Does Academic and Market Cooperation Increase the Efficacy of Hungarian Research, Development and Innovation (RDI) Projects?

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Abstract: As supported by numerous studies and publications, the scientific literature places great emphasis on the collaboration between the market and the academic actors, when evaluating the effectiveness of RDI projects. The main objective of this research is to investigate the effectiveness of projects managed in cooperation between market and academia in the Hungarian innovation ecosystem. To this end, the paper provides a literature review of the aspects and applicability of the triple helix model along with its extensions and developments. The model will be examined in economic, cultural and political contexts. Relying on the triple-helix model, the author examines the impact of joint ventures of market and academic actors on the effectiveness of RDI projects. The primary research is conducted among active actors in the Hungarian innovation space, seeking to answer whether the results are consistent with international research and literature.

Keywords: innovation; research, development and innovation (RDI); RDI project collaboration; triple helix model

1 Introduction

Based on the triple-helix model, I assume that there is a strong link between the success of RDI projects and the cooperation between the academic and market sectors. That is, projects are more successful when research organizations and professional market organizations work together on a RDI project. This is followed by a definition of how this cooperation should take place. I assume that synergies are best exploited when there is a partnership between project members. So, the collaboration is more effective when academic and market actors work in consortia, rather than in a contractor or subcontractor relationship. In summary, my hypothesis is that "RDI projects are more effective when there is a collaboration and equal partnership (consortium) between academic and market actors. In this research and publication, I seek to answer this question.

2 Literature Review

Knowledge creation and knowledge supply are at the heart of the knowledge economy and are critical for economic and social progress. It should be emphasized that the European Commission makes a significant policy effort in this area. [1] The renewed interest in innovation, the wider application of innovation methodologies and the need to develop an innovative mindset is reflected in two textbooks published in 2023. Gabriella Cserháti's book stresses that the success of innovative ideas and initiatives depends on how they are implemented [2]. Efficacy depends, among other things, on the choice of project management tools and the extent to which the characteristics of innovation implementation are put into a broader context. [3] [4] The methodology of innovation is described by Csaba Deák, who makes it clear that validating innovation and achieving its objectives "requires sophisticated processes, in-depth knowledge, and the use of the right tools". Therefore, the author describes in detail the innovation process along with its tools and methodologies [5]. In the present research, as well as in several other studies, discussion has been devoted to the innovation of SMEs [6]. In their book, Stukovszky and Illyés conducted a benchmark study of SME models and defined the optimal innovation life cycle of SMEs in Hungary [7]. While the objectives of the work are multifaceted, its main mission is to transform the technocratic, scientific and often perhaps overrated or overthought meaning of innovation into a concept that can be used in the everyday life of enterprises, supporting their operations and performance.

Innovation is a multi-stakeholder activity, involving companies, universities, research institutes, design institutes, independent experts/consultants and of course public organizations. [8] RDI collaborations between universities and industry are increasingly important for the discovery and development of innovations in new products, services and processes. [9] [10] Consequently, they can have a social impact in terms of employment, economic development and public health. Precisely because of their social impact, the number of such collaborations has increased dramatically during the Covid-19 pandemic. However, university-industry projects need to bridge the cultural gap between stakeholders [11] [12].

This takes us to an important tool defined by Etzkowitz and Leydesdorff. The concept of the triple helix innovation model was introduced in the mid-1990s. [8] According to this model, the potential for innovation and economic development in a knowledge-based economy and society lies in the changing role of higher education institutions and the academic sector on the one hand, and in the growing and flexible relationship between higher education and economic actors and government on the other hand. This creates new business and social forms, facilitating the creation, transfer and application of knowledge and innovation [13] [14] Since the conceptual foundations were laid, the model has been offered to several researchers for being tested. [15] Yuzhuo argues that the model is tailored to the Western economy, so it is worth examining how it is presented in the market,

academic and especially in the highly centralized state culture of the East. Although the focal points are elsewhere, with more emphasis on state control, the model is still valid in the East. [16] The concept can be also used in developing countries, where state actors face greater challenges. [17]

So, the model works, but as with all tools and processes, there is room for improvements. [18] Some scholars have identified society as the fourth focal point of the model [19], and have added the environmental context as the newest challenge of modern society. [20] The model clearly indicates that the main responsibility for project implementation lies with academic and market actors, and that the public apparatus provides a regulatory and support framework. [21] This is true for both the original and the two extended models. [22] [23] Fernandes and his co-authors also focus on collaboration, and they obviously show that project management involving universities and industry can significantly increase the success of innovation. [24] [25]

The importance of collaboration between the two sectors as a success factor in RDI projects is emphasized by Santos and his co-workers, while they reveal that joint risk management is another important focus area in the success of RDI project. [26] In addition to collaboration, the authors identify trust-based partnership as a success factor in their research. [27] A key challenge in defining effectiveness is to develop an evaluation method and an appropriate system that takes into account the different sets of data indicators, categorized into several groups, the large dimensions of evaluation and comparison, and the ever-evolving process of knowledge acquisition. [28] Therefore, it is worthwhile to investigate a performance evaluation method based on the improved sequential relationship analysis (G1) – an important criteria (CRITIC) through inter-criteria correlation and preferential ordering based on similarity to the ideal solution (TOPSIS). Then, they will design and implement a performance evaluation system for collaborative innovation in universities.

From 2015 to 2019, a baseline dataset was compiled using data from 73 collaborative innovation centers in Jiangsu Province, which allows empirical benchmarking. The resulting evaluation results were compared with existing comprehensive evaluation methods. The comparison indicates that the proposed evaluation method can objectively and effectively assess the performance of collaborative innovation centers [29]. Data envelopment analysis (DEA) was used to test the effectiveness of national innovation system (NIS). With the advent of technical tools, DEA programming methods other than traditional data envelopment analysis have emerged, such as network, relational network, dynamic network, loose-based model (a computer application based on slack software for instant messaging) and super-efficient DEA [30]. The methodology described above allows for an accurate and reliable calculation of innovation efficiency. As a result, the DEA is considered a useful tool for assessing the relative effectiveness of NIS. [30] This allows NIS to provide added value and sustainability to different countries by improving resource management capacities, which increases innovation efficiencies [31].

In an early initiative to measure innovation activity in Hungarian companies, Katalin Némethné Pál performed in-depth research to measure the extent of corporate innovation. She defended her Ph.D. dissertation on this topic at CORVINUS University of Budapest in 2010. [32].

In summary, the international literature argues for the usefulness of collaborations between market and academia in RDI projects. This is backed up by research from several angles, from countries with different economic maturities and political cultures. The basic concept of the need for cooperation between the actors involved has not changed, even after several modifications and extensions of the triple helix model.

3 Material and Methods

The second part of the research is the literature review, which focuses on the cooperation between academic and market actors. The literature review presents and systematizes the approaches of the best-known practitioners and models, and provides several viable perspectives in the field. The research was carried out using deductive logic. I evaluate the hypotheses I have formulated using my primary research and then confirm or refute them. The methodology of my primary research is based on quantitative data collection, which I conducted using a complex, pre-tested, standardized questionnaire. The developed research questionnaire has a modular structure with three (I-III) well separated but logically interrelated modules. The modules contain open and closed questions. The respondent is guided through the research by the logic of the structure. The first module contains a wide range of general questions about the organization, its functioning and the information related to the respondent. The second module narrows the focus to the organization's RDI activities, while the third module highlights specifically the KFI projects and KFI project management.

The questionnaire pays particular attention to the findings and recommendations of the literature and the expectations of the Oslo Manual [33]. The questionnaire meets international requirements in terms of both content and format, while at the same time incorporates national specificities, as allowed by EU legislation. This renders the questionnaire suitable for measuring and evaluating the innovation efforts of domestic companies. In the present publication, I evaluate only a few questions, which are specifically related to the cooperation between academia and the market. In this respect, I have formulated four Likert scale statements, which refer to the type of relationship and the identity of the partner. In addition to descriptive statistical calculations, I use analysis of variance to determine the relationships between different factors. In the analysis, I pay particular attention to between-group variance and significance, which I assess using the F-value and p-value.

The sample is composed of a finite number of items from a group of people who are engaged in or actively interested in RDI. The questionnaire was sent to the partner list of the Hungarian Research, Development and Innovation Office (hereinafter referred to as the NRDIO) and the then Express Innovation Agency (now the National Innovation Agency, over which the NRDIO exercises ownership rights) a total of 4 times over a one-month period in 2023. The list of partners ranges from micro, small and medium enterprises to large companies from the market sector, as well as researchers, research institutes, and universities, which means that the academic sector is also represented. In total, over 4,300 partners received a questionnaire, out of which 318 responded. After aggregating and purifying the large number received, one formed the evaluable sample that forms the basis of my research. The total purified sample consists of 287 items, and its distributions will be presented on the basis of chosen segmentation parameters.

4 Results

The aim of this research is to assess whether RDI projects are more effective when academia and market actors work together. This question is important worldwide practice and scientific literature clearly demonstrate that there is a need for collaboration between these sectors. The four statements are designed to examine whether the organization in question considers collaboration with a research institution or a market organization to be more effective. I will also look at the form of collaboration, which is effective, the options being equal partners - a quasi-consortium - or a client/subcontractor/supplier relationship (Table I). The question asked how much do you agree with the statement? (1- not at all, 4- completely agree). From the averages it is clear that the values are roughly the same, with minimal differences. The first two questions refer to research institutions: is it more efficient to work with them in a consortium (2.57) or engage them as subcontractors (2.41)? Noticeably, the average score was higher when the collaboration took place in consortium. This means that both tend to be true, but it is slightly more effective to have academic actors as consortium members. The second two statements refer to market partners in a similar distribution: participate in the project as a consortium member (2.61) or as a subcontractor (2.46), taking into account the results. In this pairing, too, the consortium was definitely scored higher, but again both statements tend to be true on the average. The four statements and their analysis are very interrelated, so I have plotted the measured results in a table against separate charts for clarity and comparability.

In terms of the percentage distribution of responses, each of them has over 50% "rather yes" response. The consortium link appears to be higher for both, 59% for academic actors and 62% for market organizations (Table II). Overall, the organizations in the sample consider the consortium form of relationship to be slightly better, and cooperation with market organizations to be slightly more

important. This is worth further examination and the correlation of the statements with the main activity will be addressed.

Table I

Contains the assessment of RDI project collaboration

Claim	Average	Source
RDI projects are more effective when they are carried out in consortia with research organizations (universities, research institutes).	2.571	1.198
RDI projects are more effective when research organizations (universities, research institutes) are suppliers to the project.	2.418	1.212
RDI projects are more effective when implemented in consortia with market organizations (professional organization, subcontractor, client, other company).	2.613	1.215
RDI projects are more effective when market organizations (professional organization, client, other company) are subcontractors in the project.	2.460	1.202

Source: own research, 2023, N = 287

Table II

Contains the percentage distribution of responses to the statement on the collaboration of RDI projects

Claim	I don't know/ I don't answer	Not true		True	
		1	2	3	4
RDI projects are more effective when they are carried out in consortia with research organizations (universities, research institutes).	8.4	9.8	22.6	34.8	24.4
RDI projects are more effective when research organizations (universities, research institutes) are suppliers to the project.	11.5	8.0	26.1	35.9	18.5
RDI projects are more effective when implemented in consortia with market organizations (professional organization, subcontractor, client, or other company)	10.5	5.2	22.0	37.3	25.1
RDI projects are more effective when implemented in consortia with market organizations (professional organization, subcontractor, client, or other company),	11.5	7.0	23.7	39.7	18.1

Source: own research, 2023, N = 287

The remainder of the research examines the relationship between organizational factors and willingness to cooperate. I will analyze the four most important factors of the overall research; these are (i) the main activity of the organization, (ii) the size of the organization (number of employees), (iii) the number of years of experience in RDI and (iv) the experience in terms of the number of RDI projects (i.e., in how many projects was the organization involved so far?). (Table III)

Table III

Contains the correlation of responses to the basic parameters on the participants of research

Main activity		
Claim	F	Sig.
RDI projects are more effective when they are carried out in consortia with research organisations (universities, research institutes).	4,808	0,003
RDI projects are more effective when research organisations (universities, research institutes) are suppliers to the project.	2,856	0,037
RDI projects are more effective when implemented in consortia with market organisations (professional organisation, subcontractor, client, other company)	3,994	0,008
RDI projects are more effective when implemented in consortia with market organisations (professional organisation, subcontractor, client, other company).	1,912	0,128
Number of employee		
Claim	F	Sig.
RDI projects are more effective when they are carried out in consortia with research organisations (universities, research institutes).	4,959	0,001
RDI projects are more effective when research organisations (universities, research institutes) are suppliers to the project.	0,909	0,459
RDI projects are more effective when implemented in consortia with market organisations (professional organisation, subcontractor, client, other company)	0,387	0,818
RDI projects are more effective when implemented in consortia with market organisations (professional organisation, subcontractor, client, other company).	0,473	0,756
RDI Experience in years		
Claim	F	Sig.
RDI projects are more effective when they are carried out in consortia with research organisations (universities, research institutes).	3,677	0,002
RDI projects are more effective when research organisations (universities, research institutes) are suppliers to the project.	5,686	0,000
RDI projects are more effective when implemented in consortia with market organisations (professional organisation, subcontractor, client, other company)	3,054	0,007
RDI projects are more effective when implemented in consortia with market organisations (professional organisation, subcontractor, client, other company).	3,373	0,003
Experience according RDI project number		
Claim	F	Sig.
RDI projects are more effective when they are carried out in consortia with research organisations (universities, research institutes).	3,041	0,011
RDI projects are more effective when research organisations (universities, research institutes) are suppliers to the project.	4,683	0,000
RDI projects are more effective when implemented in consortia with market organisations (professional organisation, subcontractor, client, other company)	2,584	0,026
RDI projects are more effective when implemented in consortia with market organisations (professional organisation, subcontractor, client, other company).	2,226	0,052

Source: own research, 2023, N = 287

The analysis of variance was performed using one-way ANOVA with the significance tested. A value below 0.05 indicates a correlation, i.e., whether the perception of a given statement is affected by a given organizational factor. Based on Table III, one can state that the organization's experience in KFI has the greatest impact on the perception of the affiliation, as this factor has an impact on all four statements. The main activity and the number of RDI projects impact the perception of the statement and the size of the organization affects only one of the statements. Most importantly, the consortium with academic actors is impacted by each of these factors, i.e., there is a correlation between them.

I can analyze these correlations one by one, according to the distribution of responses, using the data in the following table (Table IV).

Table IV

Contains the mean distribution of responses to the statement on the collaboration of RDI projects

Main activity			
Claim	Answers	Mean	Std. Deviation
RDI projects are more effective when they are carried out in consortia with research organisations (universities, research institutes)	manufacturing, production	2,588	1,198
	service	2,367	1,184
	education, researc	2,898	1,073
	etc.	1,800	1,687
	Total	2,571	1,198

Number of employee			
Claim	Answers	Mean	Std. Deviation
RDI projects are more effective when they are carried out in consortia with research organisations (universities, research institutes)	0-9	2,380	1,246
	10-49	2,305	1,183
	50-249	2,563	1,233
	250+	3,090	0,981
	don't answer	3,000	1,000
	Total	2,571	1,198

Experience in years			
Claim	Answers	Mean	Std. Deviation
RDI projects are more effective when they are carried out in consortia with research organisations (universities, research institutes)	1-3	2,073	1,501
	4-5	2,429	1,233
	6-10	2,395	1,094
	11-15	2,619	0,854
	16-20	3,059	0,748
	20+	3,037	1,030
	don't answer	1,571	1,134
	Total	2,571	1,198

Experience according RDI project number			
Claim	Answers	Mean	Std. Deviation
RDI projects are more effective when they are carried out in consortia with research organisations (universities, research institutes)	1-5	2,329	1,292
	6-10	2,973	0,833
	11-15	2,579	1,121
	16-20	2,571	0,976
	20+	2,944	1,013
	don't answer	1,250	1,500
	Total	2,571	1,198

Source: own research, 2023, N = 287

In the analysis, "RDI projects are more effective when implemented in consortia with research organizations (universities, research institutes)." I will concentrate on this statement, given that it is the main focus of my work and that all the organizational factors studied here are related to this statement.

The main activity is the only feature, where one cannot establish a trend, because there are three independent groups. Although there is no significant difference in the values, it seems that the academic sector agrees the most with the statement.

This was an expected result given the sectoral and funding environment of the Hungarian academic world. The need for flexibility and resource mobilization makes it important for academic actors to cooperate with the market. The second highest score was given by the manufacturing and production companies, just ahead of the service industry. This is also understandable, as research and development, both in terms of expertise and the research infrastructure required, is much easier and more cost-effective to carry out on an existing base, which universities and research institutes usually have. The service sector is perhaps in the "easiest" position, with less investment and infrastructure needs for research laboratories, but it also finds collaboration important.

With regard to the size of the organization, the larger the organization, the more likely it is to engage in collaboration. Micro and small companies are similar, with a minimal difference, virtually in the same category with a mean of 2.3. For medium-sized enterprises there is a clearly identifiable jump, with the average going above 2.5. For large companies, there is again a significant increase above the average of 3. For the factor "years of RDI experience", there is also a marked increase, the more experience the organization has in RDI projects, the more it agrees with the statement. Four categories are distinguished here, based on the analysis. The first is "1-3 years", where the average is modest, just above 2. This also means that organizations in this category only agree with the statement. The next category is "4-1 years", where the opinion is already strongly positive with an average of 2.4. The categories above 10 years strongly agree with the statement with "11-15 years" having an average of 2.6 and "20+ years" above 3.0. Overall, the learning curve is clear: the longer an organization has been involved in RDI activities, it participates in more complex the projects, and the more important the cooperation becomes. The previous results are likely understandable, rather than surprising, unlike the last factor, the number of RDI projects. Here again, by analogy with the previous ones, I would expect that the more projects the organization is involved in, the more important collaborations become. In contrast, we see two outlier categories, one being "6-10 projects" and the other "20+ projects". Both show a value above 2.9. The "11-20 pcs" has a similar average above 2.5 and the "1-5 pcs" category has the lowest at 2.3. It is worth noting here that the average for the organizations with the least project experience was also well above the previous factor for the smallest category of "RDI experience in years". This may be because RDI projects tend to be longer than general projects so it is conceivable that in 1-3 years the organization could have completed one or even no RDI project. Therefore, for the "1-5 projects" project number, there are well over 3 years of projects.

5 Discussion

The results should be evaluated in the sense that the research was carried out on a very relevant sample. In present there is perhaps no more representative database in the country, in terms of RDI activity and particularly RDI projects. The third branch of the tirpla helix model presented in the literature analysis, the network of state actors' contacts, was used to develop the sample. The NRDIO and the NIA are the two organizations in Hungary today that generate and support RDI projects and actors in the innovation ecosystem under the leadership of the Ministry responsible for innovation. Therefore, one can state that the organizations in the sample are the most active actors in the domestic innovation space. Overall, the findings reported in the international literature have been confirmed. Both academic and market actors in this country believe that cooperation is important for the effectiveness of RDI projects. There is a convincing majority of "rather yes" answers, with a marked average value based on the responses received. The importance of cooperation can be stated in terms of several aspects and organizational factors.

In the second part of the research, I looked at the way in which the two interacted parties (academic and market). I hypothesized that consortium cooperation, i.e., partnership, is more effective in terms of RDI project effectiveness according to the research participants' perceptions. Partnership is important because joint management is the best way to exploit synergies and reduce project risks in RDI activities in different sectors. Of course, subcontracting is not a devil's play either, it can be just as effective and efficient and certainly represents a good start. This is also evident from the results of the research, although I measured visible but not divisive values. According to these results, the consortium partnership is more effective, but the subcontracting relationship is also definitely fruitful. Therefore, I can state that the subcontractor-subcontractor relationship is a quasi-stepping stone in the functioning of RDI projects. In the longer term, experienced and growing organizations tend to relate to each other in a collaborative, subcontracting relationship.

Of course, I can see that there are limitations to research. On the one hand, to study the whole ecosystem, of course, one could broaden the scope, involving more organizations. It would be important to increase the willingness to respond, because less than 10% of the entire network of contacts took part in the survey. On the other hand, it could be important to measure the gaps in respondents' innovation activity in the research area and to refine and better specify the content of the questions.

Conclusions

Owing the results reported in this paper, one is reassured that the Hungarian innovation ecosystem agrees with a widespread and improved model essentially based on the Western technological, economic and political environment. Although the results were in line with the assumptions and expectations, I think the novelty of the research consists in the development of the sample of active actors at the heart

of the domestic innovation space, and that the results of international research and accepted models were confirmed on this basis. In Hungary, there has not yet been any research with a similar focus and on a similar basis, which specifically examines the cooperation of these sectors and the way in which they work together.

Overall, I think the research is successful, as the values are pointing in the right direction, but of course, I can also see room for improvements. The average of around 2, for some of the statements, shows that this direction needs to be strengthened among the actors in the innovation ecosystem. It is also important to highlight the categories of organizational factors. Further strong incentives for collaboration are needed for less experienced and smaller organizations. The average rating of experienced and larger organizations above 3 is, I believe, very encouraging, but at the same time I am positive that the average for the whole sample should be raised to around 3. This would require a significant increase for smaller and less experienced organizations and a more modest but equally necessary increase for their experienced larger counterparts in the average perception of working together.

As a result of the model, the main focus here is on the tasks of public actors, with programs, good practices and funding to encourage cooperation and the exploitation of its results.

List of Abbreviations

RDI: research, development and innovation

SME: small and medium enterprise

DEA: data envelopment analysis

NIS: national innovation system

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