# Suradnja gospodarstva i znanosti u Hrvatskoj: stajalište znanstvenika

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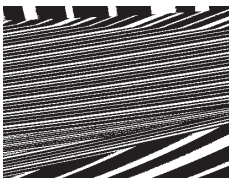

# INDUSTRY-SCIENCE COLLABORATION IN CROATIA: ACADEMICS' VIEW

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Industry-science relationship is considered to be a very important part of the innovation system and it represents one of the crucial factors in national innovation capacity. Extant studies show that a significant proportion of the products and processes that are currently sold and used could not have been developed without academic research. Both industry and academia can benefit from this relationship. Research focus in this paper is on interactions between science and the industry from the researchers' point of view based on field study in Croatia. This paper seeks to develop understanding of determinants of collaboration intensity with industry and scientists' satisfaction in this relationship. It explores scientists' motivations to collaborate and perceptions of barriers for collaboration as well as how they perceive the other side in this relationship. Research findings show strong scientist interest in the collaboration with industry. Significant motives that can explain their interest are intellectual challenge and additional income. Scientists find more powerful obstacles in their internal organizations than in external relationship with industry. They are persuaded that industry is not as interested in collaboration as they are. Less critical are those groups of scientists who have already built closer working ties with industry.

Key words: industry-science collaboration, innovations

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## INTRODUCTION

The role of research cooperation between industry and academic institutions has received increased attention in recent years, as industry-science relationship is considered to be one of the important parts of the innovation system. Some studies in developed economies show that a significant proportion of

the products and processes that are currently sold and used could not have been developed without academic research (Mansfield, 1998; Beise and Stahl, 1999). By collaborating with scientists firms gain ability to introduce products of a higher novelty level. Such innovative products can offer new benefits to users and even open up new markets, temporarily causing lucrative advantages of monopoly. Collaboration with scientists can also result in the creation of more efficient and innovative processes, which should positively reflect on the firm's ability to successfully compete on the market. Positive effects of industry-science collaboration are illustrated in several empirical studies. For example, Link and Bauer (1987a; 1897b; 1989) report positive effect of cooperative R&D on market share and absorptive capacity of firms with regard to their R&D activity. Loof and Brostrom (2004) and Zucker and Darby (2000) showed that university-industry collaboration has a significant and positive influence on innovative activity.

Industry is not the only party that tends to benefit from the collaboration. Academics also report positive effects of collaboration on their activities. Lee (2000) studied the perceptions that academics have of their gains from collaborating with industry. As reported in Carayol (2003), he showed that "a large majority, over 67% [of faculty members] say that they are experiencing substantial or considerable benefit to their academic research support by acquiring funds necessary to support graduate students and purchase lab equipment. Similarly, an equally large majority, over 66%, say that from research collaboration with industry they are gaining valuable insight into their research agendas. Over 56% also agree that they find an opportunity to field-test the practical application of their own research and theory". The new academic knowledge created in that way can be used again to help develop innovative products and processes.

Despite extensive evidence in the literature on the importance of partnering between university and industry, many researchers emphasize that our knowledge on the interaction between universities and the industry is still limited, and when it comes to issues such as systematic data analysis and the economic consequences associated with knowledge diffusion between universities and firms, very little is known (Loof and Berstrom, 2004). For example, we do not know much about motivations to collaborate and barriers to collaboration. For instance, one important barrier which has been widely acknowledged in promoting relationships between science and industry is that these are two worlds speaking different languages (Nauwelaers and Wintjes, 2001). The fact that these two groups have different perceptions and goals was shown in other studies (Radas, 2003; 2004). In order to create meaning-

ful and fruitful collaboration, both parties need to be motivated and recognize their benefit despite the differences in their goals and values.

This paper explores the motivations and barriers for industry-science relationship from the point of view of academics. We are interested in how research institutions view industry-science collaboration, and what they see as problems. We also explore how they perceive the other side in this relationship, and the impact this has on their interest for collaboration. With the aim to propose some recommendations for improvement, we discuss some potential incentives and assess their effectiveness. Finally, we explore the interest that scientists in research institutions have in forming their own start--ups, and investigate possible problems related to academic entrepreneurship.

The data comes from an empirical study that investigated industry-science relationship in Croatia in 2002. While the industry side of this relationship is investigated in Radas (2004), in this paper we focus on the academic side of the story. The paper is structured in the following way: section 2 contains literature review, section 3 reports on data collection and explains some basic data on collaboration, section 4 discusses motivations, section 5 talks about obstacles to collaboration, section 6 explores how desirable collaboration is, section 7 is about incentives for collaboration and finally section 8 summarizes all the findings.

## RELEVANT LITERATURE REVIEW

Surveying more than 100 academic scientists in the US, Lee (2000a) found that the most important reasons for collaborating were, in a decreasing frequency order: to secure funds for research assistants and laboratory equipment, to gain insight in one's own academic research, to test application of a theory, to supplement funds for one's own academic research. As secondary reasons academics reported the following: to assist university's outreach mission, to create student jobs and internships, to gain practical knowledge for teaching and to look for business opportunity. Similarly, in a study of German universities, Meyer-Krahmer and Schmoch (1998) showed that academic researchers perceive that the advantages of laboratories for interacting with industry lie mainly in obtaining additional funding and exchanging knowledge, while the disadvantages primarily reside in the short-term orientation of firms' agendas. In this paper we will examine whether motivations of Croatian scientists are similar to the ones reported in existing studies.

There is some evidence that collaboration with industry can alter academic research agendas and influence their pub-

lication record. Support to that fact is provided by several US studies. Cohen et al. (1994) in their well-known study first evidenced that collaborating with industry implied restrictions to publication. Blumenthal et al. (1996) showed that researchers receiving funding from industry reported more often that they took "commercial considerations" into account when they chose their research agendas and acknowledged more frequently that they were involved in "trade secrets" agreements. Lee (2000) shows that academic freedom is one of the concerns that academics have regarding cooperation with industry. However, it is not clear how much the considerations stemming from collaboration with industry negatively affect academic freedom, as there is no evidence that on average people who collaborate are less well published. For example, Blumenthal et al. (1997) show that even if involvement in science-industry collaborations is associated with data withholding, the latter is even more often correlated with having a high publication rate.

However, there is some evidence that academics researchers may feel positively toward industrial collaboration. For example, Dierdonck et al. (1990) examined the attitudes of the Belgian academic community towards university-industry technology transfers. They found that the academics were rather positive about the influence of linkages with the industry on their academic activities. The study showed that experience with industrial collaboration may affect the attitudes of academics toward industry in a positive direction. In this paper we will address this question for Croatia, namely we will examine how positively disposed Croatian scientists are toward the collaboration with industry, and how concerned they are about loss of academic freedom.

In developed countries, the industry-science relationships take place within one of the organizational forms of industry--science collaboration, such as university-industry research centers (Cohen et al., 1994; Santoro and Chakrabarti, 1999), and industry-science competence networks. University-industry research centers, which are partly funded by public funds and partly by interested industry, encourage diverse collaborative activities, have identifiable formal structures, and they have an explicit mission to transfer knowledge with industrial firms (Santoro and Chakrabarti, 2002). Activities in the centers usually encompass four interrelated areas: research support, cooperative research, knowledge transfer and technology transfer (Santoro and Chakrabarti, 2002). While centers are devoted to larger research areas, competence networks encompass research institutions and companies, and are created around a narrower research topic which is envisioned to find application in participating companies. Unfortunately

we can not examine these issues in Croatia, since there are no examples of such organizational structures. One explanation for such a situation is that industry is not interested in the creation of new products and processes; however it is very likely that the problem resides with both sides. To gain understanding of the academic side in that relationship, we focus on Croatian research institutions and assess their level of interest, and their perceptions of what motivates industry to seek them out.

Academic spin-offs present a particularly interesting way for academics to enter collaborations with business. University spin-offs are usually formed to commercialize technologies originating from publicly funded research institutions which take equity in the new firm. Such firms can effectively contribute to economic prosperity and job creation (Walter et al., 2005) through an influx of novel products that enable spin-offs to contribute to higher innovation capacity and efficiency of the country's industry (Rothwell and Dodgson, 1993). On the other hand, the research institution is benefited through their equity in the spin-off and additional newly created connections to the business sector.

## EMPIRICAL BACKGROUND

According to Croatian Ministry of Science classification, academic disciplines can be divided into 6 fields: technical sciences, natural sciences, biotechnical sciences, biomedicine, humanistic sciences and social sciences. In this study we consider only the first four groups of scientists, i.e. we exclude scientists from humanistic and social sciences. The reason for this exclusion is that traditionally in Croatia there has not been much collaboration between humanistic and social sciences and industry (Švarc et al., 1996).

The data for this study, which focuses on industry-science relationship in Croatia, was collected in the spring of 2002. Survey work was preceded by exploratory research, during which in-depth interviews were conducted with R&D directors from ten firms and with scientists from ten academic institutions. The topics of interviews were industry-science collaboration, motivations, perceptions of the other partner, and perceived impediments for collaboration. The purpose of exploratory research was to address the specific features of industry-science collaboration in Croatia. In the preparation for exploratory interviews current literature (Lee, 2000; Caloghirou et al., 2001) was used as a guide. On the bases of exploratory research a survey instrument was constructed. Questions that were asked in the large survey were based on the exploratory in-depth interviews. Highly structured ques-

tionnaires were distributed by e-mail to 120 chosen scientists out of which 95 responded. Scientists were chosen so that there is approximately the same number of people from each of the three academic levels (assistant, associate and full professor). The number of scientists from an institution was determined according to the institution's size. We included scientists from universities, public research institutes and private research institutes.

Before we go on to the data analysis, we define two variables that will appear more often in the text.

ACADINT is a variable that measures the scientists' interest for collaboration. Respondents were asked the question *Are scientists from your institution interested in collaboration with industry*? Answers were offered on the scale from 1 (not interested at all) to 5 (very interested).

FIRMINT is a variable that measures the firms' interest for collaboration as perceived by academics. Respondents were asked the question *Are Croatian firms interested in collaborating with your institution*? Answers were offered on the scale from 1 (not interested at all) to 5 (very interested).

Croatian firms report very weak ties and collaboration. For example, the recent 2004 Community Innovation Study on Croatian enterprises shows that out of 1272 firms participating in the study only 128 collaborate with Croatian research institutions on innovation development. Out of those that collaborate, 21.1% find the collaboration to be of low importance for innovation development, 37.5% find it to be of medium importance, while 41.4% report high importance of collaboration. From these results we can see that in innovation development very few Croatian firms have collaborative ties with academia. Broadly speaking, collaboration can happen outside of the domain of innovation. In those cases, according to Švarc et al. (1996), collaboration can be initiated by firms requiring routine services like testing, but even such routine collaboration is not very frequent in Croatia.

Is this lack of collaboration the result of low level of interest or something else? Since in this paper we view everything from the point of view of scientists, we start our examination of industry-science relationship by assessing how interested Croatian scientists are in collaborating. It is possible that scientists are interested, but that they perceive lack of interest from companies. As this might affect their enthusiasm, we also examine how academics perceive the industry's interest level. We investigate whether the expressed interest depends on the scientific discipline (Table 1).

Table 1 shows that on the scale from 1 to 5, scientists on average rate their interest in collaboration with industry as

3.87, which is significantly larger than 3 (t-value 7,65). Taking 3 as an average level of interest, this indicates that scientists express above average interest in the collaboration with industry, so the lack of interest from academia is not likely to be the cause for the established scarcity of collaboration. Among the four groups of scientists, the scientists in biotechnical sciences are the most interested in collaboration and they perceive the largest interest from the industry. This most likely reflects potential and attractiveness of that branch of science.

TABLE 1
Basic interest in collaboration by different science groups

| | Overall mean | Technical sciences | Natural sciences | Biotechnical sciences | Biomedicine | ANOVA |
|---|---|---|---|---|---|---|
| FIRMINT (Are Croatian firms interested in collaborating with your institution) | 2,96 | 2,82 | 2,78 | 3,79 | 2,91 | p=0,01 |
| ACADINT (Are scientists from your institution interested in collaboration with industry) | 3,87 | 3,80 | 3,33 | 4,50 | 3,73 | p=0,08 |

N=95

After assessing basic level of interest, we need to look at the motivations and obstacles to find out reasons for insufficient industry-science collaboration. The next two sections we devote to exploration of these issues.

## MOTIVATIONS

We have seen that scientists are not indifferent toward industry, although they believe that industry is not as interested in them. If we want to improve the collaboration, we need to understand what the encouraging factors are.

### What motivates scientists to collaborate with industry?

As the result of in-depth interviews that took place during the exploratory research phase, we identified five possible motivations that stimulate scientists to collaborate with industry. They are: intellectual challenge, additional income, access to industry equipment, possibility to publish collaboration results, and using collaboration as source of case examples for teaching. We asked respondents to rate the importance of the above motives on the scale from 1 (not at all important) to 5 (very important).

We performed multiple regression analysis with ACADINT (scientists' interest in collaboration) as dependent variable, and found that in general intellectual challenge and additional income are the only two significant motives (Table 2). These findings are similar to those in Meyer-Krahmer and Schmoch

(1998) and Lee (2000) who found that additional funding and exchange of knowledge are enriching academic research.

It is interesting that, although some of the scientists in in-depth interviews mentioned that collaboration with industry allows them access to expensive equipment that research institutions do not own, on average this is not a significant motive. Regarding possibility to publish results of joint research and using results in teaching, these are also not significant motives most likely due to the fact that the majority of Croatian companies are worried about protecting sensitive information about their R&D and innovation activities from competitors. Investigating that issue further, we explore whether these mentioned motives may be important for some fields of science although not for all. If we investigate access to equipment, we find that scientists in biomedicine and biotechnical sciences quote access to industry equipment as more motivating than other scientists (technical sciences 2.84, natural sciences 1.56, biotechnical sciences 3.56, biomedicine 3.45, ANOVA, p=0.06). However, overall, this motive is not significant in explaining the interest of academics. Similarly, we find that using practical experience in teaching is more motivating for scientists in technology and biotechnical sciences fields although in general this is not a significant motive (technical sciences 3.7, natural sciences 2, biotechnical sciences 4.43, biomedicine 2.64, ANOVA, p=0.0005).

TABLE 2
Academics' motives for collaboration (dependent variable is ACADINT)

| | Coefficient | St. error | t | p |
|---|---|---|---|---|
| Intercept | 1,252021 | 0,399751 | 3,132003 | 0,002350 |
| Intellectual challenge | 0,184169 | 0,081379 | 2,263115 | 0,026061 |
| Additional income | 0,400472 | 0,089415 | 4,478826 | 0,000022 |
| Access to industry equipment | -0,038121 | 0,084906 | -0,448982 | 0,654536 |
| Possibility to publish collaboration results | 0,015956 | 0,081628 | 0,195472 | 0,845469 |
| Source of case examples for teaching | 0,120335 | 0,081430 | 1,477780 | 0,142997 |

Adjusted $R^2$ = 0,32, F=9,8; p=0,00000; N=95

## What do scientists think motivates industry to collaborate with them?

To gain deeper understanding of why academics perceive industry to be less interested in them, we consider academics' perceptions of what drives industry to seek collaboration. From our exploratory research we identified six possible reasons (as scientists perceive them) why industry might seek out collaboration with research institutions. These are achieving competitive advantage, "buy vs. build" (i.e. search for existing research potentials then to building one's own), urgent need to solve a problem (or "putting out fire" like our interviewees in the exploratory study called it), routine services,

using name of research institution as a proof of quality (for example "tested at...."), and collaborating to fulfill some formal requirements (for example regulations). We asked respondents to rate the importance of the above motives on the scale from 1 (not at all important) to 5 (very important). In order to examine which of these motives are significant, we perform the regression with FIRMINT as the dependent variable and six above motivations as independent variables (Table 3).

We consider the ratings of possible motivations and compare them across science fields. We find that "buy vs. build" is reported as more important motive by biomedicine than by the others (technical sciences 3.39, natural sciences 3.78, biotechnical sciences 3.93, biomedicine 4.55, ANOVA, p=0.05). Routine services are also reported as more important by biomedicine (technical sciences 2.75, natural sciences 1.56, biotechnical sciences 3.29, biomedicine 3.73, ANOVA, p=0.005). In addition, scientists in biomedicine and biotechnical sciences perceive using name of research institution as a proof of quality to be a more important motive for firms seeking collaboration with them (technical sciences 3.5, natural sciences 3, biotechnical sciences 4.07, biomedicine 4.36, ANOVA, p=0.005). This suggests that industry in biomedicine relies on research institutions to supplement their own R&D strength, but this is mostly in form of outsourcing some of the routine R&D activities.

An interesting question here is what drives firm's interest in collaboration? We try to answer that question from academics' point of view. We use academics' perceptions of industry motivations to explain their perception of industry interest in collaboration. We perform regression with FIRMINT as dependent variables, and motivations as predictors (Table 3).

TABLE 3
Academics' perceptions of firms' motives for collaboration (dependent variable is FIRMINT)

| | Coefficient | St. error | t | p |
|---|---|---|---|---|
| Intercept | 1,667469 | 0,385498 | 4,32549 | 0,000040 |
| Achieving competitive advantage | 0,168303 | 0,072865 | 2,30979 | 0,023240 |
| Buy vs. build | 0,069754 | 0,084984 | 0,82078 | 0,413987 |
| Urgent need to solve a problem | -0,025492 | 0,084741 | -0,30083 | 0,764255 |
| Routine services | 0,130432 | 0,076375 | 1,70779 | 0,091201 |
| Using name of research institution as a proof of quality | 0,247218 | 0,095410 | 2,59111 | 0,011198 |
| Collaborating to fulfill some formal requirements | -0,219357 | 0,076952 | -2,85056 | 0,005436 |

Adjusted $R^2$ = 0,197, F=4,85; p=0,00025; N=95

Our findings show that academics believe that among significant reasons for firms showing interest in collaborating with them are achieving competitive advantage, and using

name of research institution as a proof of quality. Collaborating to fulfill some formal requirements is also significant, but comes with the negative sign. This means that academics believe that the more firms are pushed to collaborate to fulfill formal requirements, the less intensively they will seek collaboration with their institution. While looking for routine services as a motivation is somewhat significant, "buy vs. build", and urgent need to solve a problem do not come out as significant.

## OBSTACLES TO COLLABORATION

In order to understand relationship between industry and science, we need to know not just what motivates each side, but also what hinders them. In other words, we need to investigate barriers to collaboration.

### What hinders scientists?

In in-depth interviews during the exploratory research we discovered several possible obstacles for collaboration by scientists. Out of everything that was mentioned, we identify nine statements that were repeated most often in our exploratory interviews (Table 4). These statements suggest that obstacles may be related to one's own institution, or to the collaborating firm. The first five statements spell out obstacles related to how collaboration reflects on scientist's functioning in his or her research institution. The second group of statements voices possible problems arising from firms' attitude toward scientists. Respondents were asked to rate to which extent it is true that the offered statement is a reason that scientists are not motivated to collaborate with the industry. Answers were offered on a 5 point scale from 1 (totally untrue) to 5 (totally true).

We performed factor analysis of all nine obstacle statements, and indeed as expected we obtained two factors (we performed first principal components and then Varimax raw rotation). The first five statements load on the first factor that speaks to problems related to academic environment, while the last four statements load on second factor addresses problems coming from the partnering firm. Now we can define an index for each of the groups by averaging the responses for all the questions within the group. In order to check for reliability, we performed reliability analysis and found that for the first group of variables Cronbach alpha is 0.71 and standardized alpha is 0.71, while for the second group of variables Cronbach alpha is 0.69 while standardized alpha is 0.69. Since these numbers are high enough, we can indeed form the indexes.

| | Statements |
|---|---|
| Obstacles related to academic environment (mean=3.14, st. dev.= 0.98, N=95) | Industry is short-term oriented, which is not compatible with the long--term orientation of academic research |
| | Academic promotion rules do not include any points for results of re--search application in industry |
| | It is not possible to earn enough from collaboration because of heavy taxation (external and institution imposed) |
| | It is difficult to publish results of research collaboration with industry (e.g. confidentiality issues) |
| | Intellectual property issues are hard to resolve |
| Obstacles related to firm requirements (mean=2.62, st. dev.= 0.85, N=95) | Firms do not implement the results of collaboration |
| | Problems that firms come with are not interesting in the research sense |
| | Problems that firms come with require skills that scientists do not have |
| | Firms do not value enough the results of scientists' work |

TABLE 4
Obstacles for academics

We can see that the index for obstacles related to academic environment is higher than the value of index for obstacles related to firm requirements (this is significant, t test gives $t=3.9$, $p=0.00013$). This means that concerns related to the organization of academic life and functioning of collaboration in it are perceived to be more difficult obstacles than problems arising from interaction with firms. This is an important finding, because this is an area where policy makers can act to improve the situation by introducing changes to academic requirements in order to make it easier for scientists to both satisfy the academic rules and collaborate with industry.

We performed ANOVA to investigate whether different scientific disciplines see obstacles differently, but we did not find any significant differences, although biomedicine and biotechnical sciences rate obstacles coming from academic environment somewhat higher than other disciplines.

When we investigate obstacles as seen by the status of the research institution (i.e. universities, public institutes or private institutes) we still do not observe significant differences. All types of research institutions perceive obstacles coming from firms in a similar way (universities 2.71, public institutes 2.47, private institutes 2.71, ANOVA $p=0.52$).

However, if we consider obstacles from academic environment, comparison of public and private research institutes tells us that private research institutes rate obstacles related to academic environment much less seriously than public research institutes. This is expected because private institutes are not expected to entirely conform to the rules of academic environment (t-test, $p=0.059$).

## What hinders firms?

We have seen that scientists believe industry to be less interested in them than they are in industry. To gain deeper understanding of that fact, we asked scientists about their opinion why firms do not seek collaboration with them. Respondents were offered seven statements identified from in-depth interviews in the prior exploratory research. They were asked to rate to which extent it is true that the offered statement presents a reason for lack of interest in collaboration with scientists (Table 5). Answers were offered on a 5 point scale from 1 (totally untrue) to 5 (totally true). All the statements are correlated (we used factor analysis to verify that they all really load on 1 factor), so we formed an index by averaging the responses to all the 7 statements. To verify the reliability of the index we performed reliability analysis. With Cronbach alpha of 0.84 and standardized alpha of 0.84 we can confirm the reliability of the index.

| | Statements |
|---|---|
| Firms' internal reasons (mean=3.78, st. dev.= 0.73, N=95) | Most firms suffer from bad management |
| | Most firms lack long-term vision |
| | Most firms lack educated employees who can understand what scientists can do and thus be a bridge between their firm and scientists |
| | Most firms do not understand the importance of new technologies and innovations |
| | Firms do not have information about what scientists can do |
| | Firms do not have financial resources |
| | Firms think that scientists do abstract and inapplicable things |

TABLE 5
Obstacles for firms: academics' perceptions

Scientists from all four fields of science rate the firms' internal reasons as above average (single sample t-tests, $p<0.05$ for all four groups of scientists), which indicates that scientists believe that lack of vision, good management, information etc. in firms is responsible for the fact that they are not more motivated to seek collaboration with researchers.

We can observe that there is somewhat significant difference among the four fields of science, where biotechnical sciences see the firm's internal problems as least serious (Table 6). This probably reflects the fact that scientists in biotechnical field collaborate with biotech firms that are more new, more technology oriented and more modern in their approach to business and innovation. We have already seen that biotechnologists are also the most interested in collaboration with industry and that they perceive firms to be very interested in them. This is most likely a reflection of a high degree of collaborative activities, and it is logical that the people who have close contact with industry would be least critical.

We also investigate whether the perception of the firm's internal reasons as obstacle for collaboration is viewed differently by different research institutions. Here we find that universities perceive the firm's internal reasons to be responsible for a lack of more vigorous collaboration to a higher degree than do institutes (Table 6). This might be due to the fact that universities are more removed from industry both in culture and intensity of contacts, so they are more likely to pass more severe judgments.

| | Tech. scienc. | Natural scienc. | Biotech. Scienc. | Biomed. | ANOVA | Univers. | Public instit. | Private instit. | ANOVA |
|---|---|---|---|---|---|---|---|---|---|
| Firms' internal reasons | 3.93 | 3.81 | 3.45 | 3.69 | p=0.09 | 3.97 | 3.62 | 3.55 | p=0.02 |
| N | 56 | 9 | 14 | 11 | | 53 | 19 | 18 | |

TABLE 6
Firms' internal reasons as impediments for collaboration

After identifying that internal problems hinder companies from collaborating, the question is whether something can be done to promote the forming of relationships. In this section we have seen that those scientists who report closer collaboration with companies (like biotechnologists and scientists working at institutes) are less negative about them. This might suggest that academics' unfavorable perception of industry may be removed or at least weakened by building closer relationships with industry. Despite the slightly negative opinion that academics have about industry, our respondents are not hopeless about the potential for future collaboration. Namely, they believe strongly that if firms would start investing in own R&D, they would naturally feel the need to collaborate with research institutions. This suggests that they view the present problems not as something inherent in companies, but as something that can be changed.

## HOW DESIRABLE IS THE COLLABORATION?

When investigating motives and barriers to collaboration, we saw that academics are aware of the possible problems that collaboration can bring. On one side they have expectations of certain benefits from collaboration, and on the other side they are conscious of possible problems. The question here is which side will be prevailing. In other words, taking in account all positive and negative characteristics of industry-science relationships, do academics still think it is worth working with the industry? Do they think that it is desirable for researchers to actively pursue such relationships? To find out answers to those questions, we presented respondents with

two statements. One statement is that collaboration is desirable, and the other statement is that scientists should actively pursue potential industry partners (Table 7). We asked respondents to which extent they perceive these statements as true. Answers were offered on a 5 point scale from 1 (totally untrue) to 5 (totally true).

| | Overall | University | Public institutes | Private institutes | ANOVA |
|---|---|---|---|---|---|
| Collaboration with industry is desirable for scientific community. | mean=4.6<br>st. dev.= 0.7<br>(N=90) | 4.79<br>(N=53) | 4.53<br>(N=19) | 4.33<br>(N=18) | p= 0.047 |
| Scientists should actively pursue collaboration with industry. | mean=4.4<br>st. dev.= 0.7<br>(N=90) | 4.53<br>(N=53) | 4.21<br>(N=19) | 4.39<br>(N=18) | p= 0.24 |

TABLE 7
Desirability of relationships with industry

Data show that scientists are very positive on both issues. There is no significant difference on these statements between the four fields of science (ANOVA was used). Regarding different types of research institutions, they do not differ in their opinion on active pursuing of industry, but they do differ in their opinion on desirability of collaboration. Namely, although they are still very positive, private institutes are the most reserved on this issue (Table 7), while universities are the most positive. A possible explanation is that private institutes have to earn a substantial portion of their income on the market, which is something other research institutions do not need to do in the same extent. Due to that fact, scientists in private institutes probably have an experience of what it means to conform one's research program to the needs of industry work.

How can we explain such enthusiasm with collaboration? One possible explanation would be that these two activities are complementary, namely that the same effort that goes into academic work would be applicable in industry and the other way around. In that case researchers would not need to expand double effort to perform both tasks. We explore that issue and we find that indeed, our respondents to an above average degree consent with the statement that the world class research in their field is at the same time applicable in industry. The most positive of all the four science fields are researchers in biotechnological sciences, which is in line with their already established positive outlook on industry-science collaboration. We found no significant difference regarding type of the research institution (i.e. scientists employed at universities, private or public institutes gave similar answers).

| | Overall means | Technical sciences | Natural sciences | Biotechnical sciences | Biomedicine | ANOVA |
|---|---|---|---|---|---|---|
| World class research in your field is at the same time applicable in industry | 4.04 (N=90) | 3.84 (N=56) | 4.11 (N=9) | 4.71 (N=14) | 4.18 (N=11) | p=0.079 |
| Industry-science collaboration can endanger academic freedom | 1.85 (N=90) | 1.68 (N=56) | 1.89 (N=9) | 1.86 (N=14) | 2.73 (N=11) | p=0.02 |
| People who do applied research are not respected enough in your institution | 3.00 (N=90) | 3.11 (N=56) | 3.78 (N=9) | 2.29 (N=14) | 2.73 (N=11) | p=0.039 |
| Collaboration with industry is the domain of people who are not active in research any more | 2.12 (N=90) | 2.14 (N=56) | 1.89 (N=9) | 2.00 (N=14) | 2.36 (N=11) | p=0.84 |

TABLE 8
Complementarities of academic research and industry collaboration

Another explanation for the enthusiasm shown by academics is absence of usual academic penalties like impacts on academic freedom and lack of respect for people who do industry work. Regarding academic freedom, this is in other studies cited as one of the major concerns for academics, but in Croatia that is apparently not an important issue. From the overall mean of 1.85 we can conclude that this issue is really not perceived as a problem. However, there are some differences among scientific disciplines. Namely, researchers in biomedicine are most concerned about academic freedom. This lack of concern about academic freedom is interesting considering that in extant literature that issue is reported as one of the major worries of academic community (Cohen et al., 1994; Blumenthal et al., 1996; Lee, 2000), and as such merits further investigation. The fact that Croatian academics show no concern for academic freedom may be also driven by the low level of experience with such collaborative projects. Unfortunately, the Ministry of Science, Education and Sports as well as the National Statistical Office are not providing data on the number and type of industry-science collaborative projects, and therefore it is hard to conclude anything on this general level. If we want to speculate, we might say that one possible explanation for academic freedom not being an issue is because Croatian industry is not so strong as to dictate research agendas[1] (of course the weakness of the industry has a serious negative impact on innovation; an excellent discussion is provided in Švarc, 2006). In addition, Croatian acade-

mics on average have more lenient and less ambitious research programs than their colleagues form the EU or the US, which allows for incorporating industry work without feeling that this different kind of research takes time from the one they need to perform to fulfill academic requirements.

Regarding lack of respect for industry work, this can be a result of possible "cultural problems" in institutions that have collaborations with industry. Namely, the culture might be emphasizing academic research and thus looking down on applications in industry, and that in turn might discourage scientists from collaboration. To investigate that issue, we asked to which extent respondents perceive as true the statement that people who do applied research are not respected enough in their institution. We observe that this concern is above average only in natural sciences, and lowest in biotechnical sciences. We also investigate whether collaboration with industry is the domain of people who are not active in research any more. Here we find that all scientific disciplines answer very similarly, namely they do not perceive that statement as true. This suggests that in academia the quality of research and the image of people who do work with industry is positive, which bodes well for the collaboration.

## INCENTIVES FOR COLLABORATION

Although scientists were positive about the fact that they should actively pursue relationship with industry, we investigated this issue in more detail. We asked them whether they agreed that initiative should come from industry, research institutions or government (respondents could check one or more of these three choices). Most respondents agreed that initiative should come from industry (91% of respondents), while 79% of respondents agree that initiative should come from the research community. It is interesting that only 39% of respondents agree that initiative should come from government (Table 9). One plausible explanation is that as collaboration is a relationship between two partners, it is logical that these partners should be direct initiators for a concrete research project. Although government is not preferred as a direct initiator, this does not diminish the possible role of the government as facilitator of these collaborations (Table 10).

Although we do not find any differences among scientific disciplines, when we look into types of research institutions, we find that a significantly larger percentage of research institutes, both private and public, agree that scientists should take initiative in brokering the relationship with industry. Universities are more likely to wait for the initiative from the industry, while institutes advocate equal role. This is most li-

kely the result of institutes' better relationships with the industry. Interestingly, a larger percentage of respondents from research institutes is also more positive about initiative coming from the government. That might be the result of the fact that large public institutes due to their size have some influence with the Ministry of Science and through that can exercise some "bargaining muscle". There is no significant difference regarding type of the research institution (universities, private and public institutes gave similar answers).

| | Overall | Universities | Public institutes | Private institutes | Significance Chi square test |
|---|---|---|---|---|---|
| Initiative should come from industry | 91%[2] | 88.68%[3] | 89.47% | 94.44% | p=0.77 |
| Initiative should come from research institutions | 79% | 69.81% | 89.47% | 94.44% | p=0.034 |
| Initiative should come from government | 39% | 30.19% | 57.89% | 57.89% | p=0.09 |
| N | 90 | 53 | 19 | 18 | |

TABLE 9
Sources of initiative for collaboration

To be more concrete, we decided to pin down possible enticements for collaboration. We considered three types of incentives (Table 10). Since we have seen that academics strongly believe that if companies were to invest more in R&D they would naturally seek collaboration with scientists, we proposed two incentives targeted at firms. These are: tax breaks for investment in own R&D, and tax breaks for joint projects with research institutions. The third incentive is direct government financing for joint industry-science projects, and is directed to both industry and academia. To investigate possible usefulness of these incentives, respondents were asked to rate them according to their effectiveness.

| How would you rate following incentives from least effective (1 point) to most effective (3 points) | Means (N=95) |
|---|---|
| tax breaks for firms for investment in own R&D | 2.0737 |
| tax breaks for joint projects with research institutions | 2.4421 |
| direct government financing for joint industry-science projects | 2.0421 |

TABLE 10
Incentives for collaboration

We see that tax break for joint projects is rated as the most effective incentive (differences with the two other variables are significant, t-test values are 3.20 and 3.49). This is an interesting result, because it suggests that although academics believe that firms would seek them out if given possibility to increase R&D investments, they still would not like to com-

pletely relinquish choice of activities to industry. This is why they prefer that tax breaks be provided for the specific purpose of collaboration with research institutions.

Except for fiscal incentives in the form of tax breaks, it is possible to improve collaboration by lessening the organizational burden for researchers. For example, one concern that was heard in exploratory interviews is that finding partners for collaboration takes time, connections, and skills. If scientists perform those tasks themselves, this time is taken from their research time, so one idea how to help them is to establish special small liaison firms associated with a research institution. The function of those firms would be to search for partners in industry and to do all or part of the work associated with managing the project once it is started. We asked respondents to what extent they would say it was true that such firms would have a positive effect on collaboration. The respondents are almost neutral on that issue (score of 3.36 on the scale of 1 (totally untrue) to 5 (totally true)). This might indicate that scientists are either not confident that such firms could perform their function properly (maybe because they would work in a highly bureaucratized environment of research institutions), or that regardless of how capable the liaison is, there is just not enough demand on the market. This skepticism is in line with the current thinking about technology transfer (Decter et al., 2006). Unlike university-industry research centers, such offices operate on the premises of linear innovation model which postulates that innovation originates in R&D and is developed and commercialized down the road. In this way the linear model ignores the role of technology in shaping the aims, methods, and productivity of science and neglects the non-scientific origins of many technological developments. In addition some authors (Mowery et al., 2004; Nelson, 2001) claim that technology transfer offices are actually impeding the flow of technology from universities to industry by imposing transaction costs to potential adopters who are already well aware of university research. This is not surprising taking in account that the potential adopter of the new technology needs to have sufficient absorptive capacity to adopt (Cohen and Levinthal, 1990). As absorptive capacity is related to firm's own level of research (Thursby and Thursby, 2004), it turns out that only firms with a reasonable level of research capability and contacts with the academic community can be adopters (Decter et al., 2006). In all fairness, we need to say here that some authors have found that technology offices do help in promoting academic research (Etzkowitz and Goktepe, 2005).

Collaboration requires time; moreover sometimes joint research projects might be so involving that they completely

occupy the researcher. This is usually not possible because of the requirements that the home institution imposes, which might lead to unpleasant situations for the researcher. This is why we explored whether giving time for collaboration could be an incentive for scientists (Table 11).

| | Mean (N=95) |
|---|---|
| Is giving leave to scientists who want to spend some time working with industry on a project a good incentive? (1 extremely bad, 5 extremely good) | 3.68 |
| Is giving leave to scientists who want to spend some time starting their own company a good incentive? (1 extremely bad, 5 extremely good) | 2.75 |

TABLE 11
Giving time off for collaboration

We asked whether giving leave to scientists who want to spend some time working on an industry project would be a good inducement. We also asked whether giving leave to people who want to start their own firm would be a good stimulus. While giving leave to people to work in industry is rated above average, giving them leave to set up own company is rated below average (significantly lower, t-test gives $p=0.000003$). This is most likely because losing one member, even for a limited time, imposes organizational stress on the institution. In other words, the same amount of work has to be done, just by fewer people. While the person who goes to industry for a limited time can be seen as a gain more than a loss because she/he will bring back new knowledge and connections, the person who takes leave to set up own company is seen more as a loss than as a gain. Since this person might not be around any more, new acquired knowledge might not be transmitted to other people in the organization, therefore from the collective point the sacrifice of bearing organizational stress makes much less sense. We also investigated whether views on the leave for collaboration differs by type of research institution or by scientific field, and found no statistically significant discrepancy.

## CONCLUSION

It is a known fact that the low standards of technological capabilities and industrial research in Croatia have resulted in inadequate science-industry cooperation (Švarc, 2006). To examine whether some measures can be taken to remedy the situation, two separate empirical studies were conducted focusing on industry and respectively on research institutions in Croatia (Radas, 2003, 2004). The purpose of these studies was to explore motivations, obstacles, and perceptions of the other partner in collaboration. In this paper we focus on the study of industry-science relationship from the point of view of research institutions in Croatia.

The encouraging result from this study is a high level of goodwill among scientists; our findings show that scientists in Croatia express above average interest in the collaboration with industry. This indicates that the established scarcity of collaboration is not caused by the lack of interest from academia (among the four groups of scientists, the scientists in biotechnical sciences are the most positive). We find that intellectual challenge and additional income are significant motives that can explain academics' interest in cooperative work with the industry. These results are in line with extant studies (Lee, 2000; Meyer-Krahmer and Smooch, 1998) which quote knowledge and additional funding as major motives.

Concerning obstacles for collaboration, we find that the organization of academic life and functioning of collaboration in it are perceived to be more difficult obstacles than problems arising from interaction with firms. This is important information for policy makers, because some obstacles may be removed by introducing changes to academic rules and requirements.

Croatian scientists believe that industry is not as interested in them as they are in the industry. To gain deeper understanding of that fact, we consider academics' perceptions of industry's motivations to seek collaboration. Croatian academics believe that the firm's interest in collaboration can be explained by several possible motives. In their opinion significant motives for firms are achieving competitive advantage, and using name of research institution as a proof of quality. Forcing firms into collaborations with formal requirements is perceived as having negative impact. Motives such as routine services, "buy vs. build", and urgent need to solve a problem are not significant. In comparison, US academics surveyed in Lee (1996) believe that observation of the scientific development is the major reason for industrial firms to stay in contact with universities, followed by solution of technical problems and recruitment of personnel. Croatian academics also believe that lack of vision, good management, information etc. in firms is responsible for the fact that the industry is not more motivated to seek collaboration with researchers. However, those groups of scientists who have closer working ties with industry also tend to be less critical. Academics moreover believe that if firms would start investing in own R&D, they would naturally feel the need to collaborate with research institutions. This suggests that Croatian academics view the present problems not as something inherent in companies, but as something that can be changed.

Taking in account all positive and negative characteristics of industry-science relationships, Croatian academics still perceive collaboration as desirable. This can be explained by aca-

demics' conviction that high quality academic research is at the same time applicable in industry. In addition, people who do industry work are not less respected for it in their institutions. An interesting finding is that academics are not worried about the impact of industry collaboration on academic freedom, as opposed to their colleagues from the developed economies (Cohen et al., 1994; Blumenthal et al., 1996; Lee, 2000).

Although Croatian scientists are positive about the fact that they should actively pursue relationship with industry, 91% of respondents agreed that initiative should come from industry, while 79% of respondents agree that initiative should come from the research community. Only 39% of respondents agree that initiative should come from government. The government's role is perceived as being facilitator of industry-science relationship by providing favorable conditions, for example by providing tax breaks. Academics believe that tax breaks for joint projects with research institutions would be a very efficient means to get firms to collaborate. Another possibility (which is rated lower by academics) is providing tax breaks to industry for R&D investments. Except for fiscal incentives in the form of tax breaks, it is possible to improve collaboration by lessening the organizational burden for researchers. Establishing special technology transfer offices at research institutions could be helpful (although they have their limitations), but Croatian academics were reserved regarding that idea. This is maybe because they are not sure whether such firms would be nimble and capable enough, and whether there would be enough demand in Croatia for their services. Another idea that we presented for evaluation to our respondents was giving time off for industry work. This idea was received more positively in case the person remains as a full member of the research institution. In the case when a scientist leaves to start his/her own firm, providing him/her with a faculty leave is not considered as a positive action.

How does all this bode for future industry-science relations in Croatia? Overall this study shows that there is a large amount of goodwill among Croatian scientists regarding collaboration with industry. Academics' outlook for the future is optimistic; they believe that strengthening the industry would naturally prompt companies to seek collaboration with them. This may prove to be an accurate assessment. Namely, currently the technological capability or innovation orientation of Croatian industry is not high enough as to require much input from academics (Švarc, 2006), which is also most likely the cause for absence of university-research centers or competence networks in Croatia. On the other hand, looking at the number of patents and publications in world class re-

search journals, the research community in Croatia does not appear to have the ability to generate new technological breakthroughs. This speaks for the necessity of establishing a good innovation policy that would strive to strengthen both communities, as well as create favorable conditions for collaboration on the bases of existing demand from the industry and current capabilities of Croatian researchers.

## NOTES

[1] In support of this statement we quote Švarc (2006) "... some selected indicators of the technological capabilities of companies (such as the numbers of patents, ISO standards 9000 and Internet hosts) reveal that Croatia now lags behind not only developed countries, but also the newly integrated European countries that it used to compare more favorably with ... The most recent data on national competitiveness and innovativeness rank Croatia relatively low in the list of 80 countries ... confirming that it needs an urgent re-design of its national development strategy aimed at strengthening technology and research capacities in the business sector."

[2] This means that 91% of all the respondents agree that initiative should come from industry.

[3] This means that 88.68% of respondents from university agree that initiative should come from industry.

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# Suradnja gospodarstva i znanosti u Hrvatskoj: stajalište znanstvenika

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Odnosi između znanosti i gospodarstva smatraju se vrlo važnim dijelom inovacijskoga sustava i jednim od krucijalnih čimbenika nacionalnoga inovacijskog kapaciteta. Dostupne studije pokazuju da zamjetan dio proizvoda i procesa koji su u prodaji ili u upotrebi ne bi bili razvijeni bez znanstvenog istraživanja. Gospodarstvo i znanost mogu imati obostrane koristi od suradnje. U ovom članku žarište je istraživanja na odnosu između znanosti i gospodarstva, promatranog sa stajališta znanstvenika, a koji se temelji na prikupljenim izvornim podacima u Hrvatskoj. U članku se nastoji razviti razumijevanje o determinantama koje utječu na suradnju s gospodarstvom i na zadovoljstvo znanstvenika tim odnosom. Rezultati istraživanja pokazuju snažan interes znanstvenika za suradnju, a motivi koji mogu objasniti njihov interes jesu intelektualni izazovi i dodatni izvor prihoda. Znanstvenici

smatraju da se stanovita ograničenja suradnje nalaze više u njihovoj internoj organizaciji nego u vanjskim odnosima s gospodarstvom. Oni su uvjereni da gospodarstvo nije tako zainteresirano za suradnju kao što su to oni sami. Manje su kritični oni znanstvenici koji su već uspostavili veze s gospodarstvom.

Ključne riječi: suradnja gospodarstva i znanosti, inovacije

# Die Zusammenarbeit von Industrie und Wissenschaft in Kroatien: Aus akademischer Sicht

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Die Beziehungen zwischen Wissenschaft und Wirtschaft gelten als äußerst wichtiger Bestandteil des Innovationssystems und als ein Schlüsselfaktor der nationalen Innovationskapazitäten. Verfügbare Studien zeigen, dass ein wesentlicher Teil der im Verkauf oder im Gebrauch befindlichen Artikel oder Dienstleistungen ohne das Zutun der wissenschaftlichen Forschung nicht entwickelt worden wäre. Sowohl Wirtschaft als auch Wissenschaft können von ihrer Zusammenarbeit profitieren. Dieser Artikel richtet seine Aufmerksamkeit auf das Verhältnis von Wissenschaft und Wirtschaft und betrachtet diese Wechselbeziehung aus akademischer Sicht. Mit ins Spiel kommen hierbei Daten, die die Autorinnen in Kroatien gesammelt haben. Die Verfasserinnen bemühen sich um ein Verständnis der Determinanten, die Einfluss haben auf die Zusammenarbeit zwischen Industrie und Wissenschaft sowie auf die diesbezügliche Zufriedenheit der Akademiker. Die Untersuchungsergebnisse zeigen ein reges Interesse der Wissenschaftler an dieser Zusammenarbeit; als Ausschlag gebende Motive dafür gelten die intellektuelle Herausforderung und Nebenverdienstmöglichkeiten. Nach Meinung der Wissenschaftler ist im internen Aufbau wissenschaftlicher Einrichtungen eher nach diese Zussammenarbeit behindernden Barrieren zu suchen als in den äußeren Beziehungen zur Wirtschaft. Sie sind jedoch davon überzeugt, dass die Wirtschaft an der Zusammenarbeit nicht im selben Maße interessiert ist wie die wissenschaftliche Seite. Weniger kritisch zeigen sich Akademiker, die bereits Beziehungen zu Wirtschaftskreisen ausgebaut haben.

Schlüsselwörter: Zusammenarbeit zwischen Wirtschaft und Wissenschaft, Innovationen