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RESEARCH COOPERATION BETWEEN UNIVERSITIES AND BUSINESSES AS A SOURCE OF INNOVATIVENESS*

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Abstract: The aim of this article is to determine the extent to which research cooperation between universities and businesses affects the results of innovative activities. A research hypothesis has been adopted that there is a very high level of interdependence between the research cooperation of universities and businesses and the effects in the area of economic innovation. In order to empirically verify the proposed research hypothesis, the correlation relationship between the variable of university-business research cooperation in 2013-2017 and selected variables determining the effects of innovation activity in 2018 in EU economies was examined. The results obtained in the study allowed for a positive verification of the research hypothesis, confirming the important role of research cooperation between universities and businesses in the context of creating innovation in the economy.

Keywords: cooperation of universities and businesses, innovation efficiency, innovativeness of the economy.

1. Introduction

Currently, the growing role of cooperation between universities and industry for economic development is observed in both developed and developing countries (Freitas, Marques, and Silva, 2013; Guan and Zhao, 2013). Cooperation between universities and industry is a response to market failure in the area of innovation, and allows to fully exploit the potential of R&D investments (Martin and Scott, 2000;

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D'Este and Patel, 2007). With the growing importance of universities in the social system of knowledge production, their impact on innovation in the economy becomes more diverse. Therefore, universities are encouraged to cooperate with industry, among others, by supporting their employees and students in the aspect of starting entrepreneurial activity. By developing research collaboration with the private sector, universities become successful business units that can maximize their relevance to society (Huang and Chen, 2017). In addition to their core mission of teaching and research, universities also undertake technology transfer, which is the basis for the commercialization of science. This approach implies benefits for companies (Etzkowitz, Webster, Gebhardt, and Terra 2000) which, by conducting innovation processes, strengthen their competitiveness (Piątkowski, 2010). Companies must be open to working with external partners who can support their innovation efforts by providing knowledge and resources (Moon, Mariadoss, and Johnson, 2019). Companies that are open to seeking external partners have a greater capacity to implement innovations (Li-Ying, Wang, and Salomo, 2014). Cooperation with a research institution is less problematic for companies than cooperation with a potential market competitor, as information can be made available more easily (Veugelers and Cassiman, 2005).

2. Purpose, methodology and research area

The aim of this article is to determine the extent to which research cooperation between universities and businesses affects the results of innovative activities. Hence a research hypothesis has been adopted that there is a very high level of interdependence between the research cooperation of universities and businesses and the effects in the area of economic innovation.

The literature on the subject abounds in numerous studies on the impact of university-business cooperation on innovation in the broad sense. For example, George, Zahra and Wood (2002) showed that such cooperation is positively reflected in the company's innovation performance. In their research, they used various variables such as the number of patents, the number of products in the market, the number of products in the development stage and the net sales value in relation to the asset value to measure the level of innovation and the financial standing of companies. Interesting studies were also carried out by Lööf and Broström (2008), who proved that cooperation between universities and businesses results in increased sales of innovations and more industrial patents. Eom and Lee (2010), on the other hand, used measures such as the number of patents, the share of revenue from product innovation sales and labor productivity in their Korean market research. They showed a positive correlation between cooperation between universities and businesses and the growth of patents from product innovations. However, they did not notice any positive impact of the above mentioned cooperation on sales volume or work efficiency.

The article uses domestic and international literature, as well as statistical data included in the *Global Innovation Index 2019*[1] (Cornell University, 2019) report on economic innovation. The survey included data for all Member States of the European Union for 2013-2018.

The paper first of all addresses the issue of the theoretical conditions of research cooperation between universities and businesses in terms of its impact on the creation of an innovative economy. The following data were presented: on research cooperation of universities and businesses in the Member States of the European Union in 2013-2017; the Global Innovation Index 2019 and its selected groups and subgroups concerning the effects of innovative activities. Subsequently, in order to empirically verify the research hypothesis proposed above, the relationship between university-business research cooperation in 2013-2017 and selected variables determining the effects of innovation activity in 2018 in EU economies was examined using the r-Pearson correlation coefficient.

3. Theoretical conditions of research cooperation between universities and businesses

Cooperation in R&D activity consists in starting joint R&D undertakings of businesses and scientific entities. It may take the form of research and development consortia as well as be initiated at the request of a company when the research and development entity becomes a subcontractor. In both indicated cases, there is a transfer of knowledge in both directions: from the scientific entity to the enterprise and from the enterprise to the scientific entity (Weresa, 2014, p. 48). In relation to jointly conducted research, it is easier to carry out research work on behalf of a business entity, and it is also easier to settle the project and indicate the owner of potentially obtained intellectual property rights. On the other hand, such a solution may be characterized by a lack of mutual exchange of experiences, or problems in communication between the parties (Czerniak, 2012, p. 88).

[1] The Global Innovation Index is the result of cooperation between representa-tives of several entities, namely: Cornell University; INSEAD – the Business School of the World, a renowned management and business school; and the World Intellectual Property Organization (WIPO). The publication is published annually. The latest edition of the report, dated 2019, includes 129 countries ranked in terms of their economies' innovation performance. The Global Innovation Index consists of 80 individual indicators divided into seven groups. Within each group of variables, three sub-groups of indicators are additionally distinguished. All indicators were standardized using the min-max method and their value was between 0 and 100. Additionally, within the Global Innovation Index, two innovation sub-indexes were determined: the Innovation Input Sub-index and the Innovation Output Sub-Index. The latter sub-index was used to conduct the research in this article. Innovation outputs are the results of innovative activities within an economy. Although the Output Sub-Index includes only two pillars, it has the same weight in calculating the over-all GII scores as the Input Sub-Index. There are two output pillars: Knowledge and technology outputs and Creative outputs (Firlej, 2019, p. 37).

In higher education, small-scale basic and laboratory research is often undertaken as part of scientific projects, which in most cases are not aimed at the commercialization of their results, however businesses report a growing demand for the implementation of R&D results in their operations, which may result in the production of new or a wide range of modified goods. As a result, the competitive capacity of these companies is expected to increase. It is worth noting that the process of transition from research conducted by a scientific unit and obtaining a satisfactory result to the stage of production of a given good is long-lasting and involves the risk of failure. Therefore, there is room for the activity of businesses that can provide financing for the project (Irwin and Klenow, 1996). In this case, the transfer of knowledge from research units to businesses may be carried out through the so-called *spin-off* companies, which are established in order to commercialize the research results obtained by researchers employed in the relevant units and universities. These companies are usually characterized by a high level of innovation, and their elementary resource is the unique knowledge created at universities. These companies operate mainly in sectors such as information technology, biotechnology and medical technology. It is worth noting, however, that the legitimacy of such companies depends on a well-functioning venture capital market. In Poland, unfortunately, such investors do not offer a sufficient supply of capital, which is one of the barriers to the creation of *spin-off* companies. Moreover, numerous legal and institutional barriers are also observed, which are related to the start of a business activity by a researcher. As a result, this form of knowledge commercialization does not meet with greater interest (Weresa, 2014, p. 49).

Knowledge transfer from universities to businesses can also take place directly by selling patents or granting licences. Patents introduce innovations in markets by stimulating competition and contributing to technological progress, which is often attributed to their leaders. Patents are considered to generate a temporary monopoly position for their holders, which distorts prices and thus increases social costs. On the other hand, they provide an incentive for many business entities to invest in an innovative project that enables them to gain a leading position on the market. Such investments also generate social benefits through technology development and economic growth (Oleksiuk, 2012, pp. 66-67).

Technology transfer through *spin-off* companies can be supported by the functioning of business incubators and science parks, which usually noticeably support the development of this type of projects by encouraging employees and university graduates to take on the role of entrepreneurs. Incentives of this kind seem to be needed as researchers are usually neither willing nor particularly prepared to set up and run businesses. It is worth noting that the role of science parks is to facilitate and accelerate commercialization, and their functioning is not the only condition for establishing *spin-off* companies. An essential and most important condition is that universities produce new and valuable knowledge, which is

characterized by the possibility of commercialization. A similar situation is found in the case of technology licensing offices, whose market success is mainly determined by their ability to offer innovative technology with the possibility to apply it on the market (Czerniak, 2012, pp. 90-91).

It should be stressed that research cooperation between universities and businesses is not the main and most important objective of their activities. The most important role of universities is to shape high quality human capital and carry out basic research (Mark, 2016, pp. 1-17). In the case of basic research, companies are often not interested in carrying out such research because of the high risk of failure, limited financial resources or positive externalities. Thus it is necessary for the public sector to carry out and finance this type of research, with particular emphasis on universities, as without its participation this area would remain underfunded in relation to the social optimum (Firlej, 2018, pp. 79-80). Yet it is hard to imagine that a higher education institution would be a place of creating only theoretical knowledge (in which case the institution would be isolated from society) or only useful knowledge (created for the market). It should be stressed that while respecting academic values, modern universities should carry out internal changes in order to promote openness to cooperation with their surroundings in the aspect of knowledge--based economy. Such a solution allows for progress, while the abandonment of changes may lead to backwardness and the creation of universities akin to those medieval. At the same time, the creation of socially useful knowledge does not exclude the possibility of carrying out research also on a theoretical level (Pleśniarska, 2016, p. 38).

Effective government policy also plays an important role in stimulating research cooperation. Firstly, it is important for universities to be broadly independent in the financial and educational areas as well as in their interaction with businesses. Universities are then given the opportunity to seek out the best students and receive an incentive to apply for new sources of funding to carry out projects with the required specificity. Secondly, competition in applying for funding from the state budget, foundations or industry is important. The level of supply of higher education research is a result of its financing from budgetary resources. However, the innovation of the economy results not only from the number of new solutions, but also from their quality, with particular emphasis on the possibility of using them in practice. Thirdly, a moderate reduction in the amount of funds that universities receive from the state budget may have a positive impact on university-business cooperation. This may force universities to look for alternative forms of funding. In turn, financing research from such sources will cause universities to carry out only the research for which there is demand. This may result in the fact that research will no longer be carried out not because there are funds for it, but because the market demands it (Czerniak, 2012, p. 91).

4. Research cooperation of universities and businesses in the Member States of the European Union

The issues of research cooperation between university centres and businesses can be presented empirically, among others, by means of one of the synthetic indicators which is cyclically presented in the Global Innovation Index. The results of the surveys which answer the question whether universities and businesses cooperate in the field of research activities, are presented in Table 1. The indicator takes values on a scale from 1 to 7, where 1 means no cooperation, and 7 means intensive cooperation in many areas.

Table 1. Research cooperation of universities and businesses in the Member States of the European Union in 2013-2017

Country	2013	2014-2015	2016	2017	Country	2013	2014-2015	2016	2017
EU 28	4.34	4.37	4.12	4.18	Lithuania	4.56	4.61	4.12	4.1
Belgium	5.53	5.58	5.26	5.3	Luxembourg	4.9	4.9	4.65	4.8
Bulgaria	3.04	3	3.38	3.4	Hungary	4.26	4.27	2.92	3.4
Czech Republic	4.41	4	3.66	3.9	Malta	3.77	3.86	4	4
Denmark	4.81	4.9	4.84	4.8	Netherlands	5.25	5.38	5.5	5.6
Germany	5.39	5.34	5.35	5.4	Austria	4.79	4.68	4.81	4.8
Estonia	4.39	4.36	4.08	3.9	Poland	3.54	3.5	3.29	3.2
Ireland	5.2	5.24	5.11	5	Portugal	4.6	4.68	4.03	4.2
Greece	3.01	3.06	2.65	2.5	Romania	3.33	3.59	3.33	3.1
Spain	3.98	3.77	3.51	3.5	Slovenia	3.77	3.96	3.76	3.8
France	4.46	4.58	4.29	4.2	Slovakia	3.29	3.36	3.31	3.3
Croatia	3.46	3.39	2.87	2.7	Finland	5.82	5.97	5.72	6.6
Italy	3.71	3.73	3.68	3.8	Sweden	5.34	5.33	5.16	5.2
Cyprus	3.79	4.19	3.35	3.4	United Kingdom	5.58	5.67	5.47	5.4
Latvia	3.6	3.67	3.35	3.1					

Source: own compilation based on (*Global Innovation Index*, n.d.).

The leading countries in the area of university-business research cooperation are Finland, the Netherlands and Belgium, which were rated highest by respondents, whilst the worst results for this type of cooperation were recorded in Greece, Croatia, Latvia and Romania. The rating of university-business cooperation varies greatly. The best countries on the list obtain very good results, with an upward trend, showing a high level of cooperation in many areas. However, there is a concern that the countries with the weakest results are also seeing a downward trend in terms of joint research carried out by universities and businesses (Table 1).

Table 2. Innovation of European Union Member States according to the Global Innovation Index 2019

Country	Global Innovation Index 2019 (GII 2019)	Effects of innovative activities (sub-index under GII 2019)	Knowledge and technological achievements (group 6 under GII 2019)	Creative production (group 7 under GII 2019)
EU 28	49.14	41.11	39.9	42.3
Belgium	50.18	39.63	40.8	38.5
Bulgaria	40.35	32.61	31.4	33.8
Czech Republic	49.43	43.44	43.8	43.1
Denmark	58.44	47.55	46.4	48.6
Germany	59.19	51.1	52.7	49.6
Estonia	49.97	43.83	36	51.7
Ireland	56.1	50.08	56.9	43.3
Greece	38.9	27.61	25.1	30.1
Spain	47.85	38.42	37.2	39.7
France	54.25	45	45	45
Croatia	37.82	28.28	25.6	31
Italy	46.3	37.87	38.9	36.8
Cyprus	48.34	41.13	41.2	41.1
Latvia	42.23	35.17	27.5	42.8
Lithuania	41.46	32.34	24.4	40.3
Luxembourg	53.47	49.2	42.2	56.2
Hungary	44.51	38.67	42.8	34.6
Malta	49.01	43.44	31.9	55
Netherlands	61.44	57.49	61.8	53.2
Austria	50.94	39.06	36.7	41.4
Poland	41.31	31.66	30.9	32.4
Portugal	44.65	34.6	29.8	39.4
Romania	36.76	28.02	30.03	25.8
Slovenia	45.25	36.4	30.7	42.1
Slovakia	42.05	35.55	34	37.1
Finland	59.83	51.62	55.1	48.1
Sweden	63.65	56.87	61.8	51.9
United Kingdom	61.3	54.38	56.6	52.2

Source: own compilation based on (Cornell University, INSEAD and WIPO, 2019).

According to the latest edition of the report (2019), the most innovative EU economies are Sweden, the Netherlands and the UK. These countries achieved the best results in the European Union in terms of total innovation, the effects of innovative activities, as well as knowledge and technological achievements. In terms of creative production, these countries also recorded significant results, ranking just behind Luxembourg and Malta (Table 2).

In order to quantitatively verify the research hypothesis, the r-Pearson correlation coefficient was calculated between the variable of research cooperation between universities and businesses and selected variables determining the effects of innovative activity. The number of pairs of variables was equal to the number of EU Member States and amounted to *N=28*. Due to the necessity to take into account time delays, the survey used statistical data from 2013-2017 (explanatory variable) and 2018[2] (response variables), (Table 3).

Table 3. Correlation matrix of the value of the r-Pearson correlation coefficient of a variable of research cooperation between universities and businesses and selected variables concerning the effects of innovative activity

Explanatory variables	Year	Response variables			N	p
		Effects of innovative activities (sub-index under GII 2019)	Knowledge and technological achievements (group 6 under GII 2019)	Creative production (group 7 under GII 2019)		
Research cooperation between universities and businesses	2013	0.812	0.784	0.660	28	0.01
	2014	0.808	0.781	0.655		
	2015	0.808	0.781	0.655		
	2016	0.833	0.779	0.711		
	2017	0.834	0.795	0.691		

Source: own calculations and studies.

As a result of quantitative research on the level of the r-Pearson correlation between selected variables concerning research cooperation between universities and businesses in 2013-2017 and selected variables concerning the effects of innovative activities (values of the variables according to the *Global Innovation Index 2019* report) in the European Union Member States (*N=28*), a high or very high level of dependence was observed in most of the years considered[3]. The correlation between the variable of research cooperation of universities and businesses with the sub-index of innovative activity effects was very high. A slightly lower level of correlation, but still a very high one, was noted for the relationship between the above mentioned variable and the synthetic variable of knowledge and technological achievements. In turn, the lowest level of correlation among the surveyed relationships was between the research cooperation of universities and businesses and the variable of creative production. It should be noted that effective and good-quality cooperation may in this case determine the increase in interest of

[2] *The Global Innovation Index 2019* includes countries' innovation performances in 2018.

[3] The interpretation of the strength of the relationships between the examined variables was carried out according to the J. Guilford scale.

businesses in undertaking R&D activities and thus stimulate their outlays on such activities.

All cases of correlation for the studied explanatory variable turned out to be positive and statistically significant, and the optimal level of time lag was noted for a single year.

5. Discussion and conclusions

The empirical research carried out in the paper showed a high or very high degree of correlation between university-industry cooperation in 2013-2017 and the innovation of the economy in the member states of the European Union in 2018. It should be noted that the calculations were limited to a selected group of indicators and countries. More advanced research is required to confirm the observations obtained. However, it is worth pointing out that the results correspond to those obtained by George et al. (2002), Lööf, Broström (2008) and Eom, Lee (2010), who identified the impact of university-business cooperation as a factor stimulating the development of broadly understood innovation.

However, carefully analyzing the results of the conducted research, it is necessary to group the emerging reflections and present the following conclusions:

1. The beneficial impact of cooperation between universities and businesses was observed at a very high level in the area of innovative activities. It was reflected in particular in the area of knowledge and technological achievements, which included groups of indicators on creation, impact and diffusion of knowledge. University--business cooperation also had a very positive impact on the results in the area of creative production, measured by groups of indicators including intangibles, creative products and services, and online creativity. However, in this case it was less important than in the area of knowledge and technological achievements. The reason for the slightly lower correlation for creative production may result in the fact that its development may be influenced by other factors, such as those strongly related to university activity.

2. The presented cooperation implies the necessity of the flexible transformation of the role of universities in the direction of simultaneous basic research, and the shaping of educated human capital resources, as well as undertaking broadly understood cooperation with enterprises in order to commercialize knowledge. The question arises as to what steps a modern university can take to skillfully combine its elementary academic role with the requirements of a changing reality. It seems that one of the valuable solutions would be to take actions for the cooperation of a selected group of students with businesses in order to solve specific problems from the economic world. This could be a valuable combination of knowledge gained at university and business practice, while at the same time giving students the opportunity to develop teamwork skills that are more conducive to creating innovative solutions than individual work.

3. University-business cooperation can take many forms, ranging from joint research to the creation of *spin-off* companies, or the sale of patents or the granting of licenses. The state should stimulate cooperation between universities and businesses, among others, by ensuring the broad autonomy of universities on many levels, introducing competition in universities' applying for financial support from the state budget and its moderate reduction.

4. University-business cooperation must not take place at the cost of reducing or stopping the universities' basic research, as this could result in an undersupply of scientific knowledge in the innovation system, resulting in fewer innovations. This is due to the very nature of scientific knowledge, which has strong characteristics of a public good, and therefore businesses are not particularly interested in carrying out this type of research.

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WSPÓŁPRACA BADAWCZA UNIWERSYTETÓW I PRZEDSIĘBIORSTW JAKO ŹRÓDŁO INNOWACYJNOŚCI

Streszczenie: Celem artykułu jest określenie, w jakim stopniu kooperacja badawcza uniwersytetów i przedsiębiorstw wpływa na efekty działalności innowacyjnej. Przyjęta została hipoteza badawcza, że pomiędzy współpracą badawczą uniwersytetów i przedsiębiorstw a efektami w obszarze innowacyjności gospodarki występuje bardzo wysoki poziom zależności. W celu empirycznej weryfikacji zaproponowanej hipotezy badawczej zbadano zależność korelacyjną między zmienną współpracy badawczej uniwersytetów z przedsiębiorstwami w latach 2013-2017 a wybranymi zmiennymi określającymi efekty działalności innowacyjnej w 2018 r. w gospodarkach unijnych. Wyniki uzyskane w badaniu pozwoliły na pozytywną weryfikację postawionej hipotezy badawczej, potwierdzając ważną rolę kooperacji badawczej uniwersytetów z przedsiębiorstwami w kontekście kreowania innowacyjności gospodarki.

Słowa kluczowe: współpraca uniwersytetów i przedsiębiorstw, efektywność innowacji, innowacyjność gospodarki.