive relationship between *academics' research quality* and commercialization of research activities (Perkman *et al*., 2011; Van Looy *et al*., 2011).

Motivation of universities, i.e. university researchers for cooperation with industry is often hindered by the fact that science and industry are still two distinctively organized and functionally differentiated spheres, where norms and values differ very much. Lam (2011) claims that a diversity of motivations exists, where many university researchers cooperate for the reputational and intrinsic reasons with financial rewards playing a relatively small part. D'Este and Patel (2007) add that individual characteristics of researchers may be more important than characteristics of their departments or universities.

2.3. Science-industry cooperation: the role of intermediary institutions

In analysing barriers to university-industry collaboration, Bruneel *et al.* (2010) distinguish orientation-related differences from transaction-related barriers (conflicts over intellectual property, dealing with university administration). They find that prior experience of collaborative research lowers orientation related barriers, that greater levels of trust reduce both types of barriers, and that breadth of interaction diminishes orientation-related but increases transaction-related barriers. Inter-organizational trust is claimed to be one of the strongest mechanisms for lowering the barriers to interaction between universities and industry. 'Building trust between academics and industrial practitioners requires long-term investment in interactions, based on mutual understanding about different incentive systems and goals. It also necessitates a focus on face-to-face contacts between industry and academia, initiated through personal referrals and sustained by repeated interactions' (Bruneel *et al*., 2006: 867). Similarly, Balconi and Laboranti (2006) find that university industry cooperation is based on teams of researchers on both sides; strong connections are associated with high scientific performance, cognitive proximity and personal relationships.

A number of other authors point to the importance of intermediary institutions between university and industry. Universities with established policies and procedures for the management of technology transfer (technology transfer offices, science parks) perform better as far as science industry cooperation is concerned (Caldera and Debande, 2010). Staff employed by the intermediaries is also important. Conti and Gaule (2011) claim that one of the reasons why US outperform Europe in university technology licensing is that US technology transfer officers employ more staff with experience in industry.

3. MAIN FEATURES OF THE ANALYSED CASE STUDIES OF SCIENCE INDUSTRY COOPERATION

The above overview puts forward the following propositions to be tested by the case studies. Frequency and extent of science industry cooperation depends on: (i) firms, i.e. on the extent and nature of firms' in-house R&D and innovation activity, which also determine their absorption capacity, (ii) universities[7], i.e. existence of quality research and scientific productivity in PROs, on critical mass of knowledge in specific areas of expertise, and on motivation of researchers, (iii) intermediaries, i.e. on development of a portfolio of intermediary institutions (such as technology transfer offices, technology parks and centres, incubators and development agencies) and their quality, and on (iv) adequacy of national policy and institutional framework, supporting science industry cooperation.

We analyse three cases of science-industry cooperation, one in chemical, one in pharmaceutical and one in food-processing industry. Each case can be characterised by a different level of research intensity of the firm as well as the size of firm. On the PRO side, we have both, a public research institute as well as university departments. In each case, partners from both sides have been interviewed, based on a semi-structured questionnaire covering six main topics:

a/ Main features of the cooperation project: (i) motivation, (ii) objectives, (iii) development of cooperation, (iv) realisation of expectations;

b/ Conditions for science-industry cooperation: (i) relevance of existing conditions for cooperation in the particular case, (ii) criteria in seeking cooperation partners, (iii) main strengths, weaknesses and difficulties of cooperation, (iv) do innovation system characteristics support science industry cooperation or not, (v) what is the explanation for the current state of science-industry cooperation;

c/ Guiding principles of science-industry cooperation: (i) who should set the targets of cooperation, (ii) the most important criteria for the success of cooperation, (iii) how should the success be assessed;

d/ What has been the most important knowledge in the particular case of cooperation: (i) which type of knowledge: tacit or codified – is more important for the particular case, (ii) how important are different ways of knowledge creation; do partners have different views on that;

e/ Measures for improving innovation capacities in a particular sector: (i) areas in a particular sector where the innovation capacity is assessed as weak and the reasons for this, (ii) what measures should/could be introduced in the particular company/PRO to improve innovation capacity;

f/ What must science and industry change/do in order to improve cooperation: (i) which strategies should be implemented at the level of national innovation system to improve the exchange between science and industry, (ii) good and bad examples of cooperation and the reasons behind them (iii) how supportive was the innovation infrastructure in facilitating cooperation?

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7 The case studies include also cooperation with public research institutes, so we apply the term public research organisations- PROs throughout the text.

The interviews were carried out in 2009 and 2010. For the list of interviewees and partner institutions see Appendix 2.

3.1. Case 1: Cooperation in the field of structural determinations and texture analysis of pharmaceutical products

3.1.1. Main features, motivation and development of cooperation

Case 1 analyses cooperation between the Laboratory for Inorganic Chemistry and Technology of the National Institute of Chemistry Slovenia (referred in the text as the Laboratory) and Krka, a generic producer of pharmaceuticals, one of the largest companies in Slovenia with EUR 1,010 million of sales, EUR 171 million of net profit, 8,569 employees and 9.0% share of R&D expenditures in sales[8]. Chemical and especially pharmaceutical sectors are among the most R&D and innovation intensive sectors in Slovenia. For the pharmaceutical sector, permanent R&D and innovation is a *sine qua non* of existence. The same is true for chemistry and pharmaceuticals as a science. National Institute of Chemistry is the second largest research institution in Slovenia with 269 researchers, being among the most prominent in Slovenia in terms of publications and citations.

Krka has a big R&D department, clearly set R&D objectives and invests significant amount in R&D in pharmaceuticals. On the other hand, pharmaceuticals are not among the Laboratory's basic activities. This determines the nature of cooperation, which is focused on very specific tasks, i.e. the use of Laboratory's Nuclear Magnetic Resonance (NMR) in analysing structural determinations and texture analysis of pharmaceutical products. This is necessary to assess whether Krka's generic medicines fulfil the patenting requirements. According to Krka's Director of Research, the Laboratory is capable of providing Krka with specific analytical work, which is closely supervised by Krka's internal research team. Krka assesses Laboratory's cooperation as highly beneficial. The Laboratory possesses equipment for specific testing purpose not available in Krka, excellent knowledge of a specific analytical technique and has specific knowledge/ skills, which are insufficiently available in Krka. Basic principle of cooperation is team work of Krka's and Laboratory's staff; this leads to significant level of cross-fertilisation of knowledge. The nature of work dictates very close cooperation on a daily basis with continuous monitoring of progress and active participation of research teams. Officially the cooperation is regulated through five-year framework contract between the Laboratory (and not the National Institute of Chemistry) and Krka, which gets annexed with specific annual programme of cooperation.

Both Krka and Laboratory have comprehensive science-industry cooperation with other partners as well. Krka has a well-developed cooperation with various universities and R&D institutes in Slovenia and abroad. High R&D intensity of pharmaceuticals and the fact that R&D contents need to be well protected to avoid leakage of sensitive information determine company's cooperation with science. The nature of Krka's activity calls for a systematic development of all phases of the research process: (i) from the basic research, which is mainly done

8 Data for 2010, http://www.krka.si/media/prk/dokumenti/5200_krka_annual_report_2010_slo_200611.pdf

internally due to highly specific knowledge required, (ii) to several testing phases, which are carried out internally and/or in close cooperation with specialised scientific institutions, and (iii) to monitoring of the quality, where again very specific external knowledge is being sought.

The most important criteria in Krka's search and selection of partners from PROs are the type and quality of service/ specific knowledge, which can be provided. Krka's long experience in cooperation with PROs in Slovenia puts it in a position of a well-informed partner, who knows where the specific capacities and expertise is and how they can be best employed. Krka's systematic support of certain research areas has long-term effect in joint research projects development. In cases where the type of knowledge needed cannot be provided in Slovenia, Krka has a wide network of R&D partners in different countries. In each case of R&D outsourcing, cooperation is started on a relatively small, well defined topic, which, if results being satisfactory, has later evolved in a more permanent and broader cooperation. Since cooperations are carefully entered into and develop only after satisfactory 'trial deals', Krka experiences high satisfaction in cooperation with PROs. This was also the case with the National Institute of Chemistry, where Krka has cooperation agreements with several laboratories. Still, the PRO's responsiveness is sometimes less than required due to the relatively small size of human resources in public R&D sector in the specific topics that Krka needs.

3.1.2. Determinants and problems of cooperation

Krka's involvement in science-industry cooperation is decisively influenced by its own intensive R&D activity and by R&D nature of the sector in which cooperation with science is a must. Also, Krka needs to have a very active recruitment policy and uses several different ways to secure sufficient inflow of human resources: different scholarships, competitions for best research studies and diploma works at the universities as well as direct cooperation with professors and researchers.

The basic precondition for cooperation on the science side is the underlying philosophy of the Laboratory that it is its duty as a PRO to cooperate with industry, which differs from the more common approach of Slovenian PROs who often set their R&D priorities without taking into account the needs of the industry. Consequently, Slovenian researchers in PROs are often not specialised enough, which results in difficulties to respond to the specific needs of the industry.

Objectives setting and mutual understanding of partners. Krka's Director of Research is very well aware that industry and science have different objectives in cooperation. People from the science sector are pressed for the bibliometric results, while researchers in industry need to apply the research results in production as quickly as possible to secure competitive position. In its science-industry cooperation, Krka clearly is a dominant partner. The goals and the contents of cooperation contracts with PROs are set by Krka. For Krka, the ultimate aim of cooperation is that it contributes to the introduction of new and/ or improved products and processes. Krka expects its science partners to respond in reasonably short time, be flexible and have a high level of knowledge and expertise. Ability to participate in a team work in developing new knowledge and adjustability of the researchers is crucial; this is often achieved best by continuous exchange of personnel or by close interaction of the key personnel from both partners working on a particular issue.

In cooperation with industry, the Laboratory looks for establishment of joint R&D capacities, sharing of R&D costs, experiences for students and practical verification of theoretical findings. Of course, money is important as well: 20% of Laboratory's budget comes from cooperation with industry. Laboratory's experience is that the cooperation is based primarily on well-identified needs and objectives of firm, which is a starting point of any science-industry cooperation. Both Krka's Director of Research and Head of the Laboratory stress the importance of gradual building of cooperation. Most of Laboratory's cooperation with industry began rather informally/ spontaneously and has developed gradually.

The leading role of Krka in the cooperation is reflected also in its attitude to the knowledge resulting from the cooperation. In pharmaceuticals, the codified knowledge is of crucial importance. Krka has built in specific clause in all its cooperation agreements to protect the knowledge derived from joint R&D work. Krka expects its partners to act accordingly. In the case of science partners' research papers, their publication is often delayed to account for the time of obtaining the patent and is always pre-checked by the company.

3.1.3. Relevance of innovation policy measures

The cooperation in this case has developed with no support from the government, even though both partners apply to various programmes under R&D and innovation policy. Krka does not need outside intermediary institutions due to the strength of its in-house R&D unit who has, as already mentioned a good overview of the scientific capacities at PROs in the country. One of the key problems identified by both partners is the irregularity in government's announcements and funding of support measures like co-financing of joint R&D projects. For a firm, which strategically depends on research inputs, the stability, transparency and regularity of available support measures is a key determinant of their effectiveness. This is why the programme of financing Young Researchers[9] has been assessed as one of the most beneficial also from the science- industry cooperation point of view.

3.2. Case 2: Cooperation in the field of improving animal meat quality, with the aim of producing meat with enriched nutritive fatty acids

3.2.1. Main features, motivation and development of cooperation

Case 2 analyses cooperation between Department of Animal Science, Faculty of Agriculture of the University of Zagreb (Croatia) and Emona RCP - Nutrition Research and Development Department of Jata Emona, which employs 265 people and is involved in the production and distribution of feeds for all domestic animal species, including various

9 The scheme has financed postgraduate study and research training for young researchers and enabled people from firms to go into the science sector for a certain period of time for M.A. or Ph. D. A candidate had to work on a particular research project within a firm, but received mentorship support at the public R&D unit (for more see http://cordis.europa.eu/erawatch/index.cfm?fuseaction=search.resultList).

sorts of mixtures and vitamin enriched feeds. Cooperation was initiated by Emona RCP. The project looks into different impact feeds may have on the quality of meat with particular aim of enriching the animal feeds to produce more Omega 3 fatty acids in the animal's meat. Within cooperation Emona RCP has been primarily involved in the research on appropriate mixtures of feeds, while the task of the Department has been to investigate the influence of different corn varieties in the diet of pigs on pork fatty acid composition.

3.2.2. Determinants and problems of cooperation

The interviewees recognise the need for science-industry cooperation in food-processing industry and acknowledge that existing science-industry links in the sector are very weak. They identify a number of barriers to more science-industry cooperation within the industry and the science sectors, in their mutual perception and relationship.

Industry sector barriers. In Slovenia, agriculture and food processing have traditionally been treated as low-tech, low value-added industries where R&D has a limited role to play. There is no tradition of science-industry cooperation in Slovenian food processing sector and no dedicated intermediaries. The main barriers to more R&D and innovation in Slovenian agriculture and food processing firms are: (i) small size of firms, (ii) lack of R&D and innovation activities, of awareness of the need for R&D and of its potential contribution, (iii) small number of in-house R&D units in firms; (iv) inadequate financial instruments for R&D in food processing. Lack of R&D units seriously limits the opportunities for science-industry cooperation. The interest in most firms lies with cost reduction applications and relatively routine improvements in the processes. Their "R&D" or development departments mostly perform routine procedures, like quality control and testing. Investing in knowledge is not seen as a factor of competitive strategy. Jata Emona is no exception in this regard. Even the existing knowledge or capability to produce new knowledge by its own research unit-Emona RCP is not yet seen as company's competitive advantage.

Science sector barriers. On the science side, two distinctive factors inhibit science-industry cooperation. The first is that Slovenian food technology science is predominantly concentrated at the Biotechnical Faculty of the University of Ljubljana. The people there are overloaded with teaching and publishing, with little motivation to do research/ consulting work for industry. The second factor is the lack of opportunities for human resource flows from science to industry sector. Slovenia simply does not have sufficiently large food processing firms to offer attractive career to highly educated people who could form in-house R&D base.

Objectives setting and mutual understanding of partners. According to Emona RCP and the Department, objectives of cooperation are quite different for each partner. Science sector looks for good internationally published papers, participation at international symposia, some additional financing, maybe also some teaching material. The research team in a business R&D unit must always think of finding practical applicable solutions, and finally of the maximisation of economic returns. Therefore it is of crucial importance to establish mutual understanding and trust between partners. In the case of cooperation between Emona RCP and the Department mutual understanding seems to be adequately established. At the science side, the empirical results of the project were used by the PhD candidate to complete his dissertation. At the business sector side, the expertise developed during the empirical research helped to develop new products and increase competitiveness. According to Emona RCP, successful cooperation projects work in the following way: testing enables the partner(s) at the university to generate empirically based research, suitable for publication, on one hand, and brings a working solution to the industrial process, on the other. The key determinant of the success is the ability of business R&D unit to act as an intermediary between the PRO and the firm. Cooperation of Emona RCP with different PROs has developed through years, first on the personal basis (researcher to researcher) and then upgraded into institutional cooperation in specific projects.

The messages of Emona RCP – Department cooperation are that: (i) productive cooperation does not develop quickly or easily. Good cooperation can only be found where the partnership has been developing over a longer period of time, where both sides have learned to understand each other; (ii) competent R&D unit in a firm, with a good understanding of the potential of theoretical advancements for practical purposes and a good knowledge of the complexity of production process and its economics is the main factor in establishing mutual understanding between science and industry; (iii) objectives and targets of science-industry cooperation should primarily be formulated and set by the industry side. Within this context partners must come to a clear understanding of each others' objectives. Objectives of each side need to be recognised and respected by the other side. Joint work should be designed in way that both sides meet their objectives. Only in such way both sides benefit.

3.2.3. Relevance of innovation policy measures

The awareness of the existence of policy measures, which could support their cooperation, was particularly low in this case. Partly, this can be attributed to the fact that often innovation measures exclude agriculture and food processing industry as the recipient sector. On the other hand, the interviewees mentioned that they believe their cooperation is so specific that it would not fit under standard joint-research project classification. According to Emona RCP, no intermediary institution is focusing on promotion of cooperation in the food processing sector or has the adequate knowledge in the field to act as such.

3.3. Case 3: Cooperation in the field of development of melamine-based foam

3.3.1. Main features, motivation and development of cooperation

Case 3 analyses cooperation between the Department of the Polymer Engineering, Organic Chemical Technology and Material at the Faculty of Chemistry and Chemical Technology, University of Ljubljana (referred in the text as the Department) and chemical company Melamin. The cooperation under current contract began in 2002. Melamin manufactures melamine film sheets for finishing chipboards, resins, adhesives, synthetic sizing agents, impregnated textile materials for use in the footwear industry, has EUR 34.3 million of turnover and 192 employees. Cooperation is concentrated on the development of melamine-based foam and is formalised in a long-term contract.

Department at the University is involved in the basic research – collection of the relevant literature on the subject, analytical and laboratory phase of research – which is then used by Melamin's R&D Unit for the applied research. The cooperation includes human resource development aspect, i.e. Melamin's employees pursue their postgraduate studies at the Faculty of Chemistry and Chemical Technology, while young researchers from the Department can apply their theoretical research to empirical testing in Melamin for the purpose of their doctoral theses. The cooperation is characterised by its gradual evolvement around specifically agreed research topics.

Melamin has a long lasting cooperation with the University of Ljubljana, but initially the agreement was more a formality than contextually embedded in Melanin's production programme and Melamin's management was rather indifferent to science-industry cooperation. In 2002, today's Head of Melamin's R&D Unit joined the company. He completed his doctoral studies within the Young Researchers Programme under the mentorship of the Head of the Department. He proposed the establishment of cooperation of Melamin with the Department and succeeded to change the attitude of Melamin's management.

At approximately the same time, Melamin launched a new development concept, based on two basic premises. The first had been that all the products should be based on the same raw material to increase the amount of the raw materials purchased and consequently decrease per unit purchasing prices. The second premise had been to diversify end products and increase the value added. Here, the R&D Unit was expected to play the key role. The in- house R&D capability was insufficient to meet the new requests, therefore Melamin leaned on the cooperation with the Department. The crucial push was the previous acquaintance between the Head of Melamin's R&D Unit and the Department. The Head of the Department had previous experience in a business sector and was well aware of what kind of services a company needs from science. On the other hand, Head of Melamin's R&D Unit understood the motivation of science sector to enter into cooperation with industry. Mutual interest and acquaintance have been the crucial factors for launching and maintaining successful cooperation.

What the Department sees as the most beneficial aspect of the cooperation is the ability to earn extra resources for R&D equipment. The possibility to work on specific topics through the entire process, i.e. from the definition of the problem, search for the theoretical solutions to developing a response in practice and testing it, is also important. In short, researchers at the university have the opportunity to test their ideas in practice and to increase the quantity and quality of publishable results.

3.3.2. Determinants and problems of cooperation

Industry sector barriers. According to the Head of Melamin's R&D Unit, the main structural problem for strengthening science-industry cooperation in Slovenia is low R&D

capacity of Slovenian firms. Consequently, PROs in Slovenia find it difficult to get interested partners in the industry sector. Low industry R&D activity and limited existence of in-house R&D units in the business sector is a significant barrier to science-industry cooperation because it is precisely these units which provide a necessary impetus and absorption capacity for cooperation with science.

Another industry related barrier to more science-industry cooperation is prevailing short-term perspective in most Slovenian firms. Only a direct solution to immediate production problems is considered by the management as valuable research. They expect the cooperation to focus more on a day-to-day business and not as a process of opening up new venues for increasing competitiveness.

Science sector barriers. Structural problems of science sector are no less important barrier to science-industry cooperation. Systematic marketing of own knowledge is not at all present in PROs and existing institutional framework at universities does not support cooperation with industry. The current system lacks incentives and infrastructure for establishing the links with industry. The interviewees suggest that cooperation between universities and firms has to be established and coordinated at the highest level, if cooperation with industry is to be developed. Current attempts are far from satisfactory. The organisational set-up of, for example, the University of Ljubljana with its decentralised, highly differentiated and heterogeneous members (Faculties) cannot be served by a common Technology Transfer Office, which would coordinate marketing of university scientific capabilities[10.] At best, the University should have some broad long-term agreements with larger Slovenian firms which are important R&D investors. This would ease building up of specific science-industry partnerships at lower levels. The lack of university level support was identified as a problem also in negotiating the cooperation contract. For a single relatively small unit at one faculty it is very difficult to competently negotiate specific legal and commercial terms of the contract.

Objectives setting and mutual understanding of partners. Structural differences may result in problems of mutual understanding in setting of cooperation objectives, i.e. what kind of knowledge PROs can provide to firms. In a number of instances, the Department has been told by the firms that they received 'a lot of paper' with the results given at too theoretical level and were impossible to implement. Yet, one has to be aware that only the firms can be really specific in applied R&D work, developing innovative products for the market. Having in-house R&D department in a company is therefore necessary for successful science-industry collaboration.

Productive cooperation between science and industry does not develop quickly or easily. Much of the success in cooperation depends on good trustworthy personal relationships, which are even more important in the cases where there are few institutional guidelines for a more formalised agreement. The Department – Melamin case is the best example of this. Still, good mutual understanding is not a substitute for a more formal agreement, where issues like ownership of research equipment, patents, commercial impact of new findings etc. are more precisely defined.

10 The University of Ljubljana established in 2007 an office dedicated to promotion of cooperation with business firms, called Institute for Innovation and Development (http://www.iri.uni-lj.si/eng/). Yet the Institute is still not seen by the members of the University as their representative in dealing with the business sector, since at times even competes for the same public research sources.

The interviewees agree that the objectives of science-industry cooperation should be set by industry, but in cooperation with science. At the end of the day it is the industry who applies the innovation/ new technological solutions. PROs should assist the industry in setting these objectives. This, however, does not mean that science partner does not have its own cooperation objectives. The work should be shared and designed in a way that both sides are able to achieve their objectives. A clear understanding of each other's objectives, and respect for these, need to be a starting point in establishing the cooperation. The difference in the cooperation objectives of science and industry is clearly visible in the agreement between the Department and Melamin. The agreement specifies that all the knowledge resulting from the cooperation is the ownership of Melamin. The Department goes only up to the laboratory phase of product development, further on it is the Melamin who leads the game. The Department can publish all the results of its basic research arising from cooperation, but this includes only the data until the end of the laboratory phase. The Department always sends the scientific papers to be published for approval to Melamin. Melamin has patented some of its solutions. There have never been any ideas about joint patenting; the Department also does not have enough resources to assume financial obligations and risks of patenting and is not really interested in patenting. The interest of the Department is elsewhere, i.e. in getting additional financial resources, in publishing and in training of its staff.

3.3.3. Relevance of innovation policy measures

Melamin has been aware of some of the policy measures, but has seldom applied for support. Similar complaint was voiced as in Case 1: irregularity, frequent changes in the conditionality, heavy bureaucracy, selection criteria not adjusted to business needs. On the side of the Department, criticism was directed to the insufficient support of science-industry cooperation at the University, where the established intermediary institution is not seen as adequate. Also, broader research system conditions (research evaluation criteria) are not supportive, but in fact often negatively affect the motivation for cooperation.

4. MAIN FINDINGS AND CONCLUSION

The case studies confirm the propositions of existing literature as to the motivation for cooperation:

a/ Frequency and intensity of science-industry cooperation depends on the extent and nature of firms' in-house R&D and innovation activity;
b/ Absorption capacity of business sector is an important determinant of the intensity of cooperation;
c/ Nature of in-house R&D has important impact on the selection of cooperation partners: the more basic research is the more room is there for PROs as cooperation partners,
d/ Existence of critical mass of knowledge and quality research at the PROs, as well as PROS' flexibility to adjust to the needs of firms.

Table 1: *Summary of findings in case studies*

Case		Size	Motives	Benefits	Barriers	Specific comments
Case 1: Krka and Institute of Chemistry	Partner from industry	Large, high R&D intensive	A need for specific knowledge to complement in house resources	Possibility to tap into additional pool of knowledge on a regular basis	Response time	Systematic approach to development of several partnerships with PROs
	Partner from PRO	Large- second largest public research institute in Slovenia	Additional resources	Practical experience for young researchers; involvement in state of the art applied research	Need to maintain non-disclosure policy, causing certain lag in publishing scientific papers	Insufficient incentive for personnel in PROs to engage in cooperation with business sector
Case 2: Jata Emona and agriculture faculty	Partner from industry	Medium sized, less intensive R&D sector	A need to perform basic research to complement testing performed in company	Joint research and development of successful new formula	Lack of financial resources to implement knowledge transfer	High quality cooperation in R&D less intensive sector
	Partner from PRO	Large, yet underfinanced	Ability to participate in large-scale R&D project	Obtaining new knowledge	Low capital intensity of industrial partner prolonged application in practice	External factors (financial difficulties of parent company) nearly jeopardised entire project
Case 3: Melamin and Faculty of Chemistry and	Partner from industry	Medium, R&D medium intensive sector	Need to develop new products	Several new products, even patents	Distrust of top management towards PROs	A need fot restructuring of production process resulted in turning to R&D and innovation as sources of growth
	Partner from PRO	Small	Financial resources to renew research equipment	High quality scientific paper(s); young researcher	Difference in objectives of partners	Young research programme was detrimental for the start of cooperation

* While the Faculty/University should be classified as large, the cooperation was implemented with the Department as an independent partner/beneficiary.

In our cases, the motivation on the side of PROs is fully compatible with the theory: additional funding is the major motive, followed by access to specific empirical data which can result in publications. Also, a possibility to provide employment opportunity to graduate students is seen as important benefit of science- industry cooperation.

The case studies show remarkably high consensus among the interviewees on the determinants, problems and other aspects of science industry cooperation, regardless of the fact that they come from very different industrial sectors. The interviewed partners are relatively satisfied with the cooperation and the results have mostly met their expectations. Still, they notice a lot of barriers to more fruitful and intensive science-industry cooperation and have expressed quite a pessimistic view of science-industry cooperation in Slovenia in general. They propose a number of changes, improvements and novelties in measures for strengthening science-industry cooperation. Below, we briefly present the most important conclusions and suggestions.

Probably the strongest message of the cases is that increasing the number of companies with R&D activities is a precondition for strengthening of science-industry cooperation. R&D capacity of most of Slovenian firms is still low. To address this structural deficit, the government policy has been to offer R&D tax subsidies, yet this measure, while welcome by larger R&D investors (like Krka in our case studies), does little for the firms with no R&D units. Support to industry clusters was suggested by both the industry as well as science representatives. Clustering around the more propulsive firms may have a positive impact on other firms, which are their suppliers and customers. In the past, Slovenia had a measure co-financing cluster formation, but had decided to discontinue the support.[11]

Strengthening of firms' absorption capacity through in-house R&D departments and R&D staff is necessary to intensify the cooperation. Relatively small number of such units in Slovenian firms undermines the potential for science-industry cooperation. To address this, various measures have been designed by the government (mobility schemes, interdisciplinary research teams, young researchers from industry), but our finding was that these measures were not known to the business sector or were assessed as too bureaucratic. This inappropriate supportis of particular importance for the vast majority of small and medium-sized enterprises (SMEs), where one cannot expect them to have their own R&D departments. To increase innovation (cooperation) absorption capacity in SMEs without own R&D capacities, clustering around the more propulsive and R&D active firms may be promoted. Another possibility is to promote university spin-off firms for this particular function.

On the science side, there is a problem of insufficient capacities for cooperation with industry. PROs need more flexible institutional solutions in support of specific needs of science-industry collaboration. Possible solutions are: allow/ promote establishing of spin-off firm(s) by PROs for business oriented R&D; promote short-term mobility to solve a particular problem in a company (or even to introduce a mandatory mobility for certain professions); introduce 'non-technical' content in the S&T university programmes, in

11 See Inno Policy Trendchart Report on Slovenia, 2008.

particular economic, business and legal aspects of R&D. Improved and more transparent organisational set-up at the university level is needed, where systematic promotion of the science-industry cooperation should be undertaken at the top echelons; university promotion criteria should require practical experiences, resulting from work with companies. There is no systematic assisting of researchers or stimulating them in any way towards cooperation. Such initiatives are left entirely to individuals who have the ambition and personal affinity to work with industry.

Promotion of science-industry cooperation is also not incorporated in research projects evaluation. Evaluation of researchers, research programmes and/or projects and public research organisations is based primarily on the number of publications and citations. This results in a lack of interest among public researchers for co-operation with business sector. Current institutional framework also does not take sufficiently into account the specifics of the industrial R&D units. Such units cannot compete for the research project funding at the same public calls with the public R&D institutions, if the most important criteria in the selection process are the standard scientific criteria. At least for the applied research co-financing, the positive experience of implementing R&D projects and translating them to innovation should be valued as equally important as publishing activity for the public R&D units. Overall, the cooperation with industry should have a higher impact on the ranking of the researchers.

A common message in all analysed cases is that successful science- industry cooperation can only be developed gradually, from specific small initial tasks to a more comprehensive collaboration, most often on the basis of previous personal contacts between main actors on both sides. It is the industry who should have the main role in the cooperation objectives setting, but objectives should be set jointly in an atmosphere of mutual understanding, where both sides feel that the cooperation will help them fulfil their goals. The partners need to overcome the prejudice and move beyond stereotypes.

The case studies reflect no impact of the intermediary institutions on science- industry cooperation. While Slovenia has followed the example of other countries with a more developed innovation system and has established technology parks and centres, incubators and development agencies (Bučar, 2010), it seems that their overall impact is still not felt by either community: business or the science one. This confirms the findings of Radošević (2011), that the focus of CEE/CIS countries on providing support to "linkage capabilities" is a policy failure: …*"current bridging policies are basically trying to link weak enterprises with unreformed universities and PROs. Links are only as strong as the actors they connect."* (ibid; 376). Instead of copy-paste measures from advanced countries, Slovenia, as well as other CEE countries, needs to assess their own specifics and design measures in accordance with characteristics of their national innovation system. As identified through our case studies, strengthening in-house R&D capabilities of firms as well as reorganizing PROs so as to be better capable of cooperating with business sector is much more important in innovation policy then the support to intermediary institutions. This is especially relevant, if one tackles the innovation deficit of most SMEs by stimulating them to cluster around R&D active firms or spin-off firms or form joint research centres with PROs- like this was done in 2010-2013 period with centres of competence[12]. Also, more detailed research in the future should examine the R&D and innovation capability in business sector and evaluate the factors determining its strengths and weaknesses.

Current Slovenian R&D and innovation policy seems to have serious delivery problems. The most important are the following:

- Low visibility of measures. The interviewees show little or no awareness of the available measures for strengthening science-industry cooperation, especially the business sector representatives.
- Heavy bureaucracy. The interviewees have complained of the bureaucracy accompanying R&D and innovation related measures. A significant mistrust is felt in the documentation required by the government agencies, asking for data not easily obtainable or of confidential nature. With the co-financing from the EU Structural Funds, the procedural details have gotten worse. Sometimes, the load of paper work turns away firms from application. Simplification, coordination and better visibility of the support measures is required.
- More specificity in policy measures creation. The nature of science-industry relationship is determined significantly by the development level of a particular sector (observe, for instance, differences between food and chemical sector in Slovenia), by the size of actors in a specific area (both the business and research capacities are highly heterogeneous in different areas) and by the very size of the country itself. Therefore, design of policy measure needs to be done with Slovenian specific needs in mind and not copy-paste from best practice in a more developed environment. One such example is the university technology transfer offices, which can be highly successful in the USA, but have only limited applicability in Slovenia (or other countries) due to different university system.
- The measures should focus not only on partnerships, but on support of capacity building as well. On one hand, increasing R&D and innovation capacity in business sector is needed, while on the other, strengthening the capacity for knowledge/technology transfer in PROs.
- Importance of mutual understanding and gradual building up of cooperation. Personal contacts, informal relationships, building alliances not through formal contracts, but step-by-step by acquiring cooperation experiences are of crucial importance. Support to various activities, where representatives of the two communities, science and business can meet each other and openly discuss the issues related to their cooperation, can be a valuable instrument.
- Policy stability and regularity of measures. Frequent changes in policies and support measures do not create a positive environment for cooperation. Stability in the innovation policy, in the evaluation criteria as well as in the support measures is what makes the framework more supportive to the risky undertakings like science-industry cooperation.

12 Within financial perspective 2007-2013 Slovenia with EU structural funds supported 7 centres of competence, where partners from industry formed joint research units with PROs to address their R&D needs.

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APPENDIX 1

Innovation activity and innovation cooperation by type of partners of Slovenian and EU27 firms in 2010 (CIS 7)

	Slovenia	*EU27*
Innovation active firms[a] as % of all firms	49.4%	52.9%
% of innovative firms engaged in any type of innovation cooperation	44.7%	25.4%
% of innovative firms engaged in innovation cooperation with[b]:		
Other firms within the firm group	30.2%	36.5%
Suppliers of equipment, materials, components or software	66.8%	59.5%
Clients or customers	60.6%	49.4%
Competitors or other firms of the same sector	30.0%	26.2%
Consultants, commercial labs, or private R&D institutes	49.3%	33.7%
Universities or other higher education institutions	49.1%	42.2%
Government or public research institutes	31.9%	24.1%

Source: Eurostat, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=inn_cis7_coop&lang=en (access Aug.1st, 2013).

a/ Firms with any kind of innovation.

b/ Cooperation with multiple actors can be selected.

APPENDIX 2

List of interviewees and partner institutions

Case 1

Krka develops innovative generic medicines, i.e. generic medicines with value added, which are the product of their own in-house knowledge. It is by far the most important company in Slovenia as far as R&D activities are concerned. Company's R&D unit employs 550 researchers with EUR 88.3 million of R&D expenditures, which is 9.3% of sales (2009 data). We interviewed the Director of Research Department Aleš Hvala, Ph.D. For more on Krka and its R&D see http://www.krka.biz/en/about-krka/company-presentation/.

Laboratory for Inorganic Chemistry and Technology of the National Institute of Chemistry Slovenia employs five researchers and three young researchers, employed on the basis of the so called Young Researchers programme of the Slovenian Research Agency (the institute on the other hand employs 285 people). Research activities of the Laboratory are concentrated on the investigations of porous materials (zeolitic materials, mesoporous materials and cement research) and on materials structural analysis (x-ray diffraction, nuclear magnetic resonance spectroscopy and X-ray absorption spectroscopy). We interviewed the Head of the Laboratory, Venčeslav Kavčič, Ph.D. For more on the National Institute of Chemistry see http://www.ki.si/index.php?id=117&L=1.

Case 2

Emona RCP – Nutrition Research and Development Department, Ljubljana is a R&D unit of the enterprise Jata Emona and is involved in various R&D projects in the area of human and animal nutrition. It employs eight people involved in research, testing and development of different solutions for their own company as well as other companies. We interviewed Head of Emona RCP Matjaž Červek, Ph.D. For more on Emona RCP see http://www.e-rcp.si/o_podjetju_angla.html, and on Jata Emona http://www.jata-emona.si/about_us.html.

Animal Science Department of the Faculty of Agriculture in Zagreb which employs thirteen people is involved in R&D projects in the area of genetics, physiology, breeding, selection and nutrition of animal and meat science. We interviewed professor Ivan Jurić, Ph.D, who is the main coordinator of the cooperation project Emona RCP. For more on Faculty of Agriculture of the University of Zagreb see http://www.agr.unizg.hr/en.

Case 3

Melamin's R&D Unit employs 20 people, approximately 10% of company total employment. The work of R&D Department is based on: (i) development of new products, (ii) modification of existing products because of the demands of the market, legislation or other demands, (iii) co-operation with buyers, (iv) co-operation with production management and the inspection of quality. We interviewed the Head of company's R&D Unit Igor Mihelič, Ph.D. For more on Melamin seehttp://www.melamin.si/en/.

Department of Polymer Engineering, Organic Chemical Technology and Materials at the Faculty of Chemistry and Chemical Technology, University of Ljubljana employs seven researchers and three young researchers, employed on the basis of the so called Young Researchers programme of the Slovenian Research Agency. We interviewed Head of the Department, professor Matjaz Krajnc, Ph.D.. For more on the Department see http://www.fkkt.uni-lj.si/en/departments-and-chairs/department-of-chemical-technology/chair-of-polymer-engineering-organic-chemical-technology-and-materials/