

Collaboration of Croatian Enterprises on Innovation Development*

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Abstract

In order to develop an innovation, enterprises can collaborate either with academic institutions or other enterprises that would profit from its development. Collaboration is determined by various factors. The goal of this paper is to determine variables that are predictors of innovation collaboration in Croatian enterprises. The results of discriminant analysis suggest that the variables distinguishing between the group of companies that collaborate and those that do not collaborate are: lack of qualified personnel, number of radical innovation, investment in R&D, number of employees and market orientation. Variables used in the analysis that do not contribute to discrimination between the groups include the number of incremental innovations, too high costs related to innovation activities and a lack of appropriate financial resources.

Keywords: collaboration, innovation, discriminant analysis

JEL classification: O31, O32

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1 Introduction

Development of innovations in collaboration with different partners is a common phenomenon in the modern business. Collaboration between enterprises can be of a formal or an informal character. For the purpose of developing innovations, enterprises tend to formalise their collaboration by signing a contract. Such a means of collaboration allows accessing the resources necessary to develop a product that are otherwise unavailable. Research has shown that large enterprises are more prone to collaboration when developing a product, even though collaboration can not be considered a privilege of large firms only (Trott, 2005). One of the reasons that make large enterprises more inclined to collaboration is that they have more developed networks which help them to establish the collaboration (Račić, Radas and Rajh, 2004).

Informal collaboration is a term well known in literature. It applies to the forming of informal networks in innovation development (von Hippel, 1987). Informal collaboration in innovation development occurs when the scale of necessary collaboration, and thus the value of project, are not big enough to conclude a contract.

According to the familiarity matrix model of innovation developed by Roberts and Berry (1985), different forms of innovation collaboration are mentioned in the context of innovation complexity. Enterprises are more prone to develop radical innovations in collaboration with other firms, while they usually choose to develop incremental innovation within the firm. This approach is in accordance with the theory explaining that enterprises tend to develop innovations they possess capabilities for and hence are based on familiar technology for them (Henderson and Clark, 1990; Abernathy and Clark, 1985). Development of radical innovations requires the learning of new abilities, which increases the possibility of innovation failure on the market. Roberts and Barry (1985) argue that the solution to this problem is to choose the appropriate strategy when starting to develop a new product. Independent development of a new product within the firm is recommended for incremental innovations. If a firm is less familiar with technology and/or the market, it is recommended to use a more complex means of innovation development.

Collaboration on innovation development is generally referred to in a positive context. Even though collaboration between enterprises and other partners is desirable when developing a new product, one should also bear in mind the risks it carries. Dodgson (1992) pointed out some of them. The literature does not provide many examples of the collaboration results. It is a known fact that collaboration does not necessarily result in benefits for all the parties involved. Radas (2005) found that the intensity of collaboration between enterprises and scientific institutions in Croatia does not lead to an increased number of patents or to a rise in sales revenue of new products. This points to the incapacity of Croatian firms to use the results of collaboration. Furthermore, Dodgson (1992) states that collaboration can lead to the creation of monopoly and a decrease in the number of innovations. Finally, collaboration on innovation development is not necessarily a result of the strength of an enterprise, but of its weakness and a lack of resources necessary to develop innovations.

A firm can develop an innovation in collaboration with different partners: suppliers, consumers, competitors, manufacturers of complementary products, scientific institutions and universities, etc. The partners actually recognise the innovation potential and have their own interests in developing it (Afuah, 2003). It can be related to the Roberts and Berry model of innovation according to which an increase in the complexity of innovation novelty requires an increased collaboration with other partners. Namely, not only do the firms have no need to develop incremental innovation in collaboration with their partners, but the partners find no interest in participating due to the effects of incremental innovation.

Whether enterprises are going to develop an innovation in collaboration with one of the potential partners, and which partner they are going to choose, depends on the following factors: different technologies and market, costs of innovation development, potential collaborators' capabilities and the existence of complementary capabilities (Afuah, 2003). Factors identified by Afuah resemble the reasons for collaborating on innovation development pointed out by Dodgson (1992). These are technological, competitive and corporate reasons.



As far as the innovation collaboration of Croatian enterprises is concerned, different analyses have shown that it is not highly developed. Only 6 percent of Croatian enterprises develop their innovations in collaboration with other partners (Račić, Radas and Rajh, 2004). Also, large enterprises develop their innovations in collaboration with other institutions more often, which led the authors to the conclusion that small enterprises have a weakly developed collaboration network.

According to Prester and Podrug (2006), manufacturing firms have a highly developed collaboration with other partners. An exception is collaboration with competitors that is very poorly developed in some industries. Such a result is due to the fact that only sectors with a highly complex innovation development collaborate with competitors on this issue. Developing an innovation is one of the ways to gain advantage over competitors.

It is important to point out that these analyses concern different types of enterprises, which consequently generates different conclusions about the innovation collaboration of Croatian enterprises. Namely, Račić, Radas and Rajh (2004) analysed small, medium and large sized enterprises, unlike Prester and Podrug (2006) who analysed exclusively manufacturing firms.

Considering different factors that affect collaboration between partners as well as specific characteristics of Croatian enterprises, the aim of this paper is to determine which variables can serve as predictors of collaboration on innovation development between enterprises and different partners.

The paper does not include the partners that enterprises collaborate with. Its aim is to elaborate on the variables used to determine readiness of enterprises to collaborate on innovation development. Enterprises in certain industries can be more inclined to a certain form of collaboration or to a certain partner. However, the paper is not going to analyse the differences in enterprises regarding their readiness to collaborate. Furthermore, the paper analyses only the formal, i.e. contractual collaboration between enterprises. Since informal social networks are more difficult to identify and analyse using a questionnaire, the paper examines exclusively formal collaboration, without any intention to diminish the importance of informal collaboration.

2 Research Hypotheses

The paper tries to determine in what way the eight independent variables differentiate the members of two groups (enterprises collaborating and enterprises not collaborating on innovation development). Independent variables refer to innovation and enterprise characteristics and to the factors hampering innovation activities.

Variables related to the type of innovation – As mentioned, decision of an enterprise to establish collaboration can be motivated by the innovation characteristics, i.e. by the degree of its novelty. Enterprises tend to develop innovations in collaboration with other partners when the degree of novelty is high. Radical innovations demand more effort and significant financial resources due to their complexity, market novelty and the fact that they demand more risk. Thus, it becomes obvious why some enterprises tend to establish collaboration with other enterprises and institutions. Development of incremental innovations is less complicated, so the need for collaboration is not as pronounced. Yet, the need to establish collaboration even for incremental innovations cannot be completely ignored. Accordingly, two variables were introduced into the discriminant analysis – *the number of incremental innovations and the number of radical innovations* – in order to determine their importance when discriminating between the members of two groups.

Therefore, hypotheses H1 and H2 are the following.

H1: *Differences exist between the enterprises collaborating and the ones not collaborating with other partners on the development of incremental innovations.*

H2: *Differences exist between the enterprises collaborating and the ones not collaborating with other partners on the development of radical innovations.*

Variables related to the characteristics of enterprises assumed to have the capability of distributing members into one of the two groups based on the innovation collaboration are the *amount of total R&D investment, number of employees and the market orientation index*. The amount of total investment in R&D points to the

importance of innovation activities. Enterprises significantly investing in R&D of new products place great importance on innovations, thus trying to improve the quality of their business. These enterprises have a need to collaborate with other partners.

H3: Differences exist between enterprises collaborating on innovation development with other partners regarding the amount of total investment in R&D.

As already mentioned, large enterprises should be more inclined to collaborate with other partners in developing product innovation – the reason being developed networks they have approach to. Enterprise size variable is therefore included into the discriminant analysis.

H4: Enterprises collaborating on innovation with other partners differ in size from the ones not collaborating.

Market orientation index represents the intensity of business culture as measured on MKTOR scale, developed by Narver and Slater (1990). Enterprises demonstrating a high level of market orientation are more open to their customers and buyers, as well as to other partners. They also continually follow the development of competitor's activity and encourage collaboration and mutual activity of members from all departments of the firm. Openness of the enterprise towards the surrounding can affect its readiness to collaborate with other partners on innovation development.

H5: Market orientation differentiates between the enterprises collaborating and those not collaborating on innovations.

The third group of variables includes three *variables related to the factors hampering innovation activities*. Namely, enterprises face certain factors hampering an easy development of innovations. These internal and external factors, i.e. their intensity can encourage enterprises to establish contractual collaboration with other enterprises and institutions and to facilitate the innovation development. Factors hampering innovation activities included in the discriminant analysis

are: *too high innovation costs, lack of appropriate financial resources for innovation activities and a lack of qualified personnel.*

H6: *Too high costs of innovation activities as a factor hampering innovation development contribute to discrimination of group members.*

H7: *Lack of financial resources for innovation activities contributes to discrimination between the enterprises collaborating and those not collaborating with other partners on innovation development.*

H8: *A difference exists between the enterprises collaborating and those not collaborating on innovation development in the effect that a lack of qualified personnel has on innovation activities.*

3 Research Methodology

Data used in the analysis is gathered as part of the project “Innovation statistics in the Republic of Croatia as bases for formulating scientific and technological policies and evaluating the competitiveness of Croatian enterprises” conducted in 2004 at the Institute of Economics, Zagreb. The research is based on the *Community Innovation Survey 3* methodology used in the study of innovation activities in European Union and accession countries. The information on innovation activities of Croatian enterprises in the period from 2001 to 2003 was gathered by mail based survey.

The information used was appropriate for the needs of the present research. Only innovative enterprises were singled out in the sample, i.e. enterprises that developed and offered to the market any kind of innovation – either incremental or radical – in the period from 2001 to 2003. Given the aim of the research, discriminant analysis was used.

All outliers that could have influenced the results were excluded. Namely, discriminant analysis is extremely sensitive to the existence of outliers, i.e.



to the violation of the assumption of normal distribution due to outliers. Although literature emphasises that the analysis is not extremely sensitive to minor violations of the assumption of normal distribution existence (Klecka, 1980, as cited in Garson, 2007), its violation due to outliers is strongly reflected on the model significance (Tabachnick and Fidell, 1996, as cited in Garson, 2007). Finally, the size of the sample is 72 and is in line with the recommended sample size that must be at least four or five times bigger than the number of independent variables – in this case there are 8 of them.

The two-group discriminant analysis was employed in this paper. The first group is consisted of enterprises that developed a certain form of contractual collaboration with other partners, while the second group includes enterprises that did not develop innovations in collaboration with other firms in the period from 2001 to 2003. Dependent variable represents a true dichotomy, i.e. the groups are mutually exclusive, meaning that one unit can belong to one group only. Out of 72 units in the sample, 22 of them (or 30.5 percent of the sample) belong to the group of enterprises that had contractual collaboration with other partners, whereas 50 of them are in the second group. Hence, the first group is significantly smaller than the second, but the difference is not such as to prevent the use of discriminant analysis (Garson, 2007). Given the previous empirical findings of weak collaboration on innovations between Croatian enterprises, this ratio is in accordance with the real situation.

4 Research Results

One of the assumptions for conducting discriminant analysis regards the existence of multicollinearity between independent variables. Before the discriminant analysis was conducted, its existence had been tested on eight independent variables. Table 1 shows the matrix of average correlations within the groups. The results do not indicate the existence of multicollinearity (all correlation coefficients are below 0.8).

The first phase of discriminant analysis established to what extent the independent variables are capable of discriminating the groups. The forward stepwise method was applied for that purpose. It consists in gradually adding variables to the model until satisfactory criteria are achieved. The analysis used the values F to enter = 2 and F to exit = 1.

Table 1 Average Correlations between Independent Variables within the Groups

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|--|------|-------|------|-------|-------|-------|-------|-------|
| 1 Number of employees | 1.00 | -0.04 | 0.01 | 0.51 | -0.08 | -0.19 | -0.14 | 0.02 |
| 2 Number of incremental innovations | | 1.00 | 0.08 | 0.14 | -0.04 | -0.07 | -0.06 | 0.22 |
| 3 Number of radical innovations | | | 1.00 | -0.17 | -0.01 | -0.20 | -0.07 | 0.11 |
| 4 Total investment in R&D | | | | 1.00 | 0.06 | -0.03 | 0.00 | 0.26 |
| 5 High costs of innovation activities | | | | | 1.00 | 0.52 | 0.50 | 0.00 |
| 6 Lack of adequate financial resources | | | | | | 1.00 | 0.32 | -0.02 |
| 7 Lack of qualified personnel | | | | | | | 1.00 | -0.02 |
| 8 Market orientation | | | | | | | | 1.00 |

Source: Author's calculation.

Conclusions about the model significance were based on the Wilks' lambda test that is usually used in the discriminant analysis and represents the multivariate equivalent of F-test. Its value (0.68) points to the existence of differences between the groups, i.e. that the two groups have different arithmetic mean values.

Such a model consists of five variables having a significant impact on differentiation between the groups. According to the value of Wilks' lambda for single variables, contribution of each variable in distinguishing the groups is established. Factors contributing to the discrimination between the groups are: lack of qualified personnel, number of radical innovations, amount of total investment in R&D, size of the enterprise regarding the number of employees and market orientation. The remaining three variables (number of incremental innovations, too high innovation activity costs and a lack of adequate financial resources) do not enter the model. The value of tolerance for each of the five variables in the model shows that none is redundant. Table 2 shows the variables

that best reflect the differences between the two groups, whereas Table 3 shows the variables that are not included in the model.

| | Wilks' lambda | Partial Wilks' lambda | F to exit | p | Tolerance | R ² |
|-------------------------------|---------------|-----------------------|-----------|-------|-----------|----------------|
| Lack of qualified personnel | 0.77 | 0.86 | 10.54 | 0.002 | 0.93 | 0.075 |
| Number of radical innovations | 0.78 | 0.87 | 9.67 | 0.003 | 0.93 | 0.071 |
| Investment in R&D | 0.77 | 0.88 | 9.15 | 0.004 | 0.63 | 0.372 |
| Number of employees | 0.73 | 0.93 | 5.18 | 0.026 | 0.69 | 0.309 |
| Market orientation index | 0.72 | 0.94 | 4.47 | 0.038 | 0.84 | 0.156 |

Source: Author's calculation.

| | Wilks' lambda | Partial Wilks' lambda | F to enter | p | Tolerance | R ² |
|---|---------------|-----------------------|------------|-------|-----------|----------------|
| Number of incremental innovations | 0.68 | 0.998 | 0.16 | 0.695 | 0.92 | 0.077 |
| Too high costs of innovation activities | 0.67 | 0.982 | 1.16 | 0.286 | 0.74 | 0.264 |
| Lack of adequate financial resources | 0.68 | 0.997 | 0.18 | 0.678 | 0.88 | 0.163 |

Source: Author's calculation.

Considering that this is a two-group analysis, one discriminant function has been provided. Function evaluation according to the mean value of canonical variables shows that enterprises not collaborating provide a more significant contribution to the canonical function. Therefore, the function creates a difference between enterprises not collaborating and the ones collaborating with other partners for the purpose of developing innovation activities (Table 4).

| | |
|-------------------------------|-------|
| Enterprises collaborating | -1.02 |
| Enterprises not collaborating | 0.45 |

Source: Author's calculation.

Discriminant function is generally significant at the level $p < 0.05$. The value of Wilks' lambda (0.68) points to the existence of differences between the groups, i.e. to the influence of model variables on differentiation between the groups. Eigenvalue of discriminant function is 0.48 and points to the significance of dimensions for classification of the dependant variable. Canonical value of correlations is 0.57, which leads to the conclusion that a correlation exists between the discriminant function and the two groups. Chi-square test for the canonical function is shown in Table 5.

| | |
|--------------------|---------|
| Eigenvalue | 0.48 |
| Canonical R | 0.57 |
| Wilks' lambda | 0.68 |
| Chi-square | 26.24 |
| Degrees of freedom | 5 |
| p-level | 0.00008 |

Source: Author's calculation.

Table 6 shows the values of standardized and structure coefficients used to construct the discriminant function. Structure coefficients are a more reliable indicator of the relative strength of discriminating variables (Klecka, 1980, as cited in Ndubisi and Wah, 2004) which makes them appropriate for the forming of discriminant function. Standardized coefficients are used to evaluate the unique contribution of independent variable to discriminant function.

| | Standardized discriminant coefficients | Structure coefficients |
|-------------------------------|---|-------------------------------|
| Lack of qualified personnel | 0.68 | 0.56 |
| Number of radical innovations | -0.65 | -0.51 |
| Investment in R&D | -0.78 | -0.25 |
| Number of employees | 0.57 | 0.08 |
| Market orientation index | 0.48 | 0.09 |

Source: Author's calculation.

According to the structure coefficient values, it can be concluded that a lack of qualified personnel is the factor most contributing to the absence of collaboration between enterprises and other partners. The enterprise size according to the number of employees and the market orientation index also contribute to the absence of collaboration, but their influence is considerably weaker. On the other hand, the number of radical innovations and the amount of investment in R&D are the variables most contributing to the establishment of collaboration on product innovation.

Croatian enterprises that do not collaborate with other partners on product innovation have a lack of qualified personnel, which is a significant factor hampering the realization of innovation activities. They also have a larger number of employees and a higher market orientation index. These enterprises develop radical innovations less and invest less in R&D. Enterprises that collaborate with other partners for the purpose of product innovation develop innovations of a higher degree of novelty, i.e. they develop radical innovations and considerably invest in R&D. These enterprises have fewer employees, but the lack of qualified personnel does not represent a significant obstacle to their innovation activities. They also have a lower market orientation index.

| | Enterprises collaborating <i>a priori</i> p = 0.31 | Enterprises not collaborating <i>a priori</i> p = 0.69 |
|-------------------------------|---|---|
| Lack of qualified personnel | 2.784 | 3.840 |
| Number of radical innovations | 0.458 | -0.166 |
| Investment in R&D | -0.0005 | -0.0008 |
| Number of employees | 0.004 | 0.0065 |
| Market orientation index | 15.617 | 16.915 |
| Constant | -34.756 | -38.909 |

Source: Author's calculation.

After it had been established that the above mentioned variables discriminate between the groups of enterprises, the enterprises were classified. The two obtained classification functions are shown in Table 7. As mentioned before, the number of units in each group is different. Namely, the non collaborating

group includes more enterprises. Bearing in mind the results of research on collaboration in Croatian enterprises (Račić, Radas and Rajh, 2004), it can be assumed that their size corresponds to the real situation in the sample. Therefore, the *a priori* probability of classification functions is determined in proportion to the group size (31:69).

The classification matrix clearly shows distribution in the groups of enterprises in the sample. A total of 69.62 percent of enterprises is distributed according to the expected classification; 85.45 percent of enterprises from the non collaborating group are well classified, while 33.33 percent of those collaborating are distributed as expected. The classification matrix is shown in Table 8.

| | Percentage of correct classification | Enterprises collaborating | Enterprises not collaborating |
|-------------------------------|---|----------------------------------|--------------------------------------|
| Enterprises collaborating | 33.33 | 8 | 16 |
| Enterprises not collaborating | 85.45 | 8 | 47 |
| Total | 69.62 | 16 | 63 |

Source: Author's calculation.

5 Conclusion

Discriminant analysis was conducted with the aim of determining the combination of variables used to predict the collaboration of enterprises with other partners for the need of product innovation development. For the primary group of eight variables, the analysis has shown that five of them contribute significantly in discrimination between the groups. They are: lack of qualified personnel, number of radical innovations, amount of investment in R&D, number of employees and market orientation. Hypotheses H2, H3, H4, H5 and H8 are therefore accepted.

On the other hand, hypotheses H1, H6 and H7 are rejected. The results of discriminant analysis have shown that the number of incremental innovations, high innovation activity costs and a lack of adequate financial resources do

not contribute to discrimination between the group of enterprises that do not collaborate and those that collaborate with other partners on innovation development.

A significant problem of a lack of qualified personnel contributes most to the absence of collaboration. Although it is to be expected that enterprises facing this problem can find the solution in collaboration with other partners, it was shown that the very lack of qualified personnel posed the major problem in establishing collaboration. In other words, such enterprises lack employees who would be capable to realise the collaboration. This finding is in accordance with the conclusions reached by Radas (2005) who has shown that Croatian enterprises with experienced and capable employees develop a more intense collaboration with other enterprises and scientific institutions.

The conclusion that enterprises not collaborating on innovations develop a smaller number of radical innovations is in accordance with the initial hypothesis and the findings from the literature. A lesser tendency to develop radical innovations diminishes the need of an enterprise to develop innovations in collaboration with other partners, considering that incremental innovations do not require significant funds or capabilities.

As far as investment in R&D is concerned, it has been shown that this variable is a predictor of collaboration. It should be mentioned that enterprises more significantly investing in R&D engage in collaboration with other partners more often. These enterprises place great importance on innovations and are ready to develop them in collaboration with other enterprises.

Enterprises not collaborating have a larger number of employees, according to the discriminant analysis. Despite their size, such enterprises do not collaborate with other partners. Although it was assumed that market oriented enterprises are more ready to collaborate with other partners, the analysis has shown that enterprises with a higher level of market orientation collaborate less on innovation activities. Therefore, it can be concluded that large and market oriented enterprises are not open to collaboration, at least not to the contractual collaboration in the field of innovations.

For the purpose of testing the results of discriminant analysis, it is necessary to test the obtained model on a new data set in order to verify the model reliability. Namely, it should be noted that the test of the accuracy of predictions was based on the same results that were used for the discriminant function. Such a classification allows to identify cases which do not deviate from the derived function, whereas the classification of new cases shows the real strength of classification functions in relation to forecasts about belonging to a certain group.

This research was aimed at all enterprises regardless of the sector they do business in. It will be possible to direct the future research to a certain sector given that its specific characteristics can influence collaboration on innovation development. Furthermore, it is necessary to further examine certain forms of collaboration with different partners. Namely, it can be assumed that tendency to collaborate with a certain partner (whether consumers, suppliers, scientific institutions, or other) can depend on and be encouraged by different variables.

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