

The state of linkages between the science and industry in Poland before the reform of the sector of science and research

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Abstract

The sector of science in Poland is loosely connected with the economy. Scholars very rarely start technological cooperation with entrepreneurs to run research and development work and to create new solutions. The experts indicate that this is a result of a long-term improper scientific-technical and innovative strategy and the occurrence of many barriers for the cooperation between scientific entities and entrepreneurs. The paper discusses the results of the author's research on the technological cooperation between scholars and entrepreneurs, its intensity and nature between 2002 and 2007. The researched period is representative for nearly twenty years of Polish transformation before starting, at the end of 2008, the reform of the sector of science and research.

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1 Introduction

In the contemporary economy, the use of knowledge, human resources in the production process decides upon the rate and quality of economic growth, together with the new products, processes and solutions coming into being. The creation and diffusion of knowledge; scientific research results, as well as, research and development work have been for 30 years crucial production factors. The developed states, which have the command of these abilities and keep improving them, are able to create more competitive and innovative economies. They are called knowledge-based economies, among them there are such European States as Sweden, Finland, Denmark, Germany and Great Britain. This is confirmed by the position of these states in the innovativeness and economy ranking based on knowledge (Innovation Union Scoreboard, 2011; KEI and KI Indexes KAM, 2012). Their success results from the existence of strong relations between the participants of innovative processes at the macro and mezo-economic level – innovative networks. A very important element of these networks are relations of scientific and research entities with industrial enterprises. The process of technology transfer takes place in their framework together with the commercialization of knowledge.

Not all states are capable of using the potential of their sector of science and research for the needs of economy and business. This is caused by many factors of institutional, civilization, economic and legal nature. They create strong barriers, hindering the development of correlation between the science and industry and make the start of technological cooperation very difficult to these entities. In consequence, we can see a low innovativeness of such states, their regions and economic entities. This problem refers also to Poland which has been trying to catch up with its civilization and technological retardment for 20 years since the transformation of its system.

The research of the author (Łącka, 2011b) indicates that one of the reasons for this phenomena are rare and weakly developed links between scholars of the public scientific and research sector and entrepreneurs. In Poland, the system of private research and development institutions is in the germ stage and relates to, first of all, large business entities. This makes very difficult the flow of knowledge and technology to small and medium-sized enterprises which do not have their own research and development background available, nor relevant financial resources for innovativeness. The scientific and research potential of the public institutions of R+D sector is used up to a small degree, primarily to run basic research. The structure of current outlays for research and development in Poland is characterised by exceedingly large share of basic research (38.4% in 2009) and too small (with a dropping tendency) share of applied research (18.9% in 2009). Such polarization of the spectrum related to the research and development activities contributes to an isolation of the basic research and weakens the impact of impulses, coming from the economy, on the research and development area.

The loose connection of the scientific entities with enterprises has many

reasons for which both types of entities are responsible. There are also other reasons: a long-term inefficient scientific, technological and innovative policy in Poland, and inappropriate functioning of the institutions of technological transfer and innovation support (Łącka, 2010; Łącka, 2011a). For a dozen or so years of the existence of the market economy in Poland, the public sector of science and research was subject to some structural changes (Łącka, 2011b). However, they had no impact on the increase in the engagement of scholars into the transfer of knowledge and technology to the economy. Nor did they bring about the creation of a strong and fixed connection between the science and the industry. The slow process of changes in the public sector of R+D started only at the end of 2008. It was then, that the government prepared a set of 5 acts to reform Polish science². Their introduction was to approach the functioning of Polish R+D sector, in the aspect of financing principles and functioning, to the global standards. Its most important task is the conduct of scientific research for the needs of economic entities and in cooperation with enterprises. This will facilitate Poland's exit from its technological retardment. However, this process shall be long-term and requires a support on behalf of the State.

This paper is to present the condition of correlations between the public scientific entities and the enterprises before the start of a process of changes in the functioning and financing of Polish R+D sector. It is a result of the author's research on the technological partnership of scientific and research institutions and enterprises, run between the years 2009 and 2010. The research covered the cooperation of scholars with enterprises between the years 2002 and 2007.

2 Preliminary Notes

2.1 Material and research methods

The research was conducted amongst public universities and their organisational entities. The selection of exclusively public universities from amongst all high schools in Poland resulted from the fact that (apart from education and training) they also run research and development work. They have a scientific and research potential (as well as research background and scientific and research staff). Some of them handle institutions to support the academic entrepreneurship and innovation. The non-public universities, on the other hand, have the staff from public schools at their disposal and, on principle, have no own research background. They do not show activity in the field of technology transfer.

² This set covers the acts: on the Principles for Science Financing, on the National Centre of Research and Development, on the National Centre of Science, on Research Institutes and on Polish Academy of Sciences. These acts came into force on 1st October 2010.

78 public academic universities were under research. They represented all types of universities in Poland. There were universities of technology (18), general universities (17), medical universities (10), agricultural universities (8), physical education universities (6), military universities (5), economic universities (5), pedagogical universities (5), maritime academies (2) and theological universities (2).

An analysis of the intensity and nature of the technological cooperation between Polish universities and entrepreneurs required joining the quantitative and qualitative research. To evaluate the scale, condition, character and results of this cooperation, the probing research was applied with the use of the following research techniques: survey questionnaire prepared by the author and a guided interview. This facilitated the use of the method of descriptive statistics to numerical descriptions of the features belonging to the collectivities under research. To establish and describe the interrelations of the phenomena, the testing of correlation was applied and to determine the force of the connection between the features – the tau Kendall correlation ratio, the index of Spearman correlation and the index of Pearson *C*'s contingency.

The questionnaire contained 42 questions of various nature. There were open, closed, alternative and scales questions. The questionnaire was composed of the address data of the entities, general information on the entity under research, its scientific and research potential and cooperation with other entities apart from enterprises, the information and opinions related to the frequency and nature of the cooperation with enterprises and the opinion of the representatives of the entities of the scientific sector on the prospects for the development of technological partnership, and expectations related with it.

The quantitative and qualitative research covered finally (after the verification of 52 received answers to the survey and to the questionnaires of interviews) 50 entities from the group of universities of very differentiated nature, universities as an entirety, organisational entities of high schools, for instance, chairs, plants and also one centre of innovation and technology transfer, acting at the university.

3 Main Results

3.1 Financing sources of research activity of the universities

Because of the limited framework of this paper, only selected results related to the research on the technological cooperation between the universities and their organisational entities³ were presented. They shall allow becoming familiar with

³ The entirety of the multi-issue research of the author over the technological partnership between the scientific and research entities and enterprises and its impact on the innovativeness of the economy is presented in the book: (Łącka, 2011b). The technological cooperation of Polish scientific and research institutions with enterprises as a

the condition of the relations between Polish scientific sector entities and enterprises between 2002 and 2007, i.e. before the start of this sector's reform.

To establish the scope of relations between the university entities and the industry, the financing resources for their research activities in 2007 were reviewed. The analysis of the questionnaires showed that the most popular financing source for these activities were state resources (subsidy for the university's activities). Such an answer was received in the case of 42 entities or else, 92% of those under research. At the second place as to the number of indications were research grants financed from the resources of the Committee for Scientific Research (or the Ministry of Science and Higher Education). This source of financing for the research activities was indicated in 40 entities (80% of answers). One half of those under research, i.e. 28 entities (56%) emphasised the fact that European grants were of crucial importance. At the subsequent place, there were other sources (indicated by 21 entities or else 42% of those under research). They were the own incomes of the university, the sale of technological offer and expert opinions. Subsidies for research were used by 10 entities (20%), and the personal property by 1 university (2%). Only 5 entities (10%) indicated a private investment as the source of financing for the research activities.

3.2 Transfer of technology and commercialisation of knowledge by the universities

The share of revenues from outside its statutory business in the revenues of the entity testifies to the activity of the scientific sector entity in the cooperation with industry. They include revenues from grants and subsidies to research purposes, resources from the implementation of projects, revenues from the sale of patents and licences. It results from the analysis of the answers given by the representatives of the universities that between 2002 and 2007, the share of revenues from outside the statutory activities in the total revenues of the entity was very varied. For 72% of the entities (36 of the entities under research) the revenues of this type fluctuated from a few to 15% of the total revenues. This means that these entities conducted nearly no technology transfer. The largest activity in this field was noted only in the case of 3 entities (6% of those under research). These entities handled technological science issues and acted in the structures of two universities of technology and one general university. In 2007, their revenues out of the statutory activities made up 71 to 100% of the total revenues of the entity. In the case of the remaining types of universities and their organisational entities, the share of the revenues from outside the statutory activities in the total revenues fluctuated from 30 to 50% (12% of those

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under research) and from 51 to 70% (10% of those under research). The results obtained indicate that a majority of those under research conducted no research work used for the industry between 2002 and 2007.

This related also to the technological offer of these entities, which although varied but did not give rise to any interest of the enterprises. The universities which had at their disposal patents or patent applications (over 60% of those under research) were not able to commercialise them. Only 12% of those under research made a transaction of sale of a licence between 2002 and 2007, and 8% sold the know-how. The universities, as owners of patents, did not try to sell their inventions, frequently they would stop paying the patent protection. In their structures, professionally acting institutions to handle the technology transfer and the commercialization of knowledge were lacking. The scholars were not, in most cases, interested in the further future of their inventions as they could not get any profit from their commercialisation. The most important purpose – obtaining a patent – was achieved. This was important for the evaluation of their scientific activity at the university and for the assessment of the university itself.

No professional marketing of the science nor contacts with the external institutions which act as a go-between in the technology transfer and in the commercialisation of the effects of scientific research (such an answer was given by 92% of the entities under research) made it difficult to convince the potential industrial partners to the technological cooperation or to purchase a technological offer.

3.3 Cooperation between universities and enterprises in the transfer of technology

The empiric research was also to explain whether in the period under research public universities started any cooperation in the scope of the transfer of technology and knowledge with domestic and foreign enterprises. Pursuant to an analysis of the answers from the questionnaire and direct inquiries, we may claim that 40% of the entities under research (20 entities) had frequent contacts with enterprises of a very differentiated nature between the years 2002 and 2007. However, 60% of those under research did not start any cooperation with enterprises in the field of scientific and research activities or did it very rarely. The contacts of scholars with entrepreneurs were frequently limited to advisory, expert activities, running commissioned laboratory tests or conducting training for the needs of entrepreneurs. Only 16 entities (32% of those under research) recognized the cooperation with entrepreneurs as the technology transfer. The partners of the entities under research were primarily national enterprises belonging to small business. It results from the research that only 2 to 4% of the entities questioned cooperated in the field of technology transfer with small and medium foreign enterprises.

3.4 Barriers of the cooperation between scientists and entrepreneurs

Starting the cooperation between the scientists and entrepreneurs in Poland is difficult because of many barriers. This problem was also included in the research. The representatives of the sector of science deemed it that the most important and strongest barriers to the technological partnership between the universities and small and medium-sized enterprises between 2002 and 2007 are: no funds owned by entrepreneurs for research and development work (26% of answers), the entrepreneurs not familiar with the scientific entity (22%), unattractive price of the university (20%), reluctance of small and medium-sized enterprises to start the cooperation (14%), no strategic thinking of entrepreneurs (14%), too high expectations of the company related to the time the innovation is implemented (12%), the way of thinking of the enterprises' owners (10%). A majority of the above-mentioned barriers occurs in the opinion of the scholars mostly with the entrepreneurs. The hindrances to the cooperation, arising from inappropriate conduct of scholars and universities, related to insufficient knowledge on the demand for the technological offer and innovations (6% of indications) and no negotiation abilities of the scholars (4% of answers). None of the questioned representatives of universities mentioned as a barrier the inappropriate marketing and promotional activities of the scientific entity in the market. They did not discern the connection between this barrier and the fact that the entrepreneurs are not familiar with their activities.

3.5 Forms and objectives of the technological cooperation between universities and companies

The research was also to establish the forms of cooperation between the scientific entities and enterprises. The analysis of the questionnaires and interviews confirmed the earlier findings that the cooperation of an expert nature dominated (66% of the entities), then consulting (58%) and training (40%). The scholars and entrepreneurs cooperated also within joint research programmes financed by the government (50%), with the purpose to create new technological solutions. However, most of these research programmes did not require from the scholars an actual technology transfer. About 20% of those under research declared that trying to acquire public resources for research together with the research and development entity, they found an enterprise from the SME sector and running the joint research, they prepared the innovation for the company or conducted a modernisation of the existing solution.

The cooperation with the enterprises in the field of technology transfer was started primarily to acquire additional financial resources for research work (50% of those under research), to use the results of the hitherto scientific research in the economy (44%), to implement them (42%) and to use free staff resources and equipment of the entity (32%). Less important motives which were given: the

creation of a new product (24%), granting a patent (8%). A small impact on the start of technological cooperation by scholars have such factors as: the access to unknown knowledge resources (6% of those under research), becoming familiar with new phenomena and the potential to use them practically in the economy (10%) and the reduction of the risk of innovation (2%).

During the technological cooperation with enterprises, the universities engaged or were ready to engage the following resources:

- working time of the employees - 29 entities (58%),
- equipment and/or premises - 26 entities (52%),
- advising in the scope of modernising products - 11 entities (22%),
- new technologies (licences, know-how) - 12 entities (24%),
- consulting related to the sources for financing of research and development projects - 10 entities (20%),
- consulting while purchasing licenses and new technologies - 6 entities (12%),
- organisational work of employees while starting development projects - 2 entities (4%).

The above-mentioned answers indicate that the basis for the technological partnership of most scientific entities with the enterprises was or was to be the use of their human and substantial resources (within commissioned research or joint research) and consulting services offered by the scientific staff. Only 24% of those under research accepted the contribution to the cooperation in the form of licence or know-how.

3.6 Preferred models of the participation in benefits

During the research, the scholars were asked to give their preferred model of participation in the profits, arising from the cooperation with the enterprises. They were to select: the payment for services, covering of costs together with the motivation, a partial covering of costs with the share in profits and joint venture (a spin-off company with an industrial partner). The most preferred model of sharing the profits of the cooperation proved to be the payment for the services which was selected by 58% of those under research. The next accepted model was the covering of costs together with the financial reasoning (12%). A partial covering of costs with the participation in the profits was selected only by 6% of those under research and the joint venture - 2% of entities (1 entity). The results obtained testify to the fact that the scholars, aware of the risk of failure of their research or of the market success of the innovation did not accept the benefit in the form of a hypothetical share in the profit nor of taking up the risk of the joint venture's failure.

3.7 Evaluation of the benefits and satisfaction from the cooperation

The technological cooperation, started with enterprises allowed the universities and their entities to obtain the expected profits. Over half of those under research (52%) recognized that the work for the industry allowed them to increase the budget of the entity by supplying it with the resources, coming from private funds (the payment for commissioned work, consulting while selecting new technologies and expert opinions). They indicated equally frequently the benefit of the possibility to run the applied research and implementations for the industry (50% of the answers). For 40% of those under research, the increase in the number of contracts for research work was an important benefit coming from the cooperation. This ensured to 28% of those under research the effective use of their scientific and research potential and running research of crucial importance for the development of a given scientific branch. The cooperation with the industrial partner made it also possible to 28% of entities to improve the quality of students' education through their participation in the research for the industry. The technological partnership ensured only to a few of them (18%) the right to a patent and getting additional income from the sale of the patents and licences owned (12% of those under research).

During the research, the scientists were to evaluate the degree of satisfaction, coming from the benefits, arising from the cooperation with the entrepreneurs. Amongst 31 entities (62%) of those under research, which answered to question, 17 entities (54.85%) were satisfied with the benefits gained in consequence of the cooperation and 13 (41.93%) acknowledged the cooperation as rather satisfactory. Only one entity acknowledged its results as unsatisfactory because of a too short period of cooperation. The most frequent reasons for obtaining lower benefits than those intended in technological agreements and their lack of stability were: problems with the management of the partnership, preparation of an agreement on cooperation less advantageous to the scientific entity, impossibility to use the results of the research for the needs of scientific publications, financial instability of the industrial partner, lack of flexibility of the industrial contractor, market changes and the necessity to stop the research commissioned by the company, and the dishonesty of the industrial partner.

3.8 Relations between the features of the scientific units and the features of the technological cooperation

During the research, the interrelation between the features of the entities of the scientific and research sectors and the features of their technological cooperation with the enterprises were to be found. In the paper, only selected results of statistical research shall be presented. The analyses of the correlation indicated that the size of the research resources (human potential) had no impact

Table 1: Contingency indices for the interrelation between various benefits gained from the technological cooperation of the university entities and other features

Types of benefits	Features of the research unit				
	Number of human research resources	Number of professors	Number of doctors	Number of innovative resources	Number of patents
Effective use of the staff and equipment	0.66		0.62	0.65	
Acquisition of additional financing resources for R+D from private funds	0.69	0.61	0.66	0.68	
Access to new abilities and knowledge	0.69		0.61	0.64	
Running research of crucial importance for the science	0.70		0.65	0.69	
Access to modern machines and facilities	0.69		0.64	0.68	
Potential to implement the results of research to the economy	0.69	0.63	0.68	0.71	
Launching a new product (solution in the market)	0.68		0.68	0.70	
Patent	0.69	0.60	0.63	0.68	0.65
Revenues from sale of a patent or a licence	0.71			0.68	0.60
Reduction in the costs of research work conducted	0.65	0.60	0.63	0.71	
Increase in the number of commissions for research work	0.69	0.61	0.65	0.66	
Training, practice	0.64	0.63		0.66	
Educating students through their participation in the research for the industry	0.67		0.63	0.68	0.64

Source: own elaboration, pursuant to the statistical calculations of the contingency indices.

Table 2: Contingency indices for the interrelation between various benefits gained from the technological cooperation of the university entities and other features

Types of benefits	Features of the research unit			
	Number of patent applications	Number of implementations	Number of research programmes	Degree of benefits gaining
Effective use of the staff and equipment			0.66	
Acquisition of additional financing resources for R+D from private funds	0.61		0.62	0.65
Access to new abilities and knowledge			0.63	
Running research of crucial importance for the science	0.65		0.60	
Access to modern machines and facilities	0.60		0.64	0.60
Potential to implement the results of research to the economy	0.60		0.61	
Launching a new product (solution in the market)	0.62	0.63	0.64	
Patent			0.61	
Revenues from sale of a patent or a licence			0.66	
Reduction in the costs of research work conducted		0.65	0.71	
Increase in the number of commissions for research work	0.61			
Training, practice		0.64	0.64	
Educating students through their participation in the research for the industry	0.62		0.62	

Source: own elaboration, pursuant to the statistical calculations of the contingency indices.

on the number of innovative resources nor on the activity while taking up the technological cooperation with enterprises. The cooperation developed more with other institutions of the R+D sector but frequently, it would not have the nature of technology transfer. In their technological offer, the universities had patents and patent applications, however, the new solutions were implemented in enterprises to a too small degree. They did not influence materially the acquisition of resources outside the statutory activities. The calculations of the correlation coefficients allowed to establish that the technological cooperation with the enterprises and other institutions of the R+D sector made it possible to the university entities to gain the intended benefits determined by their scientific and research potential and the number and type of innovative resources.

Analysing the interrelation between the features of the scientific entities and determined benefits which they managed to achieve during the cooperation with the enterprises, the contingency coefficient was calculated. Because of a large number of results, it was decided that the paper shall state only these values which indicate to a rather strong, strong or very strong interrelation between the features (the contingency coefficient equals to at least 0.60). The results of the calculations were presented in Table 1 and in Table 2.

The contingency coefficients placed in Table 1 and 2 indicate strong and very strong interrelation between the human values of research resources, the number of doctors, in particular, and all types of benefits, arising from the technological cooperation with enterprises. The results of statistical calculation revealed also rather strong, strong and very strong interrelation between the benefits coming from the technological partnership and the number of innovative resources and research programmes in which the scientific entities participated. A rather strong interrelation between the number of patent applications and some types of benefits from the cooperation shall be also underlined. They were such as: the conduct of research of material importance for the science, launching a new product (solution) in the market, educating students through their participation in the research for the industry, the increase in the number of orders for R+D work and the acquisition of additional resources for the research from private funds.

4 Conclusion

The research pursued on the relations of the units of scientific sector with the enterprises in Poland between 2002 and 2007, and the analysis of the relation between the features of the R+D sector entities and the features of their technological cooperation allow to determine the size and nature of the cooperation of these institutions with the enterprises in the field of technology transfer. Based on the results of the research, we may come to the following conclusions:

- up to now, the relations between the scientific entities and enterprises have been very weakly developed which is indicated by a small per cent of the

scientific sector entities which undertake the technological cooperation with enterprises and too small number of agreements with the entrepreneurs in the field of R+D activities and innovativeness,

- the knowledge transfer and the commercialisation of technology by the entities under research was not satisfactory which is proved by the size of the revenues they gain from target projects and from the sale of research projects (grants and ordered projects) and also very low revenues from the R+D work with foreign entities,
- taking up technological cooperation between institutions of the scientific sector and entrepreneurs was made difficult by many barriers for which both entrepreneurs and scholars were responsible,
- the most frequent forms of technological cooperation of the university entities in the period under research were: expert opinions, consulting and consultations, more rarely joint research programmes financed by the government, drawing up new technological solutions and joint research,
- the relations of the science and industry brought to the universities and scholars many benefits which increased the scientific and research potential and innovativeness of these entities and had an impact on the position of the institutions in the scientific and business environment.

The reform of Polish scientific sector started at the end of 2008, and being implemented consequently from 2010 is to bring about an increase in the relation between the world of science and the economy. This will allow to approach the supply of technological offer, coming from the scientific sector to the demand for it, facilitate more intense flow of scientific research results to entrepreneurs, raise the scientific and research potential of Polish universities, and in consequence will increase the innovativeness of Polish economy.

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