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**THE QUADRUPLE HELIX MODEL AND REGIONAL DEVELOPMENT BASED  
ON INNOVATION - AN ANALYSIS OF SELECTED CASES**

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## SUMMARY

The changes taking place in the modern world pose new challenges to society. The fourth industrial revolution also known as Industry 4.0 (currently also Industry 5.0) is causing rapid changes in almost every area of human activity. There are new problems to be solved for scientists, authorities at various levels, entrepreneurs, and even consumers. The common feature connecting the needs of all groups is the desire to live in developed regions, characterized by high standards of living conditions, with access to well-paid jobs, social services and health care. The natural environment and the general level of security are also important, this is why regional authorities should pursue a regional policy such as to meet the aforementioned conditions.

Therefore, in order for any given region not to be a poorly developed region, it must “keep up with changes” or, in a better way, be ahead of them. Unfavorable phenomena cause a number of negative attributes, including the impoverishment of society, the population outflow, and finally the degradation of entire areas.

The subject of interest of this doctoral dissertation is the issue of regional development, with particular emphasis on the innovations and mechanisms supporting this development in the form of the Quadruple Helix (QH) model.

Scientific theories on regional development have a significant impact on socio-economic activity, which is why this dissertation presents the most important theoretical concepts on regional development. It is important equally due to the fact that these concepts are the starting point for the formulating recommendations for political elites and for determining how specific economic projects of public authorities can be carried out. It has been pointed out that the dynamic changes that can occur due to the very rapid technological advances make it necessary to develop new theories. Knowledge, which is largely a public benefit, or the area of scientific research, R&D, the commercialisation of research results - these issues are closely related to the concept of innovation-based regional development. In relation to this is the issue of patent protection (or other forms of intellectual property rights) by which inventors can obtain some financial awards for their creative activity. Usually, discoveries and inventions benefit public and eventually become commonplace, accessible to everyone, leading to an increase in labour productivity. The free dissemination of technological knowledge promotes further development. As a result, the balance of social benefits and the costs of research is different from the corresponding

private balance, again justifying state involvement. Other issues that are the subject of this doctoral dissertation concern innovation, which is becoming increasingly associated with networks, cooperation and connections in various institutional configurations and spatial planning. The concept of innovation is related to the concept of innovativeness of the relative region. For a given region to be an innovative region, it is necessary to have both real entrepreneurial attributes in said field and an extensive business environment facilitating the development of innovation.

The experience of many countries that are among the world's leaders in terms of innovation and basing their development foundations on this aspect, both at the level of countries and regions - for example, the USA, Germany, Israel - indicate that effective implementation of scientific research results into the economy is important for success, which is facilitated by the QH model. The key term in this aspect is the commercialisation of research. Commercialisation itself translates into the level of innovation in the economy, and these can intensify the research and development process as a feedback loop, the results of which can be implemented in the economy.

The literature on this subject indicates that the effectiveness of actions taken at the regional or national level is determined by the mechanisms and form of cooperation between key economic entities and institutions, including civilian society. The Quadruple Helix model was developed based on the Triple Helix model, which assumes the possibility of ensuring optimal cooperation among individual project participants. The Triple Helix is a model of innovation, which includes three types of entities: scientific centers (universities, research and development centers, supporting institutions), industry (enterprises) and government (including local government institutions)). The Quadruple Helix model incorporates media and civil society institutions into the existing TH model. The TH model alone is not sufficient for long-term development based on innovation. The Quadruple Helix model can be used to influence the level of development at the national level but it is more effective when implemented regionally. The multiplicity and diversity of entities within the four main centers under consideration, as well as the complicated nature of mutual relations, make the regional level seem optimal. In Poland, solutions related to the commercialisation of scientific research, their impact on the level of innovation and innovation-based development, as well as the possibility of using the Quadruple Helix model, are relatively unknown and rarely implemented in practice. Although in recent years attention has been paid to the issue of tightening cooperation between research centers and academic communities

and the enterprise sector through public institutions, however, defining "healthy" universal principles of this cooperation and mechanisms determining the basis of functioning is slow and ineffective. In addition, attention is focused on the two centers with omission or only marginal consideration of the other elements of the helix. Another key issue for increasing the innovativeness of the national and regional economy is the commercialisation of scientific research, which faces numerous challenges. For example, in Poland, there is still no clearly defined path for the commercialisation of scientific research with well-defined copyright protection. New instruments are being created to facilitate the development and implementation of scientific research results for commercialisation by entrepreneurs, but these efforts are still insufficient. Among these supportive instruments, funds can be allocated for innovations. Despite the relatively high level of financial support from the state, the effects achieved by enterprises and scientific units are still unsatisfactory.

New patterns of ethical behavior among scientists, entrepreneurs, representatives of authorities, and the media are crucial elements for the effective functioning of the Quadruple Helix model, as these entities are part of this helix. The effective commercialization of scientific research results must be based on mutual trust. This is important because without ethical action of any element of the Quadruple Helix, be it the scientific community, business, state, media or society - it will not be possible to build lasting competitive advantages. Innovation and commercialization of research has already been described in published papers and findings. In recent years, many studies on this subject have been published, but there is still a research gap regarding the effective Quadruple Helix model, as well as the creation of tools and instruments used to measure the degree of impact of the solutions adopted in the helix model on the level and dynamics of development, especially in Polish environments. Therefore, this dissertation presents and analyses the components of the Quadruple Helix model. Based on the experiences of other countries, this dissertation presents the conditions for the functioning of the Quadruple Helix model in the Podkarpackie region in Poland. This region is currently on the poorest in the entire European Union, and at the same time its capital - the city of Rzeszow, was defined in 2017 as the most innovative city in Poland.

**The main purpose** of the dissertation is to present and analyse the impact on the development of regions of the relationship between the terms of science, enterprises, government and local government institutions as well as the media and civil society, which define the Quadruple Helix model. Thanks to the improvement of cooperation mechanisms,

including mainly the commercialisation of scientific research results, it is possible to increase the level of innovation, and thus increase the level of development at the regional level and consequently at the level of entire countries.

In order to achieve the main objective, two sub-objectives have been defined. The first, theoretical one was designed to systematize theoretical knowledge in the field of regional development based on innovation, in which the effective commercialisation of scientific research plays a key role today. A Quadruple Helix cooperation model was used to achieve this goal. The second practical objective concerned the identification of factors determining regional development based on innovation, with particular emphasis on the elements that make up the Quadruple Helix (QH) model.

**The main thesis of this dissertation is formulated as follows: the use of the Quadruple Helix (QH) model contributes to the rationalization of the organization and management of innovative regional projects and to stronger support the regional development on innovation and acceleration of its dynamics.**

In order to verify the main thesis, the following partial hypotheses were formulated:

- 1) The model of regional development based on innovation is the basis for creating sustainable competitive advantages in internal and international terms.
- 2) The key to the effectiveness of the Quadruple Helix model is the ability to transform the tasks and roles of centers/entities within the helix
- 3) It is possible to quickly gain a competitive advantage thanks to the effective commercialisation of scientific research results
- 4) Barriers in the form of the lack of appropriate legal solutions, restrictive patenting procedures, high prices of innovative solutions, ineffectiveness of the institutional environment and the lack of a culture of inventiveness and innovation are the reason for the low level of development.
- 5) Close cooperation among the individual elements of the helix model may result in rational management of resources and building sustainable competitive advantages of regions.

In this work, various non-reactive and reactive research methods were used. In the case

of the former, the method of critical analysis of the literature on the subject was used in order to present the theoretical foundations of regional development based on innovation, as well as the Quadruple Helix model and its predecessor the Triple Helix. In addition to the methods mentioned above, the historical and comparative methods were used to present the evolution of development conditions and the specificity of the centers under the Quadruple Helix model and its practical use in influencing regional development in the analysed cases.

The official data analysis method was used to present the nature and scope of legal regulations defining the basis and mechanisms of TH and QH functioning. The dissertation also uses the method of analysing statistical data on selected regions in the world and in Poland. The Desk Research method was used in relation to the analysis of statistical data obtained from electronic databases EUROSTAT, OECD, World Bank, Central Statistical Office, official websites of government institutions and regional authorities, world and European innovation rankings, world rankings of universities, information contained on websites of universities, public administration units in the world and in Poland, regional statistical databases in selected regions in the world and other official data. Additionally, selected strategic documents from the European Union, countries, and regions pertaining to innovation and regional development were used. Charts, drawings, tables and maps were used to present the data. As part of reactive methods, IDI (Individual In-Depth Interview) - interviews were conducted with representatives of the basic centers forming a Quadruple Helix in the Podkarpackie region.

The work has a theoretical and empirical character. The layout of the work was subordinated to the verification of the main thesis and partial hypotheses. The work consists of an introduction, 5 chapters, conclusion, bibliography and attachments. A summary is provided at the end of each chapter. The dissertation was supplemented with a script for an in-depth interview.

The **first chapter** of the doctoral dissertation presents theoretical considerations regarding the essence of regional development based on innovation. A separate place was devoted to the conditions and determinants of this development. From the point of view of this dissertation, the issue of commercialization of scientific research and its impact on innovation is particularly important. An analysis was conducted considering both the strengths and weaknesses of the presented issues, including human potential, infrastructure and its surroundings, the activities of public institutions and financial instruments.

The **second chapter** presents the genesis and evolution of the theoretical conditions of the Quadruple Helix model. Due to the fact that this model was created by developing the previously valid Triple Helix model, an appropriate place is also devoted to this solution. A special place was devoted to the characteristics of the four main areas - centers - of the helix: scientific and academic centers, enterprises, power at a central and local government level, as well as the media and civil society. In addition, exemplary links and relationships between these centers were described, as well as the possibility of interchangeability of tasks and activities undertaken by entities that are part of each center, as well as in the relation between the centers. Mention was also made of a newer model created on the basis of the previously presented ones - i.e. the model of the five-fold helix (Quintuple Helix).

The **third chapter** presents experiences related to the use of the Triple and Quadruple Helix model and, above all, the effective commercialisation of scientific research and innovation of the economy in the regional dimension in selected countries. This chapter, on an international scale, presents how the developed mechanisms and instruments, as well as flexible relations and tasks assigned to individual quadruple helix centers, determine the level of development of individual regions. This chapter presents the situation in the states of Massachusetts and California in the USA, in the Federal State of Baden-Württemberg in Germany and in the District of Tel Aviv. The regions and countries included in the analysis come from different parts of the world, thanks to which they function in different cultural and civil environments, as well as often in different regulatory systems. They had different levels of resources and yet they can be presented as economies/regions of success in the era of the digital revolution.

The **fourth chapter** is devoted to the characteristics of the Quadruple Helix model in Polish conditions in the example of the Podkarpackie region. First, the historical and contemporary development conditions of the Podkarpackie Voivodeship were presented. A detailed statistical analysis was included, allowing to assess whether the development of the Podkarpackie Voivodeship took place in the years 2010 - 2020 and what impact innovations had on this development. The specifics of the basic helix centers from the Podkarpackie Voivodeship was also described, with particular emphasis on the tasks and functions adopted, as well as the relationships and mechanisms that occur between them. The conclusions were supplemented with the latest data and the current geopolitical situation affecting the development of the Podkarpackie Voivodeship.

The **fifth chapter** presents the results of qualitative research conducted in the Podkarpackie Voivodeship. It contains a description of the conducted research, its purpose, method, characteristics of the surveyed entities, research tools, and the course of the research and the method of qualitative data analysis. At the end of the chapter, there is an interpretation of the research results and conclusions in the form of justification for the research thesis and answers to the detailed questions of the dissertation.

A special place has been devoted to taking into account the degree of flexibility interchangeability of functions and tasks initially assigned to individual centers, as well as entities included in them. It also includes recommendations that may have an application dimension of solutions from the Podkarpackie region to other regions in Poland.

Thanks to the use of triangulation of research methods, the assumed goal was achieved and the main thesis was confirmed. However, it should be emphasized that the best effects of the model can be achieved in regions with knowledge-based democracy, characterized by long traditions of a market economy, high quality of social capital and good quality infrastructure and an appropriate level of financing. The type of financing and access to the so-called venture capital, which is common in highly developed countries. The willingness of enterprises to cooperate with other QH entities and mutual trust in relations is also important. One of the most important factors is the level of education and motivation of employees, with particular emphasis on public administration employees. It has been proven that with the support of public administration employees enterprises receive incentives to develop and avoid costly mistakes. In such conditions, the impact of the QH model is much stronger on the development of regions than in economically and socially backward areas.

The research and analyses carried out in the dissertation also allowed to confirm all five partial hypotheses.