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Cooperation between Science, Business, and Administration under the Triple Helix Model in European States: The Example of Poland

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Abstract:

Purpose: *The primary goal of the paper is to evaluate the cooperation between representatives of scientific, economic, and administrative sectors in Poland against the background of selected European countries, identify the relevant barriers, and provide recommendations for the improvement thereof. The methodological goal is to develop a research model within the Triple Helix Readiness concept and a diagnostic tool to facilitate the measurement of readiness of the Polish science, business and administration sectors to engage in practical cooperation.*
Design/Methodology/Approach: *To those ends, a triangulation of research methods was employed using diagnostic surveys and computer-assisted self-interviewing (CASI) techniques. The research tool used was an online questionnaire sent out to the relevant stakeholders (17 municipalities, 150 higher education institutions (HEIs), and 340 enterprises). The results were processed using elements of descriptive statistics. A hierarchical cluster analysis based on Ward's method was used to grade the cities and group them in terms of likelihood readiness to engage in cooperation with external entities.*
Findings: *As evidenced by the results, readiness to engage in cooperation with external entities depends on many factors. Economic operators' perspective includes the advancement of IT systems, availability of modern knowledge management tools, research and development activity, ownership or registered and submitted patents, trademarks, and training budgets. On the other hand, universities highlight the possibility of commercializing and marketing their advanced solutions.*
Originality/Value: *The principal added value provided by the paper is its contribution in the form of the scientific model and research tool applicable to the assessment of cooperation readiness of scientific, economic, and administrative entities within the framework of the triple helix approach, as well as recommendations of improvements to the effectiveness of such cooperation. The employed methodology could also be applied in comparative analyses of other European countries.*

Keywords: *Readiness, cooperation, triple helix.*

JEL Classification: *R11, O30, M21.*
Paper Type: *Research Paper.*

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1. Introduction

Given the growing complexity of relationships, networks, and socioeconomic challenges, there is an increasing emphasis on innovativeness, advanced technologies, and building a knowledge economy. The challenges are fast becoming a significant priority in the European Union. In this context, it now increasingly essential to ensure practical cooperation between three sectors: science (scientific centres, universities, research, and development centres, auxiliary institutions), business (economy, industry, enterprises), and public administration (governments, self-governments, the public sector). The dimensions of those relationships are reflected by the triple helix model whereby the cooperation potential is determined by the relationships established between the same, and the absence of meeting points significantly hinders any potential crossflow of knowledge and innovation.

The present paper focuses on evaluating the readiness of science, business, and local administration representatives to engage in cooperation. The triple helix is defined as a system based on the cooperation between entities representing three sectors, public administration, science, and business. The theory alludes to a chain composed of three spirally entwined, mutually complementary sub-chains that characterize a specific cooperation model (Bednarzewska, 2016). To date, most researchers have focused on bilateral cooperation, while significantly less scientific scrutiny has been devoted to cooperation involving three distinct centres. Additionally, there are no defined meters or methods to measure the extent of such cooperation and identification of the man barriers limiting the same.

Nowadays, the process of developing regional competitiveness requires not only adequate support for enterprises and R&D initiatives, as well as the cooperation between them, but also, and possibly above all, the establishment of an efficient system bringing together all entities capable of contributing to the attractiveness of innovative efforts made by modern centres of business services. The facilitation of cooperation between science, business, and administration tends to dominate current debates on developing a knowledge economy whose primary defining feature is its capacity for constant innovativeness through the commercialization of knowledge.

For the relationships at the levels of science and business to meet the requirements of the triple helix model, the inclusion of public authorities, especially self-governments, is necessary. By providing an environment conducive to networking, local authorities stimulate the flow of knowledge. They are the entities responsible for developing knowledge economy and continuous improvement of innovativeness in the given space. This context focuses on enterprises, while scientific and administrative players assume a supporting role relative to innovative processes developed by companies that invest their capital in the given location. An element of significant importance for regional development is foreign investors' inflow in relationships with local economic operators, universities, and administrative authorities.

However, as evidenced by long-term experience, practical cooperation between science, business, and administration is impossible. Collaboration between scientific institutions and businesses is stimulated by globalization and the internationalization of technological know-how. Scientific and technological knowledge may become available to any enterprise in the short rather than long-term perspective (Trzmielak, Grzegorczyk, and Gregor, 2016). Representatives of each of the cooperating sectors contribute specific resources and expect the specific added value to be generated in the process, as summarised in Table 1.

Table 1. *Resources and expected gains of cooperating stakeholders*

Entity	Resources	Expectations
Universities	– Knowledge – New technologies – Human resources – Creative ideas – Laboratories and research infrastructure	– Commercialisation of research results – Commissioned services and specialist expert opinions – Financing for scientific research – Employment of graduates
Local administration	– Initiative and coordination – Statutory financing – Public procurement – Support programmes – Public services	– Increased dynamics of development processes – Increased tax revenue – Job creation – Improved competitive standing – Improved image of the region/city
Business	– Capacity for risk – Market outlets, distribution channels – Investment	– New products and technologies – Qualified workforce – Participation in profits – Infrastructural development

Source: *Matusiak, 2010; Bednarzewska, 2016.*

It is noteworthy that cooperation between stakeholders is a desirable development in European countries that can take various forms. Creating closer relationships between entrepreneurs and members of academia is conducive to the exchange of knowledge and can lead to the establishment of long-term partnerships capable of creating new opportunities and stimulating innovativeness, entrepreneurship, and creativity. Practical cooperation between universities and businesses can also aid graduates in acquiring more adequate skills and adopting attitudes that will enhance their capacity for success in both professional and personal lives. There are numerous examples of efficient cooperation between academic and industrial entities in Europe.

However, the prevalent form and scope of such cooperation can vary significantly depending on the country in question, the organization of higher education institutions, and the specific knowledge domains involved (European Commission, 2018). Cooperation between stakeholders facilitates the development of innovativeness, wherein knowledge plays a key role. As observed by Branderburg (2013), building a knowledge economy is possible if the potential of science, business,

and administration partners is jointly utilized. It works together towards the adopted goals in the core of the "golden triangle' or triple helix concept (Etzkowitz, 2002).

2. Literature Review

The definition of the triple helix originates from natural science. It originally described the model of DNA structure proposed by Watson and Crick (1953), wherein two chains are spirally wrapped around a common axis. The term "helix" comes from mathematics and refers to a spiralling line forming a three-dimensional curve. Due to its interdisciplinary pedigree, the term gradually evolved and was eventually also adopted in social sciences, where it refers to specific concepts proposed in terms of modelling processes taking place in the realm of administration-science-industry relations. Relationships between public administration, science, and industry can take a variety of forms. Etzkowitz and Leydesdorff (2010) identified three basic types of interaction occurring between the groups above of entities:

- the *etatistic model* of public administration – science – industry relations describe a situation where the government sector encompasses scientific and industrial entities, determining their mutual relationships,
- the *"laissez-faire' model* is composed of three separate spheres: public administration – science – industry, with clearly defined divisions and scarce relations between the same,
- finally, the *triple helix model* describes mutual interactions between the three spheres (Etzkowitz, 2007).

The distinction between the concepts is rather significant as the triple helix model is, by definition, three-dimensional. As explained by Etzkowitz (2007), the dimensions of the triple helix model include:

1. Internal transformations within the units of each of the three nodes, which may include development of interdependence between industrial companies within a firm, e.g., alliances or clusters, or enhancement of the economic mission of HEIs.
2. Influence exerted by units from one node on units in another node, e.g., the impact of industrial or academic policies on the behaviour of companies and scientific institutions in terms of the flow of knowledge, technology, and information.
3. Establishment of new network structures because of interactions between all the nodes with a view to generating new, particularly high-tech ideas, e.g., in the form of clusters' (Skawińska and Zalewski, 2009).

However, the model described by Etzkowitz (2007) fails to provide accurate meters and measurement techniques that can be complemented by referring to other fields of science. The field theory derived from physics was used to develop a triple helix analysis method and provide a foundation for future studies on triple helix interactions

(Zhou, 2001). As observed by Leydesdorff and Etzkowitz (2000), the triple helix provides a method for analyzing innovations that seem adequate for the knowledge economy concept. Due to the existence of the internet, such relations have a global character and ought to be treated as factors of sub-dynamics rooted in a more complex system. Innovation is a product of intricate interactions between the concept of an invention, its implementation, and dissemination.

On the one hand, and political power, with the latter determining the general conditions of this system (Bogdanienko, 2012). Strategies based on bilateral relations between universities and businesses, businesses and public authorities, universities, and municipalities ultimately led to trilateral cooperation. Relations between the three primary spheres are formed in the context of the following dependencies (Trzmielak, Grzegorczyk, and Gregor, 2016):

- internal, pertaining to each entity individually,
- external, between three entities,
- external, between a triple helix entity and another organisation,
- external, between more than one triple helix entity and a different organisation.

Cooperation between scientific and business centres is stimulated by globalization and the internationalization of technological knowledge. Scientific and technological knowledge may become available to any enterprise in short rather than long-term perspective (Trzmielak, Grzegorczyk, and Gregor, 2016). The question of cooperation between the two spheres is considered in both global and national contexts A. Havas (2012) identified five strategies for global companies in cooperation with science and research centres. These include:

- a production strategy based on the production of goods or services without scientific and research cooperating in countries other than the country of the company's seat,
- a strategy of contracted research and development, with an emphasis on research and technological development based on lower costs of scientific research without production on the local market; such cooperation being conditioned by the implementation of a project initiated by the parent company,
- a strategy combining contracted research and development with a production strategy, with an emphasis on research and technological development based on lower costs of scientific research and production in a local market,
- a production and R&D strategy with an emphasis on the production of goods and services based on scientific and research cooperation in a country other than the country of the company's seat,

- and a strategy of R&D integration, integrating the research and development work of a global enterprise with that of a university located in a market other than the company's seat (Havas, 2012; Roud, 2018).

Internal relations are of key importance in ensuring that the respective entities commit to processes related to supporting the transfer and commercialization of knowledge within mutual relationships. As posited by Etzkowitz and Leydesdorff (2000), the primary goal of the triple helix model focuses on effective communication and specific expectations that shape institutional arrangements between universities, industrial actors, and the government. This observation is further explained by Leydesdorff and Meyer (2003). They point out that the triple helix model aims to capture the dynamics of communication and organization by introducing the notion of overlap in the mutual relations and exchange of feedback on given institutional arrangements (Leydesdorff and Meyer, 2003).

Entities operating witing the channels of distribution for products and services have an undeniable impact on the relations between the spheres of science and business. Suppliers and customers cooperating with universities and business representatives can effectively shape science-business relationships. Given efficient collaboration of scientific institutions with entrepreneurs and local authorities, businesses with HEIs and local administration, and local authorities with academia and entrepreneurs, mutually significant interactions are likely to emerge (Trzmielak, Grzegorczyk, and Gregor, 2016). This can explain the cooperation between three otherwise independent spheres: universities, the industry, and the government, as each of the involved parties, is likely to benefit from the same.

Higher education institutions participate in transferring knowledge and research results to the economy, contributing to the development of new technologies and products. Businesses also engage in the process as it allows them to gain access to knowledge and technologies by launching innovations on the market, which enhances their competitiveness. The process of knowledge transfer is conducive to the development of scientific research. In performing their didactic and scientific tasks, universities become a source of qualified human resources. As dictated by the relevant authorities, they also play an essential role in increasing the level of knowledge and education of economic operators and their staff. The authorities can also commission the performance of research that will be reflected in business. The Triple Helix model is widely accepted in the literature as a critical theory explaining the relationships between science, industry, and government within the framework of an innovative society. In this context, the sphere of business proves the most dynamic through its agency that innovative solutions are ultimately introduced into the economy. The authorities' role is to ensure the suitability and stability of the relations between science and business. It is noteworthy that scientific organizations are perceived as the key producers of knowledge transferred to the economic operators. The general perception is that universities conduct primarily non-profit activity, although the importance of knowledge internalization is continuously growing.

Based on American experiences and the results reported at the Massachusetts Institute of Technology, Stanford Institute, and the University of Texas in Austin, it can be concluded that the model of universities' operation is evolving with the commercialization of knowledge fast becoming an essential source of their financing (Matusiak, 2010). On the other hand, companies are fully committed to generating a profit by improving competitiveness, with the knowledge transfer taking place as dictated by strategic goals and economic indicators. Trilateral relations allow each party involved to generate added value and lead to disputes rooted in conflicting interests (Trzemielak, Grzegorczyk, and Gregor, 2016). It should be emphasized that to date, most of the relevant scientific attention has been devoted only to the industrial sector.

The studies presented in this publication and outsourcing business processes aim to bridge that cognitive gap somewhat. The deliberate choice of the study sample reflected its dynamic development and the considerable volume of investments observed in the respective locations. Nowadays, investors providing advanced business services are included in the cohesive cooperation system with representatives of local authorities, universities, and research centres, thus becoming an element of the triple helix model.

The current EU priorities include developing the knowledge economy, which is stimulated, among other elements, by the cooperation between science, business, and administration. It would be prudent to analyze the condition of said cooperation in the context of European states, identify the primary limitations to it, and provide recommendations in terms of effectively overcoming the same. Given the economic challenges faced by Europe in terms of the intensification of global competitiveness, this paper pertains primarily to the experience of European countries, with a particular focus on research conducted in Poland. The emerging economic and financial problems coupled with the continued existence of regions struggling with high unemployment rates emphasize the need for a more sustainable and flexible European market conducive to the active participation of science and administration and businesses.

Over the last ten years, the cooperation between science and business has become a key political priority for the European Commission (Davey *et al.*, 2018), consistently evoked in Commission communications and supported through various initiatives. It constitutes a bridge connecting various policy areas: innovations, higher education, entrepreneurship, social development, globalization, and economic recovery. It is noteworthy that the cooperation is strongly supported by various directorates general of the European Commission. A common area linking all the agendas is the focus of the value of cooperation between representatives of science and business in facilitating job creation and economic growth in Europe, which comes with various benefits for universities, students, businesses, and society at large. Many European regions are committed to efforts aimed at the improvement of competitiveness (OECD, 2014). Public administrations constantly seek more innovative and efficient methods of

bringing together science, talents, technologies, and markets, a process wherein higher education institutions have been identified as key stakeholders (Dowling, 2015). An integrated and effective regional ecosystem of innovation is, by definition, rooted in science, technology, and innovation. Hence, government-supported cooperation between science and business constitutes an essential aspect of regional policies that connects stakeholders under the triple helix model. Such relationships create synergy and contribute to economic development at the regional and national levels alike. The results of successful cooperation include:

- development of skills (Razvan and Dainora, 2009) and shaping future professional perspectives of students (Bozeman and Boardman, 2013; Drucker and Goldstein, 2007; Dutrenit, De Fuentes, and Torres, 2010; Van der Sijde, 2012),
- increase of the number and impact of scientific publications, including the possibility of practically applying research results (Ginzburg and Houli, 2013; Ankrah and AL-Tabbaa, 2015),
- improvement of the pertinence and innovativeness of research conducted at higher education institutions (Vaan Looy *et al.*, 2004) as well as of employment opportunities for graduates (Bozeman and Boardman, 2013; Van der Sijde, 2012; Lamichhane and Nath Sharma, 2010), which contributes to the 'universities attractiveness' to both talented prospective students and researchers,
- improvement of the innovativeness and competitiveness of businesses,
- creation of new jobs, boost to economic and social growth, improvement of living (Davey *et al*., 2011; Drucker and Goldstein, 2007; Chatterton and Goddard, 2000).

The condition of the cooperation between scientific and economic entities in Europe was presented in the European Commission's report on the subject (Davey *et al.*,2018). As follows from the data published by the Commission, both members of academia and entrepreneurs believed that the area is better developed than education as such. Nonetheless, they did identify certain underdeveloped areas of concern. These included activities related to valorization and management. Valorization activities relate to the commercialization of knowledge produced by HEIs, e.g., 'commercialization of R&D,' 'academic entrepreneurship,' and 'student entrepreneurship.' Management activities relate to a more strategic aspect of cooperation between HEIs and businesses, with the activities grouped into three categories: 'governance,' 'shared resources,' and 'industry support.'

The report indicates that most scientists involved in cooperation work with more than two partners, mostly medium or large enterprises, conducting the regional or countrywide activity. The scale of the phenomenon is reflected in the EC report (Davey *et al.*, 2018). Most European enterprises included in the study collaborate with universities from their native regions (71.7%) or countries (59.7%) to a considerable extent. At the same time, however, international cooperation with universities remains

limited, with 23.9% declaring no cooperation and only 18.7% reporting a large extent of cooperation. This shows that although technology does provide means for more global outreach, regional relations remain predominant.

An interesting study was conducted in Spain, focusing on an analysis of cooperation between universities, the industry, and public authorities and the impact on the emergence of business innovations. The primary conclusion in the study was that cooperation between enterprises on the one hand and universities and public administration institutions on the other contributes to the likelihood of innovation in Spanish companies, both in terms of product and process innovations. It was also observed that the higher the number of stakeholders included in the triple helix model, the higher that likelihood becomes (Hernández-Trasobares and Murillo-Luna, 2020). To emphasize the scope of eh positive impact of the cooperation between science, business, and administration, it is also worth mentioning a study conducted in Germany in the context of the stakeholders' agency in the process of determining the criteria of pro-innovative policy for the development of renewable energy sources (RES). The same is manifested in establishing cooperation systems, generation and transfer of knowledge, and urban localization factors. Every stakeholder has a different contribution to the RES policy. Notably, governmental, and private sector players have an essential role to play in all three aspects thereof.

Meanwhile, universities contribute mainly by generating and transferring knowledge. Therefore, in the discussed context, the integration of public authorities and private enterprises is a factor driving the establishment of pro-innovative conditions for the development of RES, whereas universities focus on creating structural knowledge conducive to the relevant innovations (Lerman *et al.*, 2021). Other authors also conducted studies on academic entrepreneurship in Europe - the case of Sweden and Ireland (Klofsten and Jones-Evans, 2000).

Research conducted on a pan-European scale suggests that there are significantly more political initiatives related to cooperation in terms of R&D than those focusing on employee mobility. Most efforts facilitating the activity of stakeholders come in the form of programs, strategies, and individual instruments. Some of the political initiatives in this context include:

- *Innovation Fund Denmark:* The main institution financing research in the country which established the Industrial PhD Programme under its Industrial Research Programme. Its goal is to facilitate the cooperation between science and business through research projects combined with educational courses. Postgraduate students progress towards their university degrees while simultaneously being employed by a private enterprise. Grants disbursed in a competition provided three-year financing, and the developed cooperation model was recognised as an example of good practices and adopted in many other European countries.

- *The French Regulation* of the mobility of scientists provides researchers with the ability to take up employment, for at least two years, in a different research institute, public administration or enterprise abroad.
- *Outside the European Union, the Great Britain introduced the Concordat to Support the Career Development of Researchers in the United Kingdom:* It is an agreement signed between the gran founder and the subsidised scientist in Great Britain with a view to promoting cross sectoral mobility of scientists, including business apprenticeships.
- *The Catapult Programme in the United Kingdom* entailed the establishment of an independent NGO operating centres where entrepreneurs can freely connect with researchers and scientists. The centres are tasked with work in specific thematic areas with the aim of improving the scientific base of British enterprises. Subsidies were awarded to nearly 3,000 small and medium enterprises whose activity was inherently linked and largely dependent on academic collaboration.

Apart from criteria directly impacting the cooperation between science, business, and administration in each country, macroeconomic factors must also be considered. EU member States were analysed in terms of the following characteristics:

- the percentage of total spending of governmental and self-governmental institutions allocated to research and development,
- the share of the export of technologically advanced products in total export (the data pertain to high technology product and the total Export figure does not include intra-Union trade),
- the percentage of the working population between 25 and 64 years of age employed in science or technology,
- the total number of patent applications in Europe – including application for invention protection submitted directly to the European Patent Office (EPO) and under the Treaty on Patent Cooperation and Establishing EPO (Euro-PCT), regardless of whether they were accepted or rejected. The data reflect the total number of applications per country. However, when an invention is submitted by more than one inventor, it is divided equally between the same and their countries of origin to prevent double counting,
- the percentage of employment in sectors of medium and high technology production, as well as the sector of services heavily relying on knowledge, relative to the total employment,
- the percentage representation of student mobility.

A brief analysis of the macroeconomic indices reveals that variable dynamics of conditions facilitating cooperation characterize the EU Member States. Each economy has its specificity. Consequently, it is difficult to identify the leader in terms of macroeconomic indicators.

Nonetheless, the economics of Germany, Luxemburg, and France stand out in the context of other European countries. The same can be said to be the best prepared for further intensification of cooperation processes. Germany took first place in terms of the number of applications submitted to the European Patent Office (18,881.70) and the percentage of total spending in the sector of governmental and self-governmental institutions allocated to research and development (2.17%). It also ranked high in terms of the percentage of employment in the medium and high technology production sector (9.9%).

On the other hand, Luxemburg can boast the highest student mobility in the European Union (72.5%) and a very high percentage of employment in science and technology (63.7%). R&D spending is also relatively high (1.52%). France should also be included in the group of macroeconomic leaders with its share of high technology export (20.5%) and several patent applications (9,502.67) standing out in the context of other countries.

Less favorable macroeconomic conditions are observed in Slovakia, Estonia, Lithuania, Bulgaria, the Czech Republic, and Poland – i.e., Eastern Europe. Here the values of indices considered in the study were generally below average. The worst results were reported for Malta, Greece, and Cyprus. Malta has the lowest percentage of patent applications in the EU, and its spending on research and development does not exceed 0.6%. Considerable barriers are also observed in Greece. The country's export of technologically advanced products stands at only 4.5%, which results from the low percentage of employment in the sectors of medium and high technology production (1.6%). Cyprus also significantly lags the countries identified as European leaders in this context.

In summary, the most optimum conditions for cooperation are provided by countries such as Germany or Luxemburg, which ranked very high in the study. Notably, over 60% of the professionally active population in Luxemburg and Sweden are employed in the science and technology sector. Luxemburg is also the only EU Member State where student mobility exceeds 70%. Germany ranked high with its total spending of governmental and self-governmental institutions allocated to research and development reaching 2.17%, directly translating to the number of patent applications submitted to the European Patent Office: 18,881.70 in 2017 alone.

The present study focused primarily on assessing the process of cooperation observed in Poland. As follows from the data of the European Statistical Office, Poland is characterized by poor student mobility, which creates specific barriers to the enhancement of cooperation with other scientific or business centers. R&D spending is also relatively low (1.06%), which translates to a rather unsatisfactory annual number of patent applications (686.64). Given the above, it became necessary to learn about the respondents' attitudes in the context of both possibilities of and barriers to cooperation (European Statistical Office).

3. Research Methodology

The study's goal was to develop a research model and a tool for measuring and identifying cooperation between representatives of science, business, and administration in Poland compared to other European states. The research model was developed based on the Net Readiness methodology adapted to the requirements of the present study. The organizational net readiness methodology (NR) was initially conceived in 1999 by analysis of Cisco Systems - Hartman, Sifonis, and Kador (2001). The model considered four specific elements, leadership, management style, competencies, and technology that jointly determine a given enterprise's capacity to effectively conduct e-business and implement projects significantly affecting the shape of the organization (Hartman, Sifonis, and Kador, 2001). The modification of NR methodology to analyze Triple Helix Readiness entailed preserving the essential NR tools but was modified to reflect better the topic of cooperation between science, business, and administration.

A decision was made to triangulate research methods. A diagnostic survey was used in combination with the technique of computer-assisted self-interviews (CASI). The research tool consisted of an internet survey set out to the relevant stakeholders (17 municipalities, 150 HEIs, and 340 enterprises). The questionnaire consisted of three parts:

- a sensitivity grid, which allowed the respondents to evaluate the extent of cooperation regarding projects implemented jointly by administrative, academic, and economic organisations in respective cities,
- an advancement test focusing on 9 areas related to the conditions determining the extent of cooperation,
- a readiness assessment sheet focusing on the areas of leadership, management style, competences, and technology. It was treated as a measure of the readiness of scientific, economic, and local administration entities to take advantage of economic conditions with a view to establishing and expanding cooperation, as evidence of readiness for activities consistent with the triple helix model. The questionnaire was complemented by the inclusion of an organisation snapshot element.

The data obtained from the sensitivity grid describe the extent of the stakeholders' cooperation. This part of the survey consisted of 6 statements to be graded on a three-tier measurement scale (Sobczyk, 2005). The data obtained from the advancement test describe the conditions of cooperation, as evaluated by the stakeholders. The responses could be given on a three-tier nominal scale on which the respondents graded each statement. The advancement test was divided into nine areas, management premise, goals, and realization shortly, stakeholders, necessary solutions, plans for implementing products and services, financial consequences, external conditions influencing the possibility of achieving goals, and tactical plans. The third part of the survey contained a readiness assessment sheet. It was composed of 20 statements grouped into four areas.

The sheet focused on evaluating the readiness of the respective sectors, public administration, science, and business to cooperate in each environmental system. The respondents used the 5-tier Likert scale to evaluate the respective areas. This allowed precise coring of the results and consequently made it possible to evaluate the advancement of the respective entities' sphere of cooperation. The sheet contained questions related to project affiliations and joint initiatives, focusing on four key areas, leadership, management, competencies, and technology. The readiness sheet yielded results in the form of scores that allowed each respondent to be classified under one of five categories:

- cooperation visionary – organisations showing the highest level of readiness for cooperation within the framework of the triple helix model,
- cooperation expert – organisations showing high readiness for triple helix cooperation but with certain elementary shortcomings,
- cooperation savvy – organisations that scored below average in terms of cooperation under the triple helix model,
- cooperation aware – organisations showing awareness of but poor readiness for operating within the triple helix model,
- cooperation agnostic – functioning within the triple helix model was beyond the scope of interest of these representatives of the science, business, or administration sectors.

Based on the obtained results, cities were classified under one of the above groups based on their diagnosed readiness to operate within the triple helix model – relative to their respective scores.

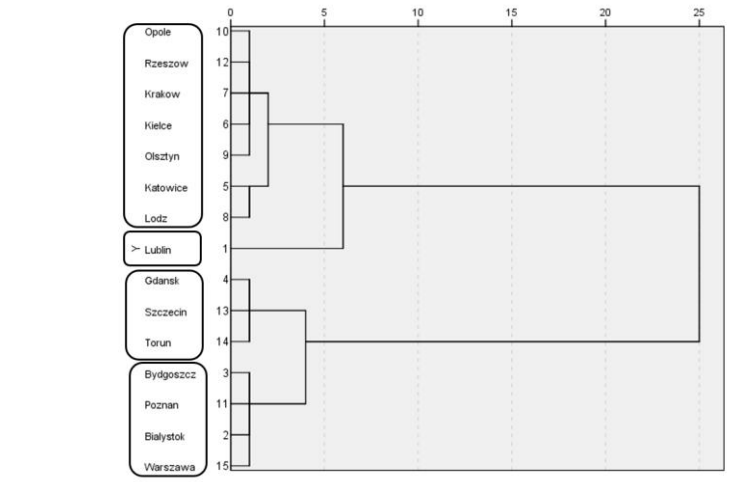
The respondents were scored following the answers given. The maximum possible score was 100 pts., and the minimum score was 20 pts. Where responses in each location (city) were provided by several organizations from a given group (science, business, administration), the scores were averaged. In the adapted Triple Helix Readiness concept, the areas of leadership, management style, competencies, and technology were treated as measures of the readiness of the science, business, and local administration sectors to take advantage of the given economic conditions to establish and expand cooperation, which in turn corresponds to their readiness to operate within the framework of the triple helix model.

The results were processed using elements of descriptive statistics. To evaluate the cities and group them in terms of the likelihood of readiness for engaging in cooperation with external entities, the method of Ward's hierarchical cluster analysis was employed. It employs the variance analysis approach in estimating the distances between clusters to minimize the sum of squared deviations within the clusters. In the discussed case, the distance was measured relative to squared Euclidean distance to emphasize more distant objects.

4. Research Results

The survey questionnaire was sent out to organizations located in 17 voivodeship capitals in Poland: 17 municipal authorities, 150 higher education institutions, and 340 enterprises. Fifteen cities were qualified to evaluate the scientific sector, and 15 each for the evaluation of the business and administration sectors, respectively. The groups were established independently for the representatives of science, business, and administration. The choice of the study group was not accidental. The conducted analyses pertained to data from the three described parts of the survey. The analyses conducted for each sector independently considered the results from assessing the level of cooperation in projects implemented jointly by administrative, scientific, and business sector entities in respective cities, relative to the conditions determining the advancement of cooperation and readiness to engage in the same. A pooled analysis was conducted for all three sectors. The identification of groups was made for the distance equal to the scaled distances). A dendrogram showing the classification of voivodeship capitals included in the study is presented below.

Figure 1. *Dendrogram for the classification of cities based on their readiness to engage in cooperation in the opinion of public administration institutions*



Source: *Own elaboration. N = 15.*

Four distinct clusters are identifiable based on the critical qualities of similarity within the groups and differed from others. The distance matrix presents groups of cities like each other regarding the evaluation in areas from the three parts of the questionnaire taken jointly.

Group one is composed of cities where public administration authorities are well prepared to build a network of cooperation with the science and business sectors. Specifically, they include Bydgoszcz, Poznań, Białystok, and Warsaw. All the cities scored high in terms of the conditions necessary for practical cooperation in municipal management, access to critical resources, and efficient implementation of economic strategies. Based on the ranking, the cities were qualified as cooperation visionaries, which evidences their high readiness for undertaking tasks entailed in cooperation network coordination.

The second and third groups are composed of cities classified as cooperation experts, however, with specific differences in their cooperation advancement. Group two includes Gdańsk, Szczecin, and Toruń. They all share similar characteristics in terms of leadership, management style, competencies, and technology; however, as observed by the surveyed representatives of municipal authorities, their lower-than-expected level of cooperation stems from the lack of sufficient financial resources and insufficient capacity to implement patents and inventions in the cities. Nonetheless, the scores obtained by the cities classify them in the group of cooperation experts.

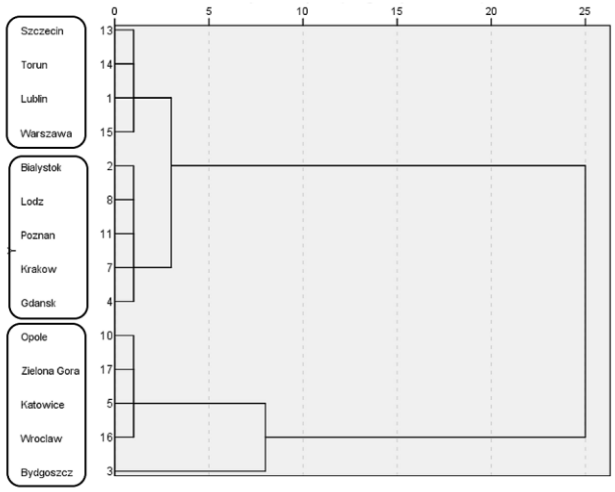
Group three is the most numerous and includes Opole, Rzeszów, Kraków, Kielce, Olsztyn, Katowice, and Łódź. All the cities show similar shortcomings that can potentially hinder cooperation with external entities. As observed by the municipalities, they lack an effective mechanism for altering the direction of cooperation projects in response to the changing conditions of their implementation. Problems also emerge from incompatible systems of verifying indices used to evaluate projects implemented in cooperation with science and business organizations. The cities obtained similar scores in the ranking based on the readiness assessment sheet and were all qualified as cooperation experts.

The different perception of cooperation characteristics by the representatives of the municipal authorities from Lublin places the city in cooperation savvy. As admitted by the respondents, certain elements may impede the realization of the adopted strategic goals. These include, e.g., the lack of a system for measuring the effectiveness of the implemented cooperation projects and, significantly, insufficient qualifications and skills of staff candidates available on the job market. Overcoming these challenges is bound to pose a significant challenge for the city shortly as it works towards improving its competitiveness and continually attract investors valuable to the local economy. The second analysis focused on the science sector. In this context, cities were classified as presented in Figure 2 below.

Group one is composed of cities best prepared for the initiation and implementation of joint initiatives in the opinion of the academia and includes: Białystok, Łódź, Poznań, Kraków, and Gdańsk. The cities in this group all meet eh requirements for engaging in cooperation to a similar extent. They are characterized by good cooperation readiness, although there are still certain elements that need improvement,

particularly in leadership and management style and aspects related to technological development.

Figure 2*. Dendrogram for the classification of cities based on their readiness to engage in cooperation in the opinion of scientific institutions*



Source: *Own elaboration. N = 14.*

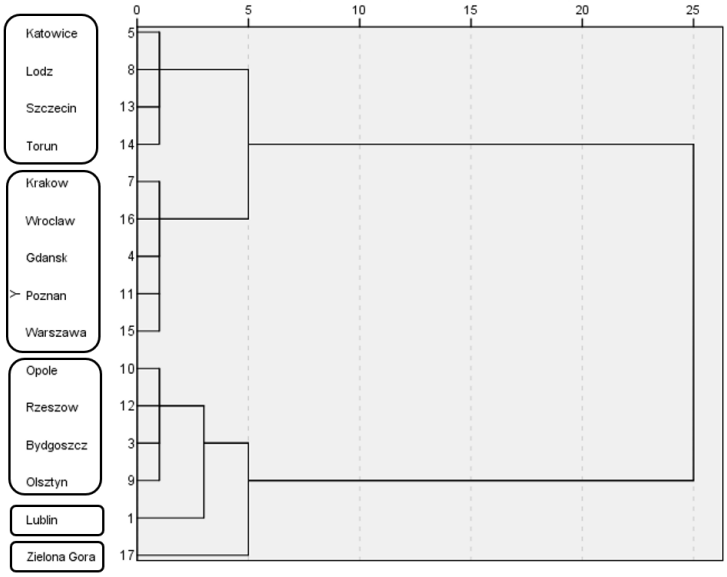
The universities in those cities evaluated the conditions for advanced cooperation as good but pointed to the lack of clearly defined and flexible systems for measuring the effectiveness of implemented cooperation projects. The universities pointed out that they had no knowledge of the structure of costs associated with project implementation or how it compares to costs borne by other cities. Nonetheless, based on the scores obtained in the readiness assessment sheet, the cities were classified as cooperation experts regarding their preparedness to engage in cooperation with the science sector.

Group two is composed of cities where scientific entities similarly evaluated their readiness to meet the conditions for engaging in cooperation. As perceived by the academia, the cities provide favourable conditions that allow the locations to be classified, based on the results obtained in the readiness assessment sheet, as cooperation savvy. The cities in this group include Szczecin, Toruń, Lublin, and Warsaw. The universities located in those cities are characterized by average readiness to realize tasks related to joint undertakings. The most significant gap relative to the expected state was the lack of adequate technology infrastructure and solutions amenable to flexible adjustment to the changing market needs. Universities also indicated requirements related to projects implemented jointly by science, business, and local administration organizations (specifically substantive and financial schedules, qualifiable expenses, independent accounting, reporting) and financed under EU funds or by the National Centre for Science, which tend to complicate the related processes significantly.

Group three includes cities that show the most substantial shortcomings relative to conditions most conducive to practical cooperation. They include Opole, Zielona Góra, Katowice, Wrocław, and Bydgoszcz. The similarities identified between the cities led to their classification under the standard group of cooperation savvy. Universities located therein scored very low in terms of leadership, management style, competencies, and technology. They reported low practical utilization of patents and inventions and a shortage of sufficient funding for their day-to-day activities. Such barriers evidence poor readiness for cooperation and ought to be thoroughly considered by the universities in question.

A similar cluster analysis was also conducted for the business sector in 15 voivodeship capitals. Representatives of business are included in the cooperation system, and the identified groups of cities in this respect are presented in the dendrogram below (Figure 3).

Figure 3. *Dendrogram for the classification of cities based on their readiness to engage in cooperation in the opinion of business organisations.*



Source: *Own elaboration. N = 15.*

Group one is composed of economic operators located in Kraków, Wrocław, Gdańsk, Poznań, and Warsaw, which showed the highest cooperation readiness. The factors conditioning effective implementation of cooperation undertakings related to leadership, management style, competencies, and technology were ranked at above-average levels. Representatives of businesses conducting economic activity in the listed locations identified specific barriers in the context of requirements related to initiating projects implemented in cooperation between science, business, and administration entities (specifically in terms of credit conditions, eligible costs,

separate accounting, own contributions) and financed under EU funds, which tend to complicate the relevant processes significantly. It is noteworthy that universities also identified this aspect as a barrier to practical cooperation. The cities in question scored similarly in terms of readiness for engaging in external relations and were classified as cooperation experts on this basis.

Group two are cities somewhat less prepared for the processes of cooperation, namely Katowice, Łódź, Szczecin, and Toruń. The respondents highlighted certain factors disrupting the establishment of external relations. Most businesses have no effective methodology to measure the impact of cooperation projects on their level of competitiveness. Entrepreneurs also observed that patents and inventions do not find practical application in the local economy. Based on the responses, the cities were classified as cooperation savvy.

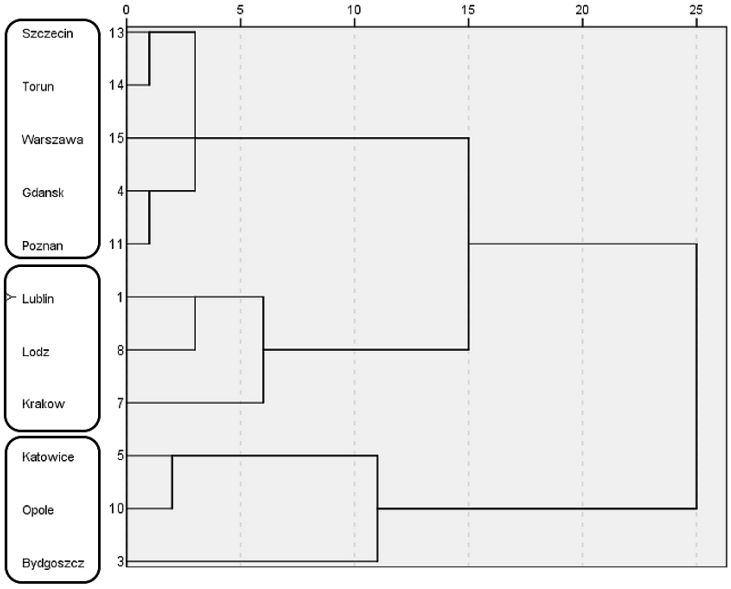
Group three includes locations showing low levels of preparedness for cooperation. The existing conditions related to management style, leadership, competitive development, and technology are not conducive to the dynamic development of relations between scientific, economic, and administrative entities. None of the businesses operating in Opole, Rzeszów, Bydgoszcz, and Olsztyn implemented an effective measure to determine the impact of cooperation on their competitiveness. Moreover, few enterprises incorporated plans for managing strategic changes relative to projects implemented in cooperation between science, business, and local administration entities. Interestingly, the locations were classified under a single group characterized by readiness for cooperation and high awareness in this context, but at the same time, low preparedness for its actual implementation.

The incompatible evaluation of cooperation provided by municipal authorities prevented Lublin from being included in any of the identified clusters. Companies investing in the city evaluated the cooperation process rather poorly compared to their counterparts in other locations. The respondents consistently admitted to not conducting market analyses and having no comprehensive information on whether investors operating in other cities utilized similar project implementation strategies. Only approx. 35% of the enterprises reported observing synergy effects in the context of cooperation. Notably, based on the score obtained in the study, Lublin was classified as an intelligent cooperation city.

The study also identified the city whose characteristics evidence a low level of cooperation readiness – namely Zielona Góra, which was classified as cooperation agnostic based on the score obtained. The factors preventing the development of cooperation were related to staff candidates' insufficient qualifications and skills on the job market, absence of observable synergy effects, and failure to perceive cooperation between science, business, and administration entities as a determinant of the city's competitive standing.

The above analyses are summarised in the overall representation of cities based on the variable related to the extent of cooperation in terms of projects implemented jointly by scientific, economic, and administrative actors in the respective cities, the conditions determining the extent of cooperation, and readiness of science, business, and administration entities to engage in the same. Clustering was conducted for the distance of 12, using scaled distances (Figure 4).

Figure 4. *Dendrogram for the classification of cities based on their readiness to engage in cooperation in the opinion of science, business, and administration entities*



Source: *Own elaboration. N = 11.*

Group one includes Szczecin, Toruń, Warsaw, Gdańsk, and Poznań. The cities are similar in terms of their readiness to engage in and expand cooperation. In most cases, the locations were classified as cooperation experts. The readiness of actors operating in the cities is high, although specific barriers still exist, which prevents them from being classified at the highest level of the relevant readiness.

Group two includes Lublin, Łódź, and Kraków. The cities were classified as cooperation savvy. Their characteristics are slightly suboptimal in terms of conditions necessary for practical cooperation, specifically in terms of the availability of human, infrastructural, and financial resources whose shortages may hinder the achievement of relevant goals related to building relations with external stakeholders.

Group three includes Katowice, Opole, and Bydgoszcz. Here, while the evaluation provided by the science and business sectors is pretty consistent and points to the cities' classification as cooperation savvy, the opinions provided by public administration entities suggest a somewhat higher classification as cooperation

experts. Indeed, the latter suggests only a slight departure from the maximum scores indicating the highest level of cooperation readiness. This discrepancy is the most evident in the case of Bydgoszcz, where science and business representatives evaluated the city as cooperation savvy, while responses from local administration entities allowed its classification as a cooperation visionary.

It is noteworthy that overall, the results obtained from surveying representatives of scientific and economic entities tended to be pretty consistent. This evidence is a similar perception of the processes of cooperation and similar levels of the two sectors' readiness to engage in cooperation relations. The respondents also identified similar barriers to the same. At the same, interesting conclusions can be reached in terms of the responses provided by public administration entities, which invariably tended to evaluate their cities' readiness for cooperation at higher levels than the other two sectors. To recapitulate, it should be observed that the respective sectors evaluated the extent of and conditions for cooperation with a focus on slightly different factors, which affected the final interpretation of the results.

Representatives of the groups included in the study drew attention to different aspects of cooperation and assessed the analyzed readiness level differently. Local administrations perceived cooperation in the context of the competitiveness of the local economy and the implementation of tools designed to attract foreign investors. New trends are currently observed in the Polish economy regarding system integration, networking, and integration of people with digitally controlled machines, the general use of the internet, and information technologies.

Enterprises are becoming more flexible in adjusting their offers to customer expectations to gain a competitive edge. More and more are required of staff members, particularly in terms of configured knowledge and skillsets. Businesses, therefore, expect universities to prepare future employees by providing them with entirely new competencies. As perceived by entrepreneurs, cooperation with academia should provide access to knowledge and research resources, the ability to jointly conduct experiments, test new products, and exchange knowledge.

Most respondents mentioned problems with introducing patents and inventions into the economy. Therefore, it is essential to identify common areas significant to the activities of all stakeholders, which would ultimately translate to higher competitiveness of cities. This competitiveness can be understood more broadly as readiness to establish long-term relations between entities in the country receiving investment, i.e., local self-government and universities, and the business entities willing to allocate their resources to the destination. The organizations ought to co-create a cohesive, goal-oriented, local system of innovation generating added value to provide a competitive edge vis-à-vis other economy.

5. Conclusions

In the entire European Union, leaders in terms of macroeconomic cooperation criteria include Germany, France, and Luxemburg, while Poland's results oscillate around medium regions. In the Polish context, the present analysis identified a group of regions around significant cities classified as cooperation visionaries but most nonetheless identified specific barriers to practical cooperation.

One of the conducted study goals was to formulate recommendations for the scientific, economic, and administrative sectors in terms of improving the effectiveness of their cooperation. Based on the obtained results, three key recommendations are provided for the relevant sectors, and three areas important from the perspective of the entire cooperation system are identified.

Specifically, the recommendations pertain to efforts on which actors involved in cooperation ought to focus on:

Municipal authorities ought to focus on developing a system facilitating the measurement of the effectiveness of implemented projects. It would be advisable to monitor the available avenues for financing the projects under EU funds and formulate quantifiable expectations relative to their implementation. Cities should identify the aspects that may tangibly improve their competitiveness and facilitate the development of the locations' positive investment image. Polish municipalities should support innovation by building upon the priority industries that actively drive local economies. They ought to monitor the number of patents and inventions generated and implemented by universities as this would provide viable feedback on the direction in which the local economy is being developed. Only practical solutions targeted at supporting the city's key industries can effectively improve its attractiveness to potential foreign investors. Every city has a particular key area in which it invests. It reflects the industry in which the significant businesses operate and how universities educate students to increase their chances of gainful employment.

The development of city specialization understood as support for priority industries is conditioned by the availability of human resources, infrastructure, and natural resources. A city specialization can focus on advanced industrial technologies, aviation, information technology, business environment services, or agriculture. By supporting and developing the respective economic activities, municipalities increase the likelihood of targeted foreign investment crucial to the given industry's development. Local authorities should actively encourage external entities to cooperate in joint undertakings, thus contributing to cooperation networks. Municipalities should flexibly select partners for cooperating within the networks. Each entity works towards specific goals, particularly regarding the expected results and the corresponding available resources, both tangible and know-how related. Administrative authorities tend to follow relatively formalized procedures of project

implementation that cannot account for changes inherent in cooperation with external partners duly, for instance, about time frames, feasibility, or financial outlays.

Universities often face similar challenges as municipal authorities. They stem from the absence of a system facilitating monitoring of the effectiveness of joint undertakings. HEIs should focus not only on theoretical considerations but also, possibly above all, on practical solutions with a potential for a market implementation supporting the development and competitiveness of local economies. In the context of recent legal changes, universities tend to target their patent activity on maximizing points gained in the parametric evaluation system. This does not always translate into solutions with actual practical applicability.

To bridge the gap between academia and business, universities ought to adapt their specializations to the trends observed in the market. This would improve their graduates' chances of finding gainful employment by instilling in them qualifications consistent with the prevailing market expectations and further tightening relations with other entities. Enterprises operating in the new economy expect their potential employees to show, sometimes very specialistic skillsets. To bridge the gap between theory and practice, universities should focus on enhancing the practical viability of topics included in their curricula. Poland is the fourth country in the European Union when it comes to university students, so the potential is there, but success depends on universities' ability to better adapt to evolving market needs. Instead, we are currently observing growing numbers of HEI graduates performing various low-paid jobs.

One of the reasons may be universities' inability to prepare their students for successfully accessing the job market correctly. A better understanding of employers' expectations towards potential employees may help HEIs modify their curricula to provide graduates with better employment opportunities in the future. In the case of postgraduate courses, entrepreneurs expect specialized programs compatible with their internal needs and strategies. It is also recommended to encourage staff exchange and secondment of research workers. Such programmes are considerably more prevalent in e.g., the USA as compared to Poland (Czerwińska-Lubszczyk, Grebski and Jagoda-Sobalak, 2020). Additionally, one could mention overcoming barriers such as high costs of projects implemented by the industry and universities - which hinders their competitiveness, excessive red tape that negatively impacts lead times, and lack of financial incentives.

In implementing cooperation initiatives, entrepreneurs do not always take their overall priority into account. Such cooperation is often conducted only in the background of primary activity, treated as a certainly added value but rarely as a core element of economic operations. Businesses feel appreciated by municipal authorities that include them in their cooperation networks as part of larger pro-investment schemes, for instance, by inviting their representatives to participate in meetings concerning the development of specific industries. Support also entails choosing investment locations, clarifying legal and fiscal particulars, and aiding promotional activities. It

could be concluded that entrepreneurs often become involved in cooperation systems primarily for reasons related to image creation and public relations. Good practice in this context would be to implement a system of indices to measure the actual effects of cooperation on overall business competitiveness, going beyond the strictly image-related dimension. Another critical recommendation relates to the introduction of monitoring tools that would facilitate cooperative effectiveness and increase the status thereof relative to other initiatives undertaken by enterprises. It is also recommended to develop a strategy for the establishment and maintenance of external relations which should specify the tactical goals applicable in the 3–5-year perspective. Such goals would help to focus on specific areas most likely to enhance the availability of qualified human resources with skill sets applicable to the specific needs of enterprises.

To recapitulate, the main areas for improvement to increase the effectiveness of cooperation pertain to developing a system for measuring the effects of implemented projects, increasing flexibility to adapt more quickly to varied expectations of partners, and developing a strategy. Efforts to eliminate gaps at the meeting point between science, business, and local administration might improve the city's investment image and its competitiveness relative to other local economies. Cooperation may be used as a valid argument in presenting the city as a mature location for investment (Carayannis, Barth, and Campbell, 2012).

The triple helix model focuses on relations existing between universities, industries, and governments. Such relationships tend to evolve. Hence other models are being introduced: the quadruple helix model expands on the triple helix by adding the fourth element of 'culture and media-based society' or 'civic society. The quintuple helix model of innovation goes even further, providing a broader context for the quad, additionally considering the perspective of 'natural environments of society.

The triple helix underscores the importance of higher education in the development of innovations. On the other hand, the quadruple helix supports the knowledge society and knowledge democracy in the development of knowledge and innovation. As understood under the quadruple helix model, sustainable development of knowledge economy requires coevolution with the knowledge society. In turn, the quintuple helix stresses the need for the socio-ecological transition of societies and economies in the 21st century. Under the quintuple helix model of innovation, the natural environments of society and the economy should also be perceived as a driving force for the development of knowledge and innovation as they determine the directions in which knowledge economy ought to be developed.

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