1 Collaboration between Industry and Science: Motivation Factors, Collaboration Intensity and Collaboration Outcome*

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Abstract

Collaboration between industry and science is considered one of the most important aspects of the innovation system. Innovation capability being crucially linked with the level of communication between scientific institutions and industry, it is important to understand why and how intensively companies collaborate with scientists, and how they rate such collaboration. The present paper explores how motives for collaboration and company approach to innovation and technology influence collaboration with scientists. The paper also examines differences among small, medium sized and large companies. Since collaboration between science and industry is expected to have a positive impact on a company's innovation capabilities, we explored how selected innovation indicators are affected by collaboration.

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1 Introduction

Co-operation between industry and science is considered one of the most important elements of the innovation system due to its expected positive effect on a company's innovative potential. For instance, Zucker and Darby (2000) have shown that collaboration with renowned scientists positively affects the number of patents and completed projects in biotechnological industry. Hall et al. (2000) have shown that projects in which scientific institutions were included were defined better and were also more likely to be successfully completed.

Successful innovation capability is today considered one of the essential competitive advantages, because innovation and new technologies are key factors of economic growth[1]. Innovation is fundamental to achieving long-term economic success. For instance, introduction of new, differentiated quality products and services that are customer-oriented allows companies to remain competitive on domestic and global markets, while introduction of new production processes facilitates higher productivity and utilization of resources. Since innovation capability is essentially linked to the level of communication between scientific institutions and industry, it is important to establish and promote this collaboration. In order to be able to do this in the best possible way, what needs to be done first is to investigate the existing situation. Primary is the understanding of the reasons that motivate enterprises to collaboration with scientists. Once we find out and comprehend the motivation factors, we will be able to make better decisions on how to stimulate collaboration. Literature contains several empirical papers that explore reasons that motivate companies to collaboration. Caloghirou et al. (2001) examined the joint research projects that were conducted in the context of European framework programmes and found several main reasons why companies collaborate with universities. Companies collaborate in order to achieve synergies in the research programme, to keep track of technological developments more easily and in order to split research costs.

Apart from motivation, it is important to know whether collaboration has any effect on a company's innovation capabilities, and hence on its performance. Lee (2000) conducted a research among American companies that collaborate with

[1] *OECD (2000).*

universities, and found that companies involved in such collaboration were able to demonstrate improvements in specific areas. Specifically, the companies gained better access to new research and inventions, and collaboration also helped them develop new processes and products. Caloghirou et al. (2001) have also found that collaboration contributes to development of new production processes, even though no significant influence of collaboration on the development of new products was shown.

Although most studies on co-operation between science and industry were conducted in developed economies, a number of studies deal with this topic in the context of transition economies where collaboration between industry and science is not well developed (Radošević and Auriol, 1999). Koshatzki et al. (2002) have shown that in Slovenia collaboration between large institutes and industry is satisfactory, while co-operation between universities and industry is weak. Similar results were shown for Croatia by Švarc et al. (1996).

This paper relies on a 2002 research that was conducted among companies and scientific institutions in Croatia with the objective of finding the best stimulating measures for promoting collaboration between industry and the scientific community (Radas et al., 2002). The research focus of the paper is motivation of companies for collaboration with scientists, collaboration intensity and satisfaction with collaboration. As collaboration is aimed at enhancing innovation capabilities of companies, research has been focused on how collaboration affects selected innovation indicators. The paper is structured in the following way: Chapter Two describes the research methodology; Chapter Three describes the motives that stimulate industry to collaboration, collaboration intensity, and satisfaction with the outcome; Chapter Four investigates possible differences in motives, intensity and evaluation of collaboration in relation to company size; Chapter Five explores the correlation between collaboration and selected innovation indicators; Chapter Six brings a conclusion.

2 Methodology

The field study on which the present paper is based was conducted in the spring of 2002. For research purposes 230 companies were selected that are engaged in activities that, according to the statistical survey of the Croatian Bureau of Statistics, involved investments in research and development between 1997 and 1999, including activities in the field of high technology. Companies were selected based on the following sources: *Privredni vjesnik's* 400 Largest List, Affiliation of Innovators' address book, company database of the Croatian Chamber of Economy and the list of companies in technological centres. Table 1 illustrates the sample structure according to the field of activity. The sample includes small, medium sized and large companies.

Table 1. **Company Sample According to Field of Activity**

Field of Activity	No. of Companies	%
Agriculture, hunting, forestry and fishing	6	2,6
Mining and quarrying	1	0.4
Food, beverages and tobacco products	23	10.0
Manufacture of pulp, paper and paper products	6	2.6
Coke, petroleum products and nuclear fuel	1	0.4
Chemicals, chemical products and synthetic fibre	22	9.6
Rubber and plastic products	7	3.0
Manufacture of non-metallic mineral products	6	2.6
Metallic products	8	3.5
Machinery and equipment	19	8.3
Electrical machines and appliances	17	7.4
Radio, television and communication equipment	15	6.5
Manufacture of office equipment and computers	4	1.7
Manufacture of medical, precision and optical instruments and watches	8	3.5
Ship building and repair	6	2.6
Manufacture of furniture	6	2.6
Electricity, gas and water supply	2	0.9
Civil engineering	8	3.5
Transport	6	2.6
Post and telecommunications	2	0.9
Computer and related services	18	7.8
Research and development	21	9.1
Architectural and engineering activities and related technical consultancy	14	6.1
Technical testing and analysis	4	1.7
Total	**230**	**100.0**

190 companies agreed to take part in the research, which is a response rate of 82.6 percent. Out of the 190 companies, 172 collaborate with universities, 106 with scientific institutes, and 139 collaborate with other companies for innovation. A large number of companies, 94 in all, collaborate with all three categories, while 13 companies collaborate with none of the mentioned partners. As research instrument a highly structured questionnaire was used. The questionnaire was prepared based on results of in-depth interviews with a large number of entrepreneurs from small, medium sized and large companies, and based on insight into recent studies dealing with the researched subject (Lee, 2000; Caloghirou et al., 2001). To majority of questions respondents had to answer using a 5 point scale.

3 Collaboration Motives, Intensity of Collaboration and Satisfaction with the Outcome

When studying collaboration, the issue of motivation of companies is extremely important and needs to be understood before moving on to further research. In order to gain a better understanding of what influences co-operation between industry and science and how entrepreneurs see the situation, they were asked about the motives for co-operation and how they perceive their companies. Questions were asked in form of statements, and respondents were able to express their agreement or disagreement with the statement using a scale from 5 to 1, with 1 meaning "I don't agree at all", and 5 meaning "I agree completely". Questions and answer averages are presented in Table 2. In order to obtain a more complete picture of collaboration, the questionnaire also included questions on how companies perceive themselves in respect to innovation and technologies.

As there is a total of 24 questions measuring motivation and perception, and some of these variables can be correlated, the correlated variables need to be grouped using the data reduction method that will yield a small number of relevant factors instead of a large number of questions. For this purpose factor analysis was used, which provided a clearer idea of motives and perception. A total of 24 questions were reduced to 9 factors[2], as listed in Table 3, which we used for further analysis.

Table 2. **List of Questions on the Company and Motives for Collaboration**

Question	Average
Our company is motivated by an access to new technologies and processes that allow achievement of competitive advantages.	3.34
Our company is motivated by the fact that it is more efficient to use existing research potentials than to develop our own.	3.39
Our company is motivated by the fact that the name of a scientific institution can be used as a proof of quality or reliability (e.g., tested at ... institute/university)	3.63
Our company is motivated by the need for solving a concrete problem.	3.61
Our company is formally compelled to collaborate (e.g. by regulations, standards ...).	2.49
Our company is mostly oriented to solving short-term problems.	2.68
Our company has a long-term vision of development.	4.17
In our company great attention is paid to innovation.	3.66
In our company great attention is paid to new technologies.	4.12
We would rather invest in development of own technology than buy a licence.	3.66
There are people at our company who understand well what scientists can do and who may act as a link between company and scientific institutions.	3.82
Our company has sufficient funds for investment in research and development.	2.87
Scientific institutes are not equipped well enough to provide an adequate service.	2.92
Scientists are concerned with abstract and unworkable matters.	2.69
Our company shows more trust in foreign consultants than they do in local scientists.	2.36
Our company has access to the most advanced technologies.	3.57
Simpler access to advanced technologies would help our company become more innovative.	3.89
Our company has problems attracting new, highly qualified staff we need for innovation.	3.07
Innovation is often conducted using new methods for networking innovating firms and institutions (e.g. joint development of new products, exchange of know-how). New networking methods are extremely important for our company.	3.42
Easier access to EU markets would help our company launch a larger number of innovative products.	3.42
According to our experience, banks and investors are sufficiently prepared to support our innovation efforts.	2.50
Croatian taxation system is sufficiently conducive to innovation in our company.	1.79
Our clients show extreme interest in innovative products.	3.75
Our clients have a very positive attitude toward our innovation activities.	3.76

[2] *The "principal components" method and "Varimax normalized" rotation method were used. The factor retention criterion is that of Kaiser.*

Table 3. **Motivation and Perception Factors**		
Factor description	**Percentage of explained variation**	**Questions contained in the factor**
Factor 1 **Innovation and technology orientation of the company**	16.7	• Our company has a long-term vision of development. • In our company great attention is paid to innovation. • In our company great attention is paid to new technologies. • Our company has sufficient funds for investment in research and development. • Our company has access to the most advanced technologies.
Factor 2 **Access to technology and market**	9.18	• Simpler access to advanced technologies would help our company become more innovative. • Easier access to EU markets would help our company launch a larger number of innovative products.
Factor 3 **Capability of scientists**	7.67	• Scientific institutes are not equipped well enough to provide an adequate service. • Scientists are concerned with abstract and unworkable matters.
Factor 4 **Concrete benefits from collaboration**	6.46	• The name of a scientific institution can be used as a proof of quality or reliability. • Need for solving a concrete problem.
Factor 5 **Client's attitude to innovation**	5.78	• Our clients show extreme interest in innovative products. • Our clients have a very positive attitude toward our innovation activities.
Factor 6 **Investments and taxes**	5.47	• According to our experience, banks and investors are sufficiently prepared to support our innovation efforts. • Croatian taxation system is sufficiently conducive to innovation in our company.
Factor 7 **Formal compulsion**	4.95	• Our company is formally compelled to collaborate (e.g. by regulations, standards ...).
Factor 8 **"Buy vs. build"**	4.67	• It is more efficient to use existing research potentials than to develop one's own.
Factor 9 **Own development capabilities**	4.35	• We would rather invest in development of own technology than buy a licence. • There are people at our company who understand well what scientists can do and who may act as a link between company and scientific institutions.

The above overview of factors and statements contained in factors shows that data was grouped logically. Now that we know what the motivation and perception factors are, we can explore the correlation between factors and collaboration features such as collaboration intensity and satisfaction with collaboration. This will provide a better insight into how collaboration intensity and satisfaction with collaboration depend on the company itself.

3.1 Intensity of Collaboration

As previously stated, the majority of companies co-operates with scientists. The existence of collaboration, in itself, does not tell us much if we do not know the extent of collaboration and factors that influence its intensity.

The companies in our sample have evaluated collaboration intensity with a mean score of 2.71 on a five-point scale. It was found that collaboration intensity in our sample is positively correlated with three factors: factor 1 (innovation and technology orientation of the company), factor 4 (concrete benefits from collaboration), and factor 9 (own development capabilities). Intensity is negatively correlated with the square of factor 8 ("buy vs. build"). Details are presented in Table 4.

Table 4. **Collaboration Intensity in Relation to Motivation and Perception Factors**

	Correlation Coefficient
Innovation and technology orientation of the company factor 1	0.30, p=0.000
Concrete benefits from collaboration factor 4	0.28, p=0.000
"Buy vs. build" $(\text{factor } 8)^2$	-0.22, p=0.004
Own development capabilities factor 9	0.23, p=0.005

Results show that companies with a stronger innovation and technology orientation have more intensive collaboration with scientists. Innovation and technology orientation includes a long-term development vision, existence of sufficient funds for research and development and availability of advanced technologies. At the same time, such companies attach great importance to innovation and new technologies. The better the ranking of the company according to these criteria, the more intensive the collaboration with scientists. In the light of empirical studies that emphasize access to technologies and enhanced innovation capabilities as the principal results of collaboration (Caloghirou, 2001; Lee, 2000), it is logical that companies that attach great importance to technologies and innovations have more intensive collaboration with scientists.

The next correlation shows that companies that embrace collaboration because of concrete motives have higher intensity of cooperation. It is a natural result, because a company that has a problem that needs solving will be more motivated to seek solution through more intensive collaboration than a company that does not have such a problem.

An interesting result is the one showing that companies with own development capabilities (which includes a desire for independent research and individuals able to communicate with scientists) have more intensive collaboration with scientists. This indicates that existence of highly educated employees in companies can be crucial for establishment of a more intensive collaboration. As it is known that the number of PhDs in Croatian companies is small (Radas et al., 2002), we wanted to find out whether an increase in the number of such employees would enhance the actual ability of companies to establish and maintain more intensive collaboration.

The only negative correlation is the one showing that companies who thought it was more efficient to use existing research potentials than to develop one's own ("buy vs. build" factor) have less intensive collaboration with scientists. This is an interesting and unexpected result, because we would expect companies that "buy" research activities have very intensive collaboration with scientists. How can we explain this interesting result? A possible explanation is that companies that rely on external resources for research and development do not do this to complement their in-house research (e.g. to achieve greater efficiency and faster innovation), but actually belong to companies that attach little importance to research and therefore prefer to buy easily implemented ready-made solutions.

Having established that a large majority of companies in our sample co-operates with scientists, the question was how motivation and perception factors affect evaluation of collaboration. We were interested to find out how companies perceive quality of collaboration and its commercial benefit.

3.2 Perception of Collaboration Quality

The companies in our sample evaluated collaboration quality with an average score of 3.52. Three factors had a statistically significant effect on evaluation of collaboration quality: factor 1 (innovation and technology orientation of the company), factor 4 (concrete benefits from collaboration) and factor 8 ("buy vs. build"). Details are presented in Table 5.

Table 5. **Collaboration Quality In Relation to Motivation and Perception Factors**

	Correlation Coefficient
Innovation and technology orientation of the company factor 1	0.23, p=0.003
Concrete benefits from collaboration factor 4	0.23, p=0.004
"Buy vs. build" factor 8	0.25, p=0.002

The analysis outcome provides an interesting insight. Companies that collaborate for concrete motives are more satisfied with the quality of collaboration. This can be explained by the fact that such companies know what they want (since they are seeking solutions to a concrete problem) and can therefore better define collaboration goals and expected results. Collaboration outcome is such that it can be immediately applied to solving the problem, which in turn leads to satisfaction of the company. Concrete motives also include routine collaboration such as the use of a scientific institution's name, certificates, etc. In case of such motives, scientific institutions probably apply well-established procedures for handling such requests, which results in a more efficient collaboration and greater client satisfaction.

As may be expected, innovation and technology orientation correlates positively to evaluation of collaboration. This indicates that companies that attach importance to innovation and technologies and intensively co-operate with scientists also highly evaluate the quality of such co-operation.

As already observed, the tendency to "buy vs. build" negatively correlates to intensity of collaboration, but we can now observe that it positively correlates to evaluation of quality. In other words, companies that highly evaluate "buy vs. build" as a motive for collaboration do not have intensive collaboration, but tend to be satisfied with the quality of services. Such companies have probably found institutions or individuals from whom they buy ready-made solutions and are satisfied with their quality.

3.3 Commercial Benefit of Collaboration

Another measured aspect of collaboration satisfaction, in addition to quality perception, is the commercial benefit of collaboration. Our in-depth interviews that preceded the survey found that a company may be satisfied with the quality of performed work without collaboration resulting in something that brings a financial result. In our sample commercial benefit is perceived as average – it was evaluated with an average score of 2.93. What is interesting is that commercial benefit is statistically evaluated considerably lower than quality of collaboration[3]. Our survey leads to the conclusion that collaboration with scientist does not bring about commercially successful results. This outcome is worrying, because one of the aims of collaboration between science and industry is to facilitate better and more successful innovation. A possible reason for this could be the poor quality of collaboration results (due to the lack of necessary equipment, technology etc. at scientific institutes). However, it is also possible that the problem lies not in collaboration results, but in the fact that companies are not able to commercialise them well because of poor or non-existent processes of development and introduction of new products (Radas, 2004).

Commercial benefit is correlated with factor 1 (innovation and technology orientation of the company), factor 4 (concrete benefits from collaboration) and factor 8 ("buy vs. build"). Details are presented in Table 6.

[3] *T-test was made for dependent samples, t=7.73, p=0.00000.*

Table 6. **Commercial Benefit of Collaboration in Relation to Motivation and Perception Factors**	
	Correlation Coefficient
Innovation and technology orientation of the company factor 1	0.26, p=0.001
Concrete benefits from collaboration factor 4	0.40, p=0.000
"Buy vs. build" factor 8	0.19, p=0.016

The strongest correlation is to the factor that describes concrete benefits from collaboration. Our results indicate that if a company enters into collaboration for a specific concrete problem, the perceived commercial benefit will be higher. This is a logical result, because a concrete problem is usually formulated as a part of a defined procedure leading to a final goal. In this case, a company is not involved in a risk of precompetitive research, but seeks to solve a problem that stands in the way of commercialisation. Specific types of concrete motives are certificates, testing or use of a scientific institution's name as a means of enhancing the value of products and thus generating a positive financial result without the need for the company to make investments or undergo risks. This certainly contributes to satisfaction with the commercial benefit of collaboration.

The results show that satisfaction with commercial effects of collaboration grows with the growing innovation and technology orientation. This result is encouraging because it shows that companies that attach great importance to innovation and technology not only have intensive collaboration, but also show satisfaction with the commercial effects of collaboration.

The "buy vs. build" factor also correlates positively to evaluation of commercial benefit. This is understandable, because companies would not buy ready-made solutions unless they were able to achieve satisfactory commercial effects.

4 Company Size and Collaboration

Existence and intensity of collaboration in research and development can depend on the size of the company, just like the motives for collaboration. For instance, large companies have larger financial and human resources available for investment in joint projects with scientific institutions. Large companies also have long-term programs for development of new products, and are therefore able to invest in precompetitive research. On the other hand, it is known that radically new technologies come from small-size companies that employ highly educated people who maintain links with scientific institutions.

In order to examine whether different sized companies differ in motives and evaluation of collaboration, we divided them into three groups: small, medium sized and large companies. According to a customary classification, small companies have 50 employees or less, medium sized companies have 51 to 250 employees, and large companies 251 employees or more. In the following, we will explore whether these three groups differ in motivation, perception, intensity and satisfaction with collaboration.

4.1 Motivation and Perception in Relation to Company Size

Motivation for collaboration can depend on the size of the company. To find out the differences, motivation and perception factors were examined in relation to company size. This was done using ANOVA, with company size as the grouping variable. Out of the nine factors, statistically significant difference was observed in 4: factor 2 (need for access to technology and market), factor 6 (investments and taxes), factor 7 (formal compulsion) and factor 9 (own development capabilities). Details of ANOVA are presented in table 7[4].

[4] *Observe that the table contains factors, so the smallest possible value is -2.5 and the largest +2.5.*

Table 7. **Company Size and Motivation and Perception Factors**				
	Averages			
	ANOVA significance	**50 employees and less**	**51 to 250 employees**	**250 employees and more**
Need for access to technology and market factor 2	p=0.00619	0.322940	0.141776	-0.263278
Investments and taxes factor 6	p=0.00229	-0.482034	0.137563	0.187052
Formal compulsion factor 7	p=0.02108	-0.336886	-0.012687	0.219326
Own development capabilities factor 9	p=0.00337	0.375535	-0.391295	-0.004321

** For other factors no statistically significant difference was observed among the three company groups, which is why they are not mentioned here.*

The results show that the need for access to technologies and market is the strongest in small companies and the weakest in large companies. This is not surprising, given that large companies already have established ways of obtaining technologies and are already present on the markets, while for small companies both presents a challenge (the difference between small and medium sized companies is insignificant).

Small companies are least satisfied with innovation investment support and tax incentives. Large companies evaluate investments and taxes significantly better and medium sized companies approach this result (the average is almost the same, but the variance is somewhat larger). These findings indicate that small companies in Croatia face much greater difficulties in obtaining funding.

An interesting finding is that formal compulsion as a motive grows with the size of the company. A possible explanation for this result is that large companies operate in older markets that are already well regulated by laws and thus have more reasons to name formal compulsion as a motive for collaboration with scientists. Small companies name formal compulsion less often as a reason for collaboration, which may come from the fact that small companies exist on markets on which no regulations or standards are imposed requiring engerprises to co-operate with scientists. If such standards do exist on the markets of small companies, it is possible that compliance is voluntary (e.g. ISO standards). Compliance with such standards requires a considerable effort from the organisation, and a large number of small companies have neither the internal capability nor the need for meeting such standards (the analysis of the number of companies certified to ISO standards shows that among certified companies small companies have a small share). Another explanation of this result is that small companies see themselves as very progressive and technologically advanced, and even though there may be some form of collaboration based on formal reasons, small companies consider formal motives much less important compared to other reasons.

Self-perception of small companies as very progressive is visible from the results in regard to company's own development capabilities. Small companies describe themselves as being above-average development oriented with above-average competent scientific staff. In this respect medium sized companies are below the average, and large companies around the average. This is concurrent with some recent studies in the world which have found that small companies are more innovative and advanced than large companies. An interesting situation is that of medium sized companies - they are statistically significantly weaker than both small and large companies, which may lead us to the conclusion that with respect to investments in own development (as an alternative to buying licences) and staff qualifications medium sized companies are in the worst position.

4.2 Collaboration Type, Intensity and Evaluation in Relation to Company Size

To determine whether there are any differences in the intensity of collaboration and satisfaction with collaboration among companies of different size, ANOVA was conducted in which company size was used as a grouping variable. Details are presented in Table 8.

Table 8. **Collaboration Type and Evaluation According to Company Size**				
	Averages by employee number			**ANOVA significance**
	50 and less	**From 51 to 250**	**251 and more**	
Collaboration intensity	2.297872	2.355556	2.787500	p=0.040
Evaluation of collaboration quality	3.473684	3.583333	3.527027	p=0.896
Evaluation of commercial benefit of collaboration	2.842105	2.944444	3.013514	p=0.703

The table shows that the only statistically significant difference is that in collaboration intensity, with large companies having more intensive collaboration than others. This result is not unexpected, given that large companies have more material and human resources available for collaboration.

An interesting finding is that among the three company groups there is no difference in the way they evaluate quality of collaboration or in their rating of commercial benefits of collaboration. Nevertheless, within each of these groups we again find that evaluation of quality is statistically more significant than evaluation of commercial benefit. This means that perception of commercial benefit is not something that is limited to one type of company, but appears as a significant effect in small, medium sized and large enterprises alike.

5 Collaboration Outcome: Influence of Collaboration on Innovativeness

Having analysed the motives for collaboration, intensity of collaboration, satisfaction with collaboration quality, and commercial aspects of collaboration, we need to examine the ways in which collaboration with scientist affects innovativeness of a company. Innovativeness is measured using four indicators. The first indicator is the number of patents registered over a period of three years prior to the beginning of this field study. As a second indicator, we looked for the number of new products, services or processes introduced on the market in the same period. Since the number of new products in itself may not be an indicator of the importance of products for the company, as a third indicator we used the percentage of revenue generated from the sale of new or improved products in the same period. As the last indicator, we used the costs associated with innovation activities in the year preceding the field study[5].

We were interested to find out whether there is a correlation between company innovativeness and existence of collaboration with scientists. To state it more precisely, the question that we wanted to answer was whether collaboration with scientists affects a company's innovativeness.

The data analysis method used was linear regression method, with innovativeness indicators used as dependent variables, and collaboration intensity, evaluation of collaboration quality and commercial benefit of evaluation used as independent variables. Company size was also used as an independent variable, because previous results have shown that different sized companies have different motivation for and intensity of collaboration.

The regression analysis has shown that there is no statistically significant correlation between any of the four independent variables and innovativeness indicators, except in one case. The only significant correlation is between innovation activities costs and evaluation of collaboration quality. Results of the regression analysis are presented in Table 9.

Table 9. **Dependence of Innovativeness Indicators on Collaboration**

Innovation Indicators	**Regression Significance (independent variables: company size, collaboration intensity, evaluation of collaboration quality, evaluation of commercial benefit of collaboration)**
Number of patents	Not significant
Number of new products/services /processes	Not significant
Percentage of new products in revenue	Not significant
Costs of innovation activities	$p=0.01$; the only significant variable is evaluation of collaboration quality

[5] *This includes research and development, purchase of machinery and equipment associated with product and process innovation, patent and license acquisition, industrial design, education and training and innovation marketing costs.*

An interesting finding is that there is no correlation between collaboration intensity and innovativeness of a company. In other words, greater intensity of collaboration does not contribute to the level of innovativeness. How can this be explained? To a large degree collaboration between industry and science is routine in nature and includes testing, certifications and the like (Švarc et al., 1996). Since collaboration is not focused on creation of new products, we can expect innovation to be unaffected by such collaboration. But what happens with non-routine collaboration? It would be worrying if such collaboration would have no effect on innovation. This would indicate that collaboration does not result in products, services or processes that can be commercialised. That this could indeed happen is confirmed by the fact that evaluation of the commercial benefit of collaboration is significantly lower than evaluation of collaboration quality. To explore this important issue, in some future survey routine and non-routine collaboration should be differentiated and examined separately.

The only significant correlation shown by the data analysis is the correlation between costs of innovation activities and evaluation of collaboration quality.

6 Conclusion

Collaboration between industry and science is considered one of the most important aspects of the innovation system. In order to understand better this collaboration, it is important to explore why enterprises co-operate with scientific institutions, how intensively they co-operate, how they rate their collaboration and what are its outcomes.

The present paper is based on a field study conducted in the spring of 2002 on a sample of 230 companies of which 190 agreed to take part in the survey. All companies are engaged in activities requiring investment in research and development, including activities from the field of high technologies.

The questionnaire was prepared on the basis of results of in-depth interviews with a large number of entrepreneurs from small, medium sized and large firms as well as on the basis of insight into recent scientific articles dealing with the researched subject. To examine motivation, companies were asked to give reasons for collaboration, and in order to be able to correlate collaboration to company characteristics, we asked them how they perceived themselves in respect to new technologies and innovation. Data analysis has shown that companies with more intensive collaboration are those with a stronger technology and innovation orientation, which includes existence of a long-term development vision, availability of new technologies, awareness of the importance of innovation and new technologies, and availability of sufficient funds for investment in research and development. Such companies evaluate collaboration quality and the commercial benefit of collaboration more highly. Companies that embrace collaboration in order to solve concrete problems also have more intensive collaboration and rank it better. Existence of employees who understand scientists well and can act as a bridge between company and scientists have proved to be an important precondition for collaboration, because data show that such companies have more intensive collaboration.

As company size can determine motives and extent of collaboration with scientists, we examined differences among companies. The analysis has shown that small companies attach much greater importance to access to technology and market, but also that they are least satisfied with innovation investment support and tax incentives for innovation. However, small companies show above-average orientation to development of own technology and employ staff of above-average competence. In line with this result, small companies state below-average compliance with formal requests as a motive for collaboration. As regards intensity of collaboration, small companies collaborate less intensively than medium sized and large companies, which is an expected result given the lack of resources in small companies. Despite the difference in collaboration intensity, there is no difference among different sized companies in evaluation of quality and commercial benefit of collaboration.

In keeping with the fact that collaboration between science and industry results in improved innovation capabilities of companies, we explored the correlation between innovation indicators on the one hand and collaboration intensity and evaluation on the other hand. An interesting finding is that collaboration intensity contributes to neither the number of patents nor to the number of new products/processes, nor does it contribute to the percentage of revenue generated from new products. This is a potentially worrying result, as it indicates that industry is not able to commercialise the results of collaboration. This is supported by the fact that companies rate commercial effect of collaboration considerably lower than quality of collaboration. This result shows that collaboration between industry and science in Croatia has failed to produce a positive effect on innovation capabilities.

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