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LINKAGES IN BUSINESS-SCIENCE COOPERATION AS A DRIVING FORCE OF TECHNOLOGICAL INNOVATION IN THE NATIONAL ECONOMY[1]

Summary

Purpose – The purpose of the article is to analyse the importance of linkages and trust in business-science cooperation. Moreover, the aim is to verify the impact of close business-science relations on the innovativeness of the national economy.

Research method – Literature studies, surveys, FGI (Focus Group Interview)

Results – The research confirms the high importance of relations and relationship management in the development of business-science cooperation. Companies that assess cooperation with science as valuable and significant to innovation, also indicate a high level of mutual relations and related fluidity in the exchange of knowledge. On the other hand, weak relations and low levels of trust often lead to problems in the implementation of joint projects, and, as a result, in the development of innovation.

Originality/value/implications/recommendations – The processes of relationship development and trust-building are as important in business-science cooperation as the carefully conducted technology transfer. Thus, companies and scientific units engaged in mutual cooperation should pay attention to both of these factors. In macroeconomic terms, the level of relations between representatives of business and science affects the number of innovations created by a given economy. As a result, it also determines its innovativeness.

Keywords: linkages; links; trust; science-business cooperation; innovativeness; national economy.

JEL classification: L14; O32

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1. Introduction

Poland is currently facing the challenge of developing a knowledge-based economy and aspires to permanently join the group of technologically developed, post-industrial countries [Jędrzejczak, Sterniczuk, 2020]. The goal is to catch up with the West as an equal, highly innovative party. However, to achieve that goal, Polish economy still needs significant improvements, especially those connected with the processes of development and implementation of new technologies that would maintain competitive advantages in an open global economy [e.g. Matusiak, 2010; Pietruszka-Ortyl, 2020; Szymańska, 2021]. The ability to introduce the technological innovation on the market is related to the level of use of both internal (e.g. internal R&D centres) and external (e.g. scientific units) sources of knowledge [e.g., Goldfarb, Henrekson, 2003]. Therefore, strong linkages in business-science cooperation are one of the main driving forces of enterprises' innovativeness, thus also the vital indicator of the national economy development level.

One of the factors that fosters the level of development of new technologies is business-science cooperation and the related flow of scientific and technical knowledge. The level of this cooperation is closely correlated with the competitiveness of the economy of a given country or region, and it depends on whether the intellectual potential of scientific units is fully used. Unfortunately, in the recent editions of the European Innovation Scoreboard (formerly Innovation Union Scoreboard) (Table 1) and the Global Innovation Index (Table 2), the Polish economy has been classified as one of the least innovative in the European Union.

In the summaries for 2015–2021, the position of the Polish economy oscillates around the 39th place in the world and 24–25th among the European Union countries. The table also distinguishes two categories, in which the Polish economy has been in a low position for years, in consequence significantly lowering the value of the main index. These are: (1) attractive research systems and (2) linkages, in which Poland performs poorly and ranks in the distant 24–26 position (Table 1). The former indicator: 'attractive research systems' is influenced, among others, by factors such as citation rates, publishing in international teams, and the number of foreign doctoral students in research institutions in a given country. The latter: 'linkages' is related to the tendency of innovative enterprises to cooperate, to the number of publications created jointly by representatives of the public and private sectors, and to the tendency of the private sector to co-finance research and development activities carried out in the public sector. The position regarding above-mentioned two indicators show that Poland has still relatively weak linkages and not very attractive research systems. Both of these, however, influence the level of linkages in business-science cooperation, and so, weaken Polish innovativeness in comparison with other member states.

TABLE 1

The position of the Polish economy in European innovation rankings compared to 28 Member States[2] in 2015–2021

Year	Performance of Innovation Systems	Innovation Growth Performance	Attractive Research Systems	Linkages
2015	24	18	25	26
2016	23	21	26	25
2017	25	11	26	26
2018	25	14	26	26
2019	25	14	26	26
2020	25	9	26	25
2021	25	11	26	24

Source: [European Commission, 2015; European Commission, 2016; European Commission, 2017; European Commission, 2018; European Commission, 2019; European Commission, 2020; European Commission, 2021].

TABLE 2

The position of the Polish economy in the world innovation ranking compared to the economies of the world and the European Union in 2015–2021

Year	Position in the world	Position among EU Member States
2015	46	27
2016	39	25
2017	38	23
2018	39	24
2019	39	21
2020	38	22
2021	40	24

Source: [Cornell University, INSEAD, WIPO, 2015; Cornell University, INSEAD, WIPO, 2016; Cornell University, INSEAD, WIPO, 2017; Cornell University, INSEAD, WIPO, 2018; Cornell University, INSEAD, WIPO, 2019; Cornell University, INSEAD, WIPO, 2020; WIPO, 2021].

[2] Including Great Britain.

Although the low efficiency of technological innovation implementation seems to be a pan-European problem, it is especially felt in Poland. The EU rankings are consistent with numerous opinions expressed by Polish experts, disappointed by the level of utilization of the Polish development potential. They indicate the general low level of cooperation between Polish enterprises and scientific units on innovations and also, a relatively low level of expenditure on research and development [e.g., Gwarda-Gruszczyńska, 2020; Świadek, 2021]. Furthermore, they point out the problem of ineffective spending of the EU aid funds within OPIE (*Operational Programme 'Innovative Economy'*) and OPID (*Operational Programme 'Intelligent Development'*) Programmes [Tużnik, Jasiński, 2022].

2. Literature Review

To improve both the attractiveness of research systems and linkages between entrepreneurs and scientists, it is necessary to develop business-science interactions, effective knowledge transfer systems, as well as skills required to accumulate knowledge. In this paper, the author examines trust and interactions as crucial factors determining the linkages between business and science. The main aim is to determine how important those factors are, both in the micro scale, when selected enterprises are assessed, and in the macro scale, when the analysis is done from the nationwide point of view.

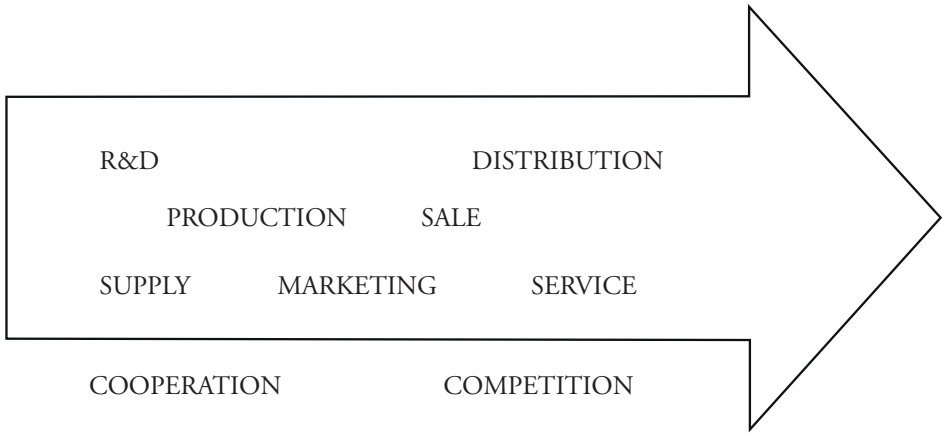
2.1. Inter-organizational linkages

According to Bengtsson and Kock, there are four types of linkages that may arise between competitors (1999): (1) Coexistence – when entities know about each other, but there is no exchange between them. (2) Cooperation is based on social and economic ties and trust in certain areas of operation, but does not exclude competition and distrust within others. (3) Competition describes a situation in which one competitor is followed by a simple and direct response from another competitor (on the principle: action-reaction). (4) Co-opetition – when the position of each partner and his ability to compete depend on the strength and position in the environment. Importantly, cooperation and coopetition may complement each other in such a relationship. Therefore, it is a form of cooperation, to a limited extent, of companies that are linked within one local market and do not establish any relations in other geographical locations or even compete there with each other [Perlmutter, Heenan, 1986].

Walley divides the areas of relations with the coopetitor into those where cooperation dominates and those where competition dominates (2007). Among the first, he lists: research and development, supply, and production of goods. Competition, on the other hand, is more characteristic of the later stages, such as: sale, distribution of goods, or servicing, as shown in Chart 1.

CHART 1

Diagram of the relationship with the coopetitor



Source: [Walley, 2007].

Regardless of the type of relationship, the ability to create and maintain linkages in the environment relies on the so-called relational competences. These are the unique merger of resources, organizational skills, and methods of functioning developed by the organization. Lorenzoni and Lipparini claim that basing on the linkages already created, companies develop their relational experience and prepare for further proinnovative interactions (1999). This experience is centered around boundary crossing individuals – a finite number of people who use ties with other entities to create added value [Tushman, 1977]. These people base their functioning both on inter-organizational and interpersonal trust, which affect the durability of relationships and their low liability to changes in the environment [Tidd, Bessant, 2013; Zaheer, McEvily, Perrone, 1998].

Relational capital is, therefore, a specific type of social capital, the level of which explains the economic efficiency of the society and influences the economic

progress of the economy [Fukuyama, 1997]. According to Nahapiet [2010], that is why selected communities maintain a high level of inter-organizational linkages, and so they have easier access to resources and a much greater chance of success as a result of cooperation. The relational capital is also related to the positive attitude of enterprises toward the co-created relationship and their belief that the cooperation will be long-term [Zieliński, 2019].

The issue of trust and relational capital is important not only because it helps to survive in an environment full of threats and uncertainty, but also enables faster achievement of the assumed goals and helps in overcoming crises. Moreover, trust between organizations is their belief that the partner will not act opportunistically [Gulati, Nickerson, 2008]. Consequently, a high level of trust increases the willingness of partners to share knowledge and continue mutual cooperation [Squire, Cousin, Brown, 2009]. Additionally, it becomes a decisive factor in contracts characterized by a high level of risk [Ring, Van de Ven, 1992].

To sum up, the level of trust between the parties is an essential factor determining the success or failure of the interaction. If it is high, it facilitates the exchange of knowledge, helps engage in relationships, and encourages reciprocity of positive behavior. Considering business – science cooperation, trust primarily supports the process of technology transfer. With a high level of credibility and predictability of the partner's activities, developed relational competences, and commitment of boundary crossing individuals, the company can rely on a faster and safer flow of important and useful scientific and technical information.

2.2. The influence of business – science cooperation on innovation

The main goal of the business-science cooperation is innovation. Basing on such cooperation, entrepreneurs can constantly find potential technological innovations or information about the latest scientific knowledge and so gain access to rare knowledge, which facilitates the implementation of innovative projects [Knoben, Oerlemans, 2006; Tidd, Bessant, 2013].

Unfortunately, the level of their innovativeness is often lower than it could have been with properly managed, trust-based science-business cooperation. Actually, one of the problems arises spontaneously as a result of the collision of commercial logic with academic logic [Van der Sijde et al. 2014]. The former wants to achieve the highest possible profit in the shortest possible time, and protect the access to the technologies. Scientists, in turn, are not operating under such a high time pressure. Moreover, they are assessed on the basis of the results

of conducted research or the number of publications, and they are more keen on sharing the acquired knowledge in the scientific community [Perkmann, Salter, 2012].

There are, however, entities that effectively combine the capabilities of their own technical base with external resources of information, knowledge, and technical resources. In this case, a significant role may be played by the ability to obtain knowledge from scientific units. It is again the idea of boundary crossing individuals who regularly and systematically obtain information on scientific and technical solutions from these units [Wiśniewska, Głodek, 2015]. Such employees often specialize in mediating between representatives of business and science. They establish personal contacts with scientists, learn about the nature of their work, and inspire them to conduct research and development in accordance with the vital interests of the company.

Among the factors intensifying the science-business linkages are [D'Este, Iammarino, 2010; Bishop, D'Este, Neely, 2011; Knoben, Oerlemans, 2006]: (1) geographical proximity of cooperating partners, (2) involvement of companies in research and development, (3) research quality of the scientific unit. The issue of geographical proximity was once introduced by Alfred Marshall (1925) who analysed so-called industrial districts. These groups of interconnected entities operating close to one another had easy access to the qualified workforce as well as to vital information and new ideas. Moreover, they could obtain semi-finished products or intermediate goods needed in the production processes quickly and cheaply. It was also the local climate, the existence of natural resources, and communication routes that made these districts so unique.

The idea of national innovation systems, which represent the political and technological perspectives for innovation in the economy could be further analyzed [Matusiak, 2010; Stawasz, 1998]. While planning the innovation strategy of a given region, one should take into account technological factors, social factors, cultural factors, economic and legal issues, and also, innovative awareness and the level of integration with innovators from abroad.

Summarizing, one of the crucial factors increasing the innovativeness nationwide is the high level of business-science cooperation in the economy. To establish such linkages, there is a need for knowledge transfer between research units and enterprises and skillful management of cooperation between them, preferably ones taking into regard local specificity, social attitudes, as well as technological, resource or financial opportunities.

The presented review helps to understand that the business-science cooperation and joint work on the development of new technologies is in fact a step

towards achieving development goals both in the micro and macro scale. On the one hand, a single enterprise can increase production efficiency and enhance, or at least stabilize, its position in the environment. On the second hand, if national research systems and linkages were to develop, the majority of enterprises could become more innovative, and so could the entire economy.

As Tidd and Bessant additionally point out, in the past, business-science cooperation occurred mostly at the time of important, often epochal changes in the world of science (2013). Currently, therefore, in the era of constant, often radical technological changes, as well as economic uncertainty resulting from such circumstances as the COVID-19 pandemic, or the war in Ukraine, these linkages should again be especially attractive for companies.

3. Linkages in business-science cooperation – research

3.1. Research Method

The analysis below uses the results of a questionnaire survey and a focus group interview (FGI), which were carried out among Polish enterprises and scientific units engaged in mutual cooperation. The research was aimed at enterprises and scientific units cooperating together within project grants run by the National Research and Development Centre (pl. NCBiR) and Chief Technical Organization (pl. NOT). For the purposes of this publication, the part of the results obtained in the study that referred to factors stimulating cooperation was used, both in the case of surveys and in the case of focus group interviews.

In the survey, there were 59 responses from the enterprises and 66 responses from the scientific units. Therefore, there were 125 completed questionnaires in total. Among them, 28 pairs were identified (28 enterprises and 28 scientific units) that jointly implemented the selected research project. The vast majority of respondents, both in enterprises and scientific units have been directly involved in the implementation of projects and have experienced the nature of business-science cooperation.

Among the participants of the FGI, there were also both representatives of Polish enterprises and scientific units. As in the case of the survey research, these people had a lot of experience in business-science cooperation, in the implementation of new technologies and were directly responsible for interpersonal linkages.

3.2. Stimulators of business-science cooperation

Table 3 shows the most important stimulators of business-science cooperation from the perspective of scientists and entrepreneurs. Among others, there was a choice of trust in the partner, trust felt from the partner's side, close relationship, liquidity of knowledge transfer, and geographical proximity.

TABLE 3

Number of respondents' indications on the most important factors stimulating cooperation – multiple choice

Respondents	Estimation of potential benefits	Trust in a partner	Trust from partner's side	Close relationship	Liquidity of knowledge transfer	Geographical proximity	Assistance in implementation processes
Scientists	22	34	21	24	29	21	10
Entrepreneurs	12	33	15	30	18	18	10
Total	34	67	36	54	47	39	20

Source: author's own elaboration.

As it turns out, the most important factor stimulating cooperation is trust in a partner – indicated by 67 respondents (54%). In the second place, the respondents indicated a close relationship – 54 (43%). Therefore, the choice of a partner largely depends on the level of mutual trust and the closeness of the relationship.

Respondents were also asked to use the five-point Likert scale (1 – weak; 5 – strong) to assess the significance of such factors as: (1) estimation of potential benefits at the beginning of the cooperation, (2) the level of trust in the partner, (3) the level of interpersonal relations, (4) the impact of geographical proximity on the effectiveness of the cooperation. From the perspective of the issues discussed in the article, it is worth noting how highly the respondents assessed the importance of trust and the level of mutual relations in opposite to other factors influencing business-science cooperation. Below, in Table 4, there are descriptive statistics of the aforementioned assessment, also conducted on a full sample of 125 respondents.

TABLE 4

Assessment of potential benefits estimation, trust in partner, interpersonal relations, and geographical proximity as factors influencing business-science cooperation within the group of 59 enterprises, 66 scientific units, and all 125 respondents

Factors	Groups	Mean	Standard deviation	Variance	Range	Min	Max
Estimation of potential benefits	*Scientists*	3.80	1.07	1.15	4	1	5
	Entrepreneurs	3.76	0.99	0.98	4	1	5
	Total	3.78	1.03	1.06	4	1	5
Trust in a partner	*Scientists*	3.95	0.62	0.38	3	2	5
	Entrepreneurs	3.85	0.81	0.65	4	1	5
	Total	3.90	0.71	0.51	4	1	5
Interpersonal relations	*Scientists*	3.98	0.64	0.42	2	3	5
	Entrepreneurs	4.02	0.80	0.64	3	2	5
	Total	4.00	0.72	0.52	3	2	5
Geographical proximity	*Scientists*	2.68	1.18	1.39	3	1	4
	Entrepreneurs	2.80	1.21	1.48	4	1	5
	Total	2.74	1.19	1.42	4	1	5

Source: author's own elaboration

Table 4 shows that both the level of trust in a partner and interpersonal relations are rated the highest among the factors influencing the business-science cooperation. The average rating of trust in the studied group is 3.90 / 5.00. The level of interpersonal relations has an even higher ratio – 4.00 / 5.00 on the Likert scale. Moreover, the relatively low level of standard deviation of these two factors suggests that hardly anyone assessed the impact of these factors as weak. Therefore, the respondents agree that it is mainly the level of relationship and trust that determines the effects of business-science cooperation.

An assessment of the correlation between above-mentioned factors was also conducted. Pearson's linear correlation coefficient was used for that purpose:

$$r_{xy} = \frac{cov(x, y)}{S_x S_y},$$

where:
cov(x,y) – covariance between the variables X and Y,
S_x – standard deviation of the variable X,
S_y – standard deviation of the variable Y,

The correlation coefficients have been compared below in Table 5.

TABLE 5

Correlation coefficients between potential benefits estimation, trust in partners, interpersonal relations, and geographical proximity

	Estimation of potential benefits	Trust in a partner	Interpersonal relations	Geographical proximity
Estimation of potential benefits	1.00	—	—	—
Trust in a partner	0.38	1.00	—	—
Interpersonal relations	0.28	0.58	1.00	—
Geographical proximity	0.04	0.10	0.01	1.00

Source: author's own elaboration

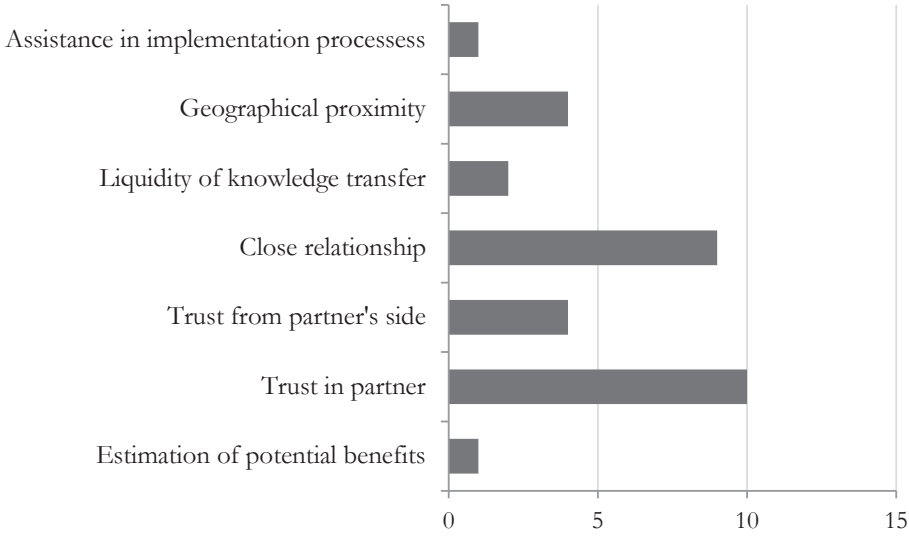
The strongest positive correlation links interpersonal relations and trust in a partner. The value of such a correlation is 0.58, and due to Wieczorkowska and Wierzbiński (2009) could be assessed as high. Thus, as could have been expected, the respondents who rated the level of relationship with the partner as strong, rated the level of trust towards them in the same way.

In addition, in pair-wise analysis, respondents very often agreed on the choice of factors that stimulate cooperation. And so, in 20 cases out of 28 (71%), they indicated at least one factor perceptible by both. Chart 2 summarizes the number of consistent indications within jointly implemented research projects.

It turns out that among the 20 coherent opinions, the partners most often indicated high trust in each other (10 times – 40% of the total 28 cases) and close relations (9 times – 36%). Therefore, if the partners establish mutual

contact, and as a result there is trust between them, very often the benefits of this relationship are felt by both parties at the same time. Based on the results for the entire population and the pairwise research, it can be assumed that it was mainly trust and close relationships that fostered the business-science cooperation.

CHART 2
The number of consistent indications of paired enterprises and scientific units for individual factors stimulating cooperation



Source: author's own elaboration

3.3. Background of the linkages

3.3.1. Trust as the main driving factor

Many opinions on how to enhance linkages between entrepreneurs and scientists emerged during the FGI. According to one of the entrepreneurs: "trust is a key factor, especially if you want to innovate for real, not fake it. If there is no trust, the project will produce a dummy, not an innovation". However, this entrepreneur further says that trust alone is not enough, since some intuition and regulations are needed in this matter. He says that, on the one hand, "after planning the work, you must always be careful about trust and remember that the highest form of trust

is control, so agreement, at least NDA[3] shall be the basis". On the other hand, "there are many cases when the NDA agreements are breached (it is sometimes difficult to define the conditions), but as a rule no consequences are drawn since the other party probably does not break this agreement on purpose. This is what trust looks like in practice".

Moreover, the problems related to trust between entrepreneurs and scientists were said to result from the low level of trust in the Polish society. Therefore, as one of the scientists claims, Polish innovation is suppressed by overregulation: "Every case is an NDA, the NDA is a lawyer who reads the letter of the law and does not understand the spirit of the case. In this way, enthusiastic cooperation at the beginning, from which you can see that something can come out, is reduced to a certain framework, but certainly not to the effect that everyone had imagined previously".

The second scientist agrees that "lawyers are starting to play an increasingly important role in the matter of trust, and often they are starting to define what will belong to whom". In turn, the third scientist presents the negative effects that may appear during attempts to regulate cooperation: "We had such an experience, where, at the very beginning of their cooperation, the two institutions put great emphasis on legal issues, and it had a completely opposite effect. We paid attention to every little detail, and the cooperation itself was rigid, overregulated, our lawyers were triggered for each decision, there was no trust at all". To sum up, a good contract is a valuable basis for cooperation and a formal support of trust. Both too low a level of regulation and overregulation may lower the level of trust between entrepreneurs and scientists.

3.3.2. Reasons for follow-up cooperation

Other vital topic concerning trust in business-science cooperation is the continuation of work with a given entity after having some successes before. As claimed by one of the scientists, "if one conducts a project with someone, then it is easier to choose the same partner later, even if he/she is not very familiar with the subject matter. It is the conviction that we can bring the matter to a good conclusion that makes us want to continue working together". The same is said by one of the entrepreneurs: "if the cooperation was good, it means that it will probably be continued in the future". Another entrepreneur adds here that: "if

[3] Non-Disclosure Agreement.

we have successfully finished a project with the scientific unit, then we often cooperate with it even better afterwards, but on a commercial basis. For example, we routinely send orders to check products that are derived from what we have developed together. The trust is already there between us".

While discussing the matter of follow-up cooperation, there has also emerged the topic of substantive and soft skills of scientists. One entrepreneur says that "if a person with whom you have worked well so far meets the requirements of a given project, it is natural not to look for other people. Why risk it?". The second entrepreneur is of a similar opinion: "Basically, the choice of a partner is sought in terms of its merit. If we are dealing with issue A, we are looking for an institution regarding issue A, if we are dealing with issue B, we are looking for an institution for issue B". Nevertheless, another entrepreneur claims: "We continue to cooperate with 'our' scientists. If we get to know a good researcher, we try to employ him or, at least, to have him with us for other projects".

What if the opposite happens, and the relationship is poor? One of the scientists claims that if they were dissatisfied with a given partner, then "even if there was another call from them, we would not cooperate with them. Because we know, it will be a torment. Even if the project was funded and there were results, it would not be a pleasure to cooperate". One of the entrepreneurs, in turn, draws attention to the dangers of renewing cooperation with the same research center: "It may turn out that other groups of scientists are more innovative, more flexible, and perhaps they are simply cheaper. You have to be constantly aware of the market and every cooperation should be considered from the business point of view".

4. Conclusions

One of the main factors influencing the innovation performance of the given economy are attractive research systems and linkages. Unfortunately, it seems that to a large degree due to the low level of these factors, Polish economy is still assessed as one of the least innovative in the European Union. That is why the author recommends to analyze the topic of trust and linkages in business-science cooperation as the crucial factor hindering Polish innovativeness. Since research and development activities are very often based on newly acquired knowledge and require the entrepreneur – *technostarter* to engage resources, time and take the risk, trust and close relationship are essential in such relations.

Surveys conducted on a group of 125 entities involved in business-science cooperation, show that indeed, such factors as trust and close relationship are assessed

as highly influential. Reversely, the same results show, e.g., a minor influence of geographical proximity on such a cooperation, giving clear information that in this comparison trust and relations are definitely more important. What is more, these two factors are characterized by the strong positive correlation in the analysed group of 125 respondents, and, concerning pair-wise analysis, are pointed out jointly by enterprises or scientific units engaged in the same projects These indications emphasize the importance of trust and close interaction in business-science relations.

According to the interviewees of FGI, the negative factors influencing the shape of contracts and the decline in trust are the low level of social trust, lack of understanding by lawyers of the so-called 'spirit of the matter' and too intense insistence, to conclude a contract, causing distrust.. In fact, to increase the level of trust in business-science cooperation, contracts should not be overregulated, so they would not be perceived as a trap by the other side. First of all, they should (1) enable the activity in a way that does not interfere with the interests of the other party, and (2) protect against a situation in which a given party cannot use the knowledge it has developed.

In general, the interview participants say that trust positively influences the decision to continue cooperation with a given partner, and vice versa, the lack of trust reduces such chances. They also indicate that further cooperation is simply profitable, because of the significant risk reduction or the conviction that a given scientist can quickly and successfully complete the work. The research results confirm that the previously established relationship between partners can foster the implementation of each subsequent project [e.g., Squire, Cousin, Brown, 2009; Zaheer, McEvily, Perrone, 1998].

An interesting theme is also the risk of continuing cooperation with the same partner, related to the existence of better alternatives on the market. It may turn out that other scientists are more innovative, more flexible or can provide the same services cheaper. Understandably, another project with a partner that has so far been difficult to work with is dangerous.

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