Monika Kondratiuk-Nierodzińska

INNOVATIVE CAPACITY AND INNOVATION SYSTEMS AND THE ECONOMIC DEVELOPMENT LEVELS OF EUROPEAN COUNTRIES

INTRODUCTION

The claim that differences in the level of technological development between countries are the main source of diversification of the level of their economic development is already rooted both in economic studies as well as in economic policy. A positive relationships between these areas is evidenced by the results of a significant amount of research which has been published in recent decades[1]. This research focused mainly on comparing the impact of various factors, including variously defined and classified innovation and technological capacities of countries on differences in the level of economic development. Therefore, the subjective approach has been dominant, while little space has been devoted to the importance of innovation activity of major groups of actors of innovation systems from the point of view of the development of economies of individual countries. The literature on the subject allows us only indirectly to infer that the most important role in this regard should be attributed to the corporate sector because some of the identified innovation capacities of countries solely or largely depend on the business characteristics of companies.

The aim of this study is to examine the importance of innovation capacities of European economies in the cross section of three major elements of the innovation system corresponding to the sectors of companies, research and the government, from the point of view of their economic development. Thus,

[1] Part 1 of this article contains a number of references to those studies.

the conducted analyses will aim to verify the hypothesis that differences in the level of innovation activity in specific sectors are related to the variation in the level of GDP *per capita* in the examined European countries.

The structure the article is as follows: the first part is an introduction to the subject of innovation capacity and, in addition to the general definition of the term, contains an overview of different approaches to the specification of specific capacities. The aim of the second part is to define the basic elements of innovation systems, in the cross section of which innovation capacities of European countries were examined and compared. The third part describes the methodological issues related to the analysis of the statistical data gathered for needs of the research in this study. The fourth part contains a description of the results of the conducted analyzes. In the last part the conclusions from the conducted analysis were formulated.

1. Innovation capacities as the main factors of economic development – literature overview

In the literature we can find some general wordings of the concept of innovation or technological capacities of economies, although the term is also quite widely used in the context of business operations. Kim defined technological capacities of the country as the 'ability to effectively use technical knowledge within the processes of assimilation, use and change of the existing technologies'[2]. In turn, the national capacity for innovation, the term used by Furman, Porter and Stern, can be defined as 'the ability of the country – both as a political and economic entity – to manufacture and commercialise a stream of technologies which are new for the world in the long period of time'[3]. These concepts have a similar meaning, hence their interchangeable use can be considered acceptable. The concept of innovation capacity is based on the idea of 'absorptive capacity' of companies of Cohen and Levinthal[4] and includes not only organised research and development activities but also

[2] Kim, L. 1997. *Imitation to innovation: The dynamics of Korea's technological learning*. Harvard: Harvard Business School Press, p. 4 cited in: Fagerberg, J., Srholec, M. 2008. National innovation systems, capabilities and economic development. *Research Policy*, vol. 37, p. 1419.

[3] Furman, J.L., Porter, M.E., Stern, S. 2002. The determinants of national innovative capacity. *Research Policy*, vol. 31, p. 900.

[4] Cohen, W.M., Levinthal, D.A. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, vol. 35, p. 128.

other skills necessary for the commercialisation of technologies. In this sense, it (the concept) can be related to the systemic look at innovation, where a broad range of factors affecting the process of creating new solutions is taken into account.

The literature points to the existence of quite different views on the elements making up a total of innovation or technological capacities of economies. The aforementioned concept of 'absorptive capacities' seems to have high importance from the point of view of the factors determining the results of innovative activities and the level of economic development of countries. According to Abramovitz[5] absorptive capacities refer to 'the degree of technological congruence', that is 'the availability of resources, production factors, technological skills, the scale of markets and consumer demand' and also to social capabilities defined as 'the level of education and technical competence in a given country, the existence of commercial, industrial and financial institutions which affect the ability of funding and functioning of modern business activity on a large scale, as well as political and social conditions which affect the level of risk, the tendency to take up business activity and its individual results'[6]. The topic of absorptive capacity was also undertaken by Verspagen who drew attention to the existence of 'intrinsic learning capabilities' of a country which he defined as dependent on variables such as the level of education of the labour resources, the quality of infrastructure and mechanisation of the economy, the differences between the sector structure of the production of the leader country and others following it, and other factors[7]. Keller also acknowledged that absorption capacities significantly affect the economic performance of the country, but narrowly defined them as specific skills and knowledge accumulated in the national human capital[8].

The mentioned concept of absorptive capacity also occupies an important place in the joint studies of Verspagen and Fagerberg who distinguished three

---

5 Abramovitz, M. 1986. Catching-up, forging ahead and falling behind. *Journal of Economic History*, vol. 46 and Abramovitz, M. 1994. The origins of the postwar catch-up and convergence boom. In: Fagerberg, J., Verspagen, B., von Tunzelmann, N. eds. *The dynamics of technology, trade and growth.* Aldershot: Edward Elgar.

6 Abramovitz, M. The origins of the postwar catch-up..., op. cit., p. 24.

7 Verspagen, B. 1991. A new empirical approach to catching up or falling behind. *Structural Change and Economic Dynamics*, vol. 2 (2), p. 363.

8 Keller, W. 1996. Absorptive capacity: On the creation and acquisition of technology in development. *Journal of Development Economics*, vol. 49.

groups of factors affecting the level of economic growth[9]: (1) innovativeness understood as the creation of new knowledge resources of the given country, (2) diffusion defined as the potential for the exploitation of knowledge created abroad, and (3) absorptive capacities understood as additional factors influencing the use of the diffusion potential. In this approach, the most important aspect of innovation capacity is the ability to create new knowledge and exploit new knowledge coming from outside, as a necessary condition for the creation of innovative solutions.

Castellacci and Natera adopted a similar view on the issue of innovation capacity of countries by identifying two main factors affecting the level of economic development corresponding to the contribution and results of the process of creating new knowledge for innovation[10]: (1) innovation capacities and (2) absorption capacities. Innovation capacities were defined in turn as: (a) the contribution to innovativeness represented by the total effort and investment outlays of each country in the field of research and development and innovation activity, (b) the result of scientific activity expressing the results of the studies and the rest of innovation activities carried out by the public research and development sector (in the original public S&T system), and (c) the outcome of activity in the field of new technologies defined as a result of the activity of private sector companies. In this approach we can see, therefore, a clear division of roles in the construction of innovative capacity of the country between various sectors of the economy – here the science-research sector and that of enterprises. Absorption capacities, as in Fagerberg and Verspagena, are understood quite broadly here, as other factors affecting the level of economic development. The authors included here[11]: (a) international trade, representing the degree of openness of the system, which in turn affects the country's ability to imitate advanced knowledge from foreign sources, (b) human capital and its characteristics, (c) the level and quality of infrastructure which affects the ability of the

[9] Fagerberg, J., Verspagen, B. 2002. Technology-gaps, innovation-diffusion and transformation: an evolutionary interpretation. *Research Policy*, vol. 31 and Fagerberg, J., Verspagen, B. 2003. *Innovation, growth and economic development: why some countries succeed and others don't.* The article prepared for First GLOBELICS Conference: Innovation Systems and Development Strategies for the Third Millennium. Rio, 2–6 November, 2003.

[10] Castellacci, F., Natera, J.M. 2013. The dynamics of national innovation systems: A panel cointegration analysis of the coevolution between innovative capability and absorptive capacity. *Research Policy,* vol. 42, pp. 581–582.

[11] *Ibidem*, pp. 581–582.

given country to absorb, adapt and implement foreign advanced technologies, (d) the quality of institutions and the management system, and (e) the level of equalizing of opportunities in society and disparities in living standards which determines the rate of diffusion and adoption of advanced knowledge in the given country.

The importance of innovation capacity resulting from the characteristics of the corporate sector is visible in Faber and Hesen who approached the topic from the perspective of factors affecting the results of innovation activity in the economy, that is resulting from national concepts of innovation systems[12]. In their opinion two groups of variables should be taken into account[13]: (1) connected with innovation processes taking place in and between companies, and (2) connected with 'innovation infrastructure' surrounding businesses and enabling them to create innovations, and composed of economic, institutional conditions, and the ones related to the context in which businesses operate, e.g. an appropriate 'climate' conducive to doing business.

Many authors emphasise the importance of human capital as an important element determining the capacity of absorption of new knowledge and technologies by the economy. The above mentioned Abramovitz pointed out the necessity of building the so-called 'social skills' which depend, among others, on the level of education and technical competences in the given country[14]. Verspagen defined 'intrinsic learning capabilities' of a country as dependent, among others, on the level of education of labour resources[15]. Keller also pointed out that the relatively high level of human capital at the beginning of the road in the process of 'catching up' is an important factor in improving the ability of acquiring new technologies from abroad. In addition, in the case when a country decides to open the economy, which gives it greater access to new technologies, the adequately higher level of human capital is essential to sustain the process of technological development and the rate of economic growth[16]. Benhabib and Spiegel[17], Papageorgiou[18] and

---

12 Faber, J., Hesen, A.B. 2004. Innovation capabilities of European nations. Cross-national analyses of patents and sales of product innovations. *Research Policy*, vol. 33.

13 *Ibidem*, pp. 195–198.

14 Abramovitz, M. The origins of the postwar catch-up..., *op. cit.*, p. 24.

15 Verspagen, B. A new empirical approach to catching up..., *op. cit.*, p. 363.

16 Keller, W. Absorptive capacity: On the creation and acquisition…, *op. cit.*, p. 202.

17 Benhabib, J., Spiegel, M. 1994. The role of human capital in economic development: evidence from aggregate cross-country data. *Journal of Monetary Economics*, vol. 34.

18 Papageorgiou, C. 2002. Technology adoption, human capital and growth theory. *Review of Development Economics,* vol. 6.

Stokke[19] also focused on human capital and the ability to learn as the most important factors determining the level of economic development as they considered them to be responsible for the country's ability to imitate and absorb advanced technologies from abroad. Human capital regarded as one of the aspects of national technological capabilities can be also found in Lall who enumerated three types of them[20]: (1) material investments (2) human capital, and (3) technological effort (the internal ability to create technology and its import). He also stated that all these capabilities are strongly interrelated. Similarly, in Archibugi and Coco (2004), who proposed a way of measuring innovation capacities of countries, human capital is among their measured aspects: (1) the creation of technology, (2) technological infrastructure, and (3) the development of human skills[21].

The above mentioned approaches to defining innovation or technological capacities of countries are not exhaustive. Fagerberg and Srholec, continuing their research on specific national capabilities as factors in economic development, defined them very broadly. In total, they define four types of capacities/factors[22]: (1) the level of the innovation system development, (2) the quality of the government system, (3) the nature of the political system, and (4) the degree of openness of the economy. In this research, the term innovative capacity was replaced by the term 'the level of development of the innovation system' and was measured by means of a relatively wide range of indicators specifying various aspects of both technological and social capacities of countries and taking into account data on patents, scientific publications, information infrastructure, ISO certificates, access to financing sources, and the level of education. But even here there are visible references to the results of activity connected with the creation of new knowledge (patents, scientific publications) and the development of human capital (the level of education). In their next article these authors treat national capacities pertaining to various aspects of innovation activity as one of the elements of broadly defined (which, as they themselves acknowledge may arouse some controversy) 'social skills' because as a result of a factor analysis they came to the conclusion that

---

19 Stokke, H. 2008. Productivity growth and organisational learning. *Review of Development Economics*, vol. 12 (4).

20 Lall, S. 1992. Technological capabilities and industrialisation. *World Development*, vol. 20, no. 2, p. 170.

21 Archibugi, D., Coco, A. 2004. A new indicator of technological capabilities for developed and developing countries (ArCo). *World Development*, vol. 32, no. 4.

22 Fagerberg, J., Srholec, M. 2008. National innovation systems, capabilities and economic development. *Research Policy*, vol. 37.

there is a strong correlation between factors of a technological, social and cultural nature in process of economic development[23].

A broad view of national innovation capacity is characteristic also for the research of Furman and his associates[24]. They stated that innovation capacities have three components[25]: (1) the existence of strong universal innovation infrastructure which consists of the political climate in the fields of science and technology, mechanisms of support for basic research and higher education, and the accumulated stock of technical knowledge which is the basis of creation and commercialisation of new solutions, (2) a specific innovative environment present within industrial clusters, that is a microeconomic environment in which companies compete, (3) the strength of ties between the previous two elements, dependent on mechanisms and institutions such as the national higher education system or the financing of new enterprises which encourage the commercialisation of new technologies.

The review of the above mentioned studies allows us to conclude that the factors which are most often included in the description of innovation capacities of economies are: (1) the ability of companies and entities from other sectors to create new knowledge, seen from both the input and the results of this process, and (2) capital human regarded as responsible for the construction of 'absorption capacities' of economies, that is the skills of acquisition and adaptation of new technologies to the needs of the given country.

The analysis of the impact of variations of these capacities on differences in the level of development of economies requires the use of appropriate indicators to measure both the results and contribution in the process of creating new knowledge as well as absorption capacities. Patents are often used as an indirect measure of the results of innovation activity, but conflicting opinions on their use have been heard for years. While some authors point out that they are 'a measure not without flaws, because not all innovations are patented and additionally patents often differ very much in terms of

---

23 Fagerberg, J., Srholec, M. 2013. Knowledge, capabilities and the poverty trap: the complex interplay between technological, social and geographical factors. In: Meusburger, P., Glückler, J., Meskioui, M. eds. *Knowledge and the Economy*. Springer.

24 Furman, J.L., Hayes, R. 2004. Catching up or standing still? National innovative productivity among 'follower' countries, 1978–1999. *Research Policy,* vol. 33 and Furman, J.L., Porter, M.E., Stern, S. 2002. The determinants of national innovative capacity. *Research Policy,* vol. 31.

25 Furman, J.L., Porter, M.E., Stern, S. The determinants of national..., *op. cit.*, pp. 905–907.

their economic significance'[26] others argue that 'empirical research shows that they can be considered a fairly reliable measure of innovation activity'[27]. However, patent statistics and other related data (e.g. patent citations) strongly reflect the stock and flow of knowledge rather than a direct result of innovation processes in the form of new products or processes and according to this characteristics they have been more frequently used in research[28]. Therefore, also in the analysis underlying this text, statistics on the number of patents were used as a measure of the result of the process of creating new knowledge.

One of the commonly used measures of contribution to the innovation process in general and the process of creating new knowledge in particular are expenditures on research and development (R&D)[29]. However, taking into account 'two faces' of research and development, representing two types of contributions necessary in the processes of innovation: knowledge and the ability to assimilate knowledge which already exists[30] they can also constitute a measure of 'absorption capacities' of economies.

Human capital resources determining, just like the engagement and level of expenditure on research and development, the economy's capability to use knowledge and technology coming from outside tend to be measured variously. Most frequently innovative capacities of the country related to

---

26 Pakes, A., Griliches, Z. 1980. Patents and R&D at the firm level: a first report. *Economics Letters*, vol. 5, p. 378.

27 Acs, Z.J., Anselin, L., Varga, A. 2002. Patents and innovation counts as measures of regional production of new knowledge. *Research Policy*, vol. 31, p. 1080.

28 See, for instance Jaffe, A.B., Trajtenberg, M., Henderson, R. 1993. Geographic localisation of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics*, vol. 108 (3); Fung, M.K., Chow, W.W. 2002. Measuring the intensity of knowledge flow with patent statistics. *Economics Letters*, vol. 74; Park, G., Park, Y. 2006. On the measurement of patent stock as knowledge indicators. *Technological Forecasting & Social Change*, vol. 73; No, H.J., An, Y., Park, Y. 2014. A structured approach to explore knowledge flows through technology-based business methods by integrating patent citation analysis and text mining. *Technological Forecasting & Social Change*. [Online] Available at: http://dx.doi.org/10.1016/j.techfore.2014.04.007

29 Also in the described research this indicator was used for this purpose – see for example Faber, J., Hesen, A.B. Innovation capabilities of European nations…, *op. cit.*; Furman, J.L., Hayes, R. Catching up or standing still…, *op. cit.*; Castellacci, F., Natera, J.M. The dynamics of national innovation systems…, *op. cit.*; Furman, J.L., Porter, M.E., Stern, S. The determinants of national innovative capacity…, *op. cit.*

30 Cohen, W.M., Levinthal, D.A. 1989. Innovation and Learning: The Two Faces of R&D. *The Economic Journal*, vol. 99.

the characteristics of human capital are described by means of indicators showing the level of education of the society of the given country[31] or the number of scientific research employees[32].

2. Main elements of innovation systems

The concept of the innovation system, although developed in parallel by at least a few researchers, derives from Lundvall who used this term for the first time in 1985[33] and referred it to the interaction between companies and institutions involved in the process of knowledge creation and Freeman[34]. In 1992 Lundvall also introduced the concept of the National Innovation System to the literature[35]. Nelson[36] and Edquist[37] also had a significant contribution to the development of this concept. Today, the term 'innovation system' is referred not only to a national scale – concepts such as regional innovation system[38], technological system[39] or sectoral innovation

[31] See, for example, Lall, S. Technological capabilities and industrialisation..., *op. cit.*; Archibugi, D., Coco, A. A new indicator of technological capabilities…, *op. cit.*; Fagerberg, J., Srholec, M., Knell, M. 2007. The competitiveness of nations: why some countries prosper while others fall behind. *World Development*, vol. 35 (10); Fagerberg, J., Srholec, M. National innovation systems, capabilities…, *op. cit.*,; Castellacci, F., Natera, J.M. The dynamics of national innovation systems…, *op. cit.*

[32] See, for example, Fagerberg, J., Verspagen, B. 1996. Heading for divergence? Regional growth in Europe reconsidered, *Journal of Common Market Studies*, vol. 34 (3); Furman, J.L., Hayes, R. Catching up or standing still…, *op. cit.*

[33] Lundvall, B.A. 1985. *Product innovation and user–producer interaction*. Aalborg University Press; Lundval, B.A. 1988. Innovation as an interactive process: from user-producer interaction to the national systems of innovation. In: Dosi, G., Freeman, Ch., Nelson, R., Silverberg, G., Soete, L. eds. *Technical change and economic theory*. London: Pinter.

[34] Freeman, C. 1987. *Technology policy and economic performance: lessons from Japan*. London: Pinter.

[35] Lundvall, B.A. ed. 1992. *National systems of innovation: towards a theory of innovation and interactive learning.* London: Pinter Publishing.

[36] Nelson, R.R. ed. 1993. *National innovation systems: a comparative analysis*. Oxford: Oxford University Press.

[37] Edquist, C. ed. 1997. *Systems of innovation: technologies, institutions and organisations*. London: Pinter.

[38] Cooke, P. 1992. Regional innovation systems: competitive regulation in the new Europe. *Geoforum*, vol. 23.

[39] Carlsson, B., Stankiewicz, R. 1991. On the nature, function and composition of technological systems. *Journal of Evolutionary Economics*, no. 1.

system[40] are already rooted in the economic literature, as well as in the language of official government documents.

Referring to the precursors of the concept of the innovation system, it can be defined as a system consisting of organisations which through their activities and resources affect the rate and direction of innovation processes, as well as of the interdependences and interactions between these organisations[41] or as a network of institutions in the public and private sectors whose activities and interactions imitate, import, modify and submit new technologies to a process of diffusion[42]. Thus, we speak clearly here about operators of a system whose activity determines the efficiency of its operation.

There are many visions of what specifically should be part of the innovation system but so far there has been no generally accepted agreement about how to define these components. Only in the framework of the Triple Helix[43], which can be considered as one of the concept of innovation systems, three groups of institutions are clearly distinguished: the business, science and government sectors. In this model, in contrast to the concepts of innovation systems where a central role in innovation processes is assigned to companies, the science sector plays a key role[44].

Another proposal of specifying components of which every innovation system is built was presented by Fischer. In his opinion, innovation systems, the purpose of which is to provide the conditions for conducting a full innovation process, should consist of four main groups of actors of the system[45]: (1) the manufacturing sector consisting of manufacturing companies and their research and development infrastructure, (2) the scientific sector, which in turn consists of two components: the education system, under which educational

---

40 Breschi, S. Malerba, F. 1997. Sectoral innovation systems: technological regimes, Schumpeterian dynamics, and spatial boundaries. In: Edquist, C. ed. *Systems of innovation: technologies, organisations, and institutions.* London: Pinter.

41 Lundvall, B. A. 2002. *Innovation, growth, and social cohesion: the Danish model.* Edward Elgar Publishing, p. 44.

42 Freeman, C. 1987. *Technology policy and economic performance: lesson from Japan.* London: Frances Pinter, p. 1.

43 Etzkowitz, H., Leydesdorff, L. 1995. The Triple Helix-university-industry-government relations: a laboratory for knowledge-based economic development. *EASST Review*, vol. 14.

44 Etzkowitz, H., Leydesdorff, L. 2000. The dynamics of innovation: from national systems and 'mode 2' to a Triple Helix of university-industry-government relations. *Research Policy*, vol. 29, p. 109.

45 Fischer, M.M. 2001. Innovation, knowledge creation and systems of innovation. *The Annals of Regional Science*, no. 35, pp. 207–209.

institutions and other training institutions operate, and the research system composed of universities and other research organisations, (3) the sector of production services, that is organisations offering assistance or specific services to companies in the process of creation and/or implementation of new products or processes[46], and (4) the institutional sector, that is formal and informal institutions which govern the relationships between the actors of the system, strengthen their potential for innovation, manage collaboration and eliminate emerging conflicts. Fischer's approach is, therefore, based on the characteristics of four main groups of entities in the innovation system. He directly took into account two of the three sectors, the relationships of which are the main element of the Triple Helix model – the corporate and science sectors. The government sector in Fischer is present both among the organisations of a scientific nature in the form of government organisations which finance and conduct research activity and offer educational services, as well as in the institutional sector, the task of which is to regulate relations between the remaining actors of the system, among others by constituting relevant regulations and laws.

Fischer's broad approach to building innovation systems, with the simultaneous placement of the main actors of the innovation processes in their centre, is similar to that adopted by the OECD. Here, too, there are four main groups of actors of the innovation system[47]: (1) companies with their capacities, (2) institutions supporting innovative activity, (3) the science system, (4) remaining research institutions. The attention is drawn here, among others, to the division of the scientific sector into the education system of learning (higher education, training, lifelong learning) and research institutions. Organisations of Fischer's so-called sector of manufacturing services are included here in the group of supporting institutions.

Doloreux presents a slightly different approach referring to the elements which make up the system of innovation at the regional level. According to the author, it is possible to differentiate four main elements of this system[48]: (1) companies, that is business entities taking responsibility for the generation and diffusion of knowledge and seen in different roles – as producers and users

---

46 A more accurate definition of this element of the innovation system would be 'a sector of support institutions for innovative activity'.

47 OECD. 1999. *Managing National Innovation Systems.* Paris: OECD, p. 23, cited in Box S. (OECD), *OECD work on innovation – a stocktaking of existing work*, Science and Technology Policy STI Working Paper 2009/2, p. 15.

48 Doloreux, D. 2002. What we should know about regional systems of innovation. *Technology in Society*, no. 24, pp. 247–248.

and collaborators and competitors, (2) institutions involved in research and development work in the industry, that is universities, government research institutions, etc., (3) knowledge infrastructure necessary to support innovative activities, namely research and development institutions, such as universities, research institutes or national laboratories but also science and technology parks, technological incubators and public agencies of technology transfer and innovation consultancy, etc., (4) innovation policy, which affects the whole system of innovation by ensuring an increase in its capability to learn and diffuse technology. Doloreux, like OECD experts, regards only formal institutions as construction elements of the innovation system: in the form of a companies responsible for the generation and diffusion of knowledge, which also, in her opinion, are the focal point of each system and institution engaged in research and development, regardless of the sector they come from (the science sector, the government and private institutions). Both elements are actually groups of the main actors of the innovation system and innovative processes occurring in it. The author mentions two more elements of the innovation system, namely the physical and organisational infrastructure of knowledge and innovation policy. It can be argued whether this approach is more accurate than the previously presented ones – whether the infrastructure of knowledge, by which the author understands physical and organisational resources at the disposal of institutions supporting innovative activity, should be analyzed separately or jointly with these institutions. The same is true in the case of innovation policy – the so-called government sector is engaged in the creation and management of the process of its implementation.

According to Carlsson and Stankiewicz, who worked in turn on the concept of technological innovation systems, the basic elements of such a system are[49]: (1) economic competences understood as the sum of a company's all capabilities to generate and use the emerging business opportunities, (2) clusters and networks, which are a form of a necessary interaction between the actors of the system with different competencies, (3) institutional infrastructure, that is a team of institutional solutions which indirectly or directly regulate the innovation processes and technology diffusion, and (4) development prospects (or development blocks) which generate development potential for the system. This approach is radically different from the ones analyzed above. Each of the elements of the innovation system enumerated by the authors belongs to a different category: economic competences refer to the

[49] Carlsson, B. Stankiewicz, R. On the nature, function and composition..., *op. cit.*, pp. 100–109.

specific capabilities of enterprises in the innovation process, clusters and networks – to relationships and connections between various actors created in the framework of the innovation system, institutional infrastructure – to physical and organisational resources at the disposal of institutions supporting innovative activity. The most difficult to grasp is the fourth of those elements of the innovation system – development prospects. It refers to the resultant of the simultaneous impact of all conditions on the outskirts of the innovation system and thus, among other things, to the macroeconomic and legal context, the conditions of the product market and production factors or the education and training system and the communication infrastructure conditioning the flow of information, mentioned by the aforementioned authors.

The most readable classifications of the elements of the innovation system are those proposed by Etzkowitz and Leydesdorff within the concept of the Triple Helix, Fischer and the OECD due to a single, subjective criterion adopted in this classification. Taking into account, following the concept of the 'Triple Helix', the three basic elements of the innovation system, namely (1) the business sector, (2) the science sector, and (3) the government sector appears to be a logical conclusion of the above conducted analysis of the structure of the innovation system, which does not exclude the fact that other elements may have a significant impact on the functioning of the system as a whole and thereby on the level of the economic development of the country. Here we should also mention the position of one of the creators of the Triple Helix model, L. Leydesdorff's, who in response to the emerging concepts of Quadruple Helix[50] or Quintuple Helix[51], notes that, in fact, he does not introduce any limit to the number of helices in the model. What is more, the variety of conditions which determine the level of economic development of countries, including those resulting from their potential to create innovative solutions, and so being of the main interest here, shows that in many economies taking into account the subsequent helices is a must

[50] Carayannis, E.G., Campbell, D.F.J. 2009. 'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, vol. 46 (3/4).

[51] Carayannis, E.G., Campbell, D.F.J. 2010. Triple Helix, Quadruple Helix and Quintuple Helix and how do knowledge, innovation and the environment relate to each other? A proposed framework for a trans-disciplinary analysis of sustainable development and social ecology. *International Journal of Social Ecology and Sustainable Development*, vol. 1 (1), cited in Carayannis, E.G., Barth, T.D., Campbell, D.F.J. 2012. The Quintuple Helix innovation model: global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*, vol. 1 (2).

– here his view is close to the approach in the concept of innovation systems. On the other hand, he warns that the introduction of more factors into the analysis of the model requires their exact specification, defining the manner of their measurement and the study of their actual role in the economy. The author thus emphasises the need of careful conduct if one wishes to move away from the simple 'Triple Helix' model to the model of 'N-helices'[52].

3. The method of research – the measurement of innovation capacities of European countries in the structure of main elements of innovation systems

The analysis method in this paper is based mainly on the construction of composite indicators within innovation capacities defined for three main elements of the innovation system singled out on basis of literature studies. In this respect, it is similar to the one used in the reports of the Innovation Union Scoreboard, except that the conducted comparative analysis applies to comparisons among countries and is carried out in the cross-section of variables characterizing them in terms of the potential to generate new technical solutions.

The selection of indicators was based on the analysis of literature, including the practices of measurement of national innovation capacity discussed at the end of Part 1 of this article. An important issue in the selection of indicators was the availability of data – unfortunately few of them can be obtained in the system of institutional sectors. Finally, data for three sectors: enterprises, higher education (which here represents the scientific-research sector) and government and three indicators were taken into account (Table 1). The number of patent applications per a million of residents shows the result of processes of creating new knowledge, while the share of R&D personnel in the total employment and expenditure on R&D are intended to show both the potential of the country to generate new knowledge and innovation and the ability to absorb knowledge and technology from outside. To assess the level of economic development of countries the indicator of GDP *per capita* was used.

[52] Leydesdorff, L. 2012. The Triple Helix, Quadruple Helix, …, and an N-Tuple of Helices: explanatory models for analyzing the knowledge-based economy? *Journal of Knowledge Economy*, vol. 3, pp. 32–33.

Statistical data were collected for 12 years (2002–2013), but the comparative analysis of aggregate indicators refers to two two-year periods: 2002–2003 and 2012–2013. The problem of incomplete data availability made it necessary to introduce certain corrections and substitutions. The previous practices for comparative analyzes between countries made it possible to define several ways of supplementing the missing data[53]. The method adopted in this paper is to replace the missing values of indicators with their value in the closest period, usually the preceding one (also in the absence of such data with the value from the next period). This method is used, among others, by the authors of the *Innovation Union Scoreboard*[54]. In the case of three indicators: P1, B1 and R1, the lack of data for the period after 2009 made it necessary to shift the analysis from 2002–2003 to 2000–2001 in the case of the initial period, and from 2012–2013 to 2008–2009 for the final period. The unavailability of some statistical data also made it necessary to reduce the analysis to 24 European countries[55]. Table A1 (Appendix) contains detailed information on the remaining data substitutions which constitute approximately 5.3% of all the indicators (23 substitutions).

Table 1

The indicators describing innovation capacities of countries and their definitions

Sector	No. of indicator	Definition of indicators
Enterprises	P1	Patent applications from the corporate sector to the European Patent Office at the national level per one million of inhabitants
	P2	R&D personnel of the corporate sector in % of total employment (full-time equivalent)
	P3	Total expenditure on R&D of the corporate sector in % of GDP

53 Freudenberg, M. 2003. *Composite indicators of country performance: a critical assessment*, OECD Science, Technology and Industry Working Papers, OECD Publishing, [Online] no. 16, p. 9. Available at: http://dx.doi.org/10.1787/405566708255 [Accessed: 30 March 2015].

54 Hollanders, H. El-Sadki, N. 2013. *Innovation Union Scoreboard 2013*, European Commission, Enterprise and Industry, p. 65.

55 The list of countries included in the analysis is contained in Appendix in Table A1.

Sector	No. of indicator	Definition of indicators
Scientific research (higher education)	B1	Patent applications from the higher education sector to the European Patent Office at the national level per one million of inhabitants
	B2	R&D personnel of the higher education sector in % of total employment (full-time equivalent)
	B3	Total expenditure on R&D of the higher education sector in % of GDP
Government	R1	Patent applications from the government sector to the European Patent Office at the national level per one million of inhabitants
	R2	R&D personnel of the government sector in % of total employment (full-time equivalent)
	R3	Total expenditure on R&D of the government sector in % of GDP

Source: own study based on information from the Eurostat on-line database: http://ec.europa.eu/eurostat/data/database [Accessed 1–24 March 2015] (Database by themes / Science and technology: Intellectual property rights / Patent / Patent applications to the European patent office (EPO) by priority year / Patent applications to the EPO by priority year at the national level / Patent applications to the EPO by priority year by institutional sector; Research and development / Statistics on research and development / R&D personnel at national and regional level / Total R&D personnel by sectors of performance, occupation and sex; Research and development / Statistics on research and development / R&D expenditure at national and regional level / Total intramural R&D expenditure (GERD) by sectors of performance).

Thanks to the collected statistical data, it was possible to calculate values of 9 variables for 24 countries and for both analyzed periods. They were calculated as the arithmetic average of values of the indicators for the two years[56]. In order to bring the values of variables to a form suitable for a comparative analysis in the form of collective indicators, including the examination of the relationship between them, it was necessary to standardise them. The standard deviation from the average is a method of the standardisation of the values of variables used in this study. The individual variables take here the value below or above 0, where 0 is the average value of standardised variables. The standardisation of the values of variables is carried out according to the formula:

[56] E.g. variable P1 for the period 2002–2003 is calculated as the arithmetic average of values of indicators describing it from the years 2002 and 2003.

$$nx_{tk} = \frac{x_{tk} - \overline{x_t}}{\sigma x_t}$$

where:
nx_{tk} – the standardised value of the variable x of the country k in the year t,
x_{tk} – the actual value of the variable x of the country k in the year t,
$\overline{x_t}$ – the arithmetic average of the value of the variable x in the year t,
σx_t – the standard deviation of the value of the variable x in the year t.

Composite indexes for each sector were calculated on the basis of the average of the three variables describing its innovation capability. Then, thus obtained values of composite indexes were compared with GDP *per capita* in the two analyzed periods.

4. The research results

The diversity of the results of individual countries in terms of national innovation capacity for which two sectors: enterprises and higher education are responsible shows a high correlation with differences in GDP *per capita* in these countries (Table 2). The analysis of the correlations also allows us to draw a conclusion that disproportions in the level of economic development are not connected with the diversity of results of individual countries in terms of innovation capacity represented by the activity of the government sector.

The conducted analysis also points to the consistent maintenance of the level of innovation capacity within individual sectors – the correlation coefficients between the values of composite indexes showing innovation capacities within the business, higher education and government sectors are high for both analyzed periods. Noteworthy is also a strong connection of the results obtained by individual countries within the measurement of innovation capacity in the business and higher education sectors – it attests to the fact that in countries where companies are highly active in the process of creating new knowledge and building the capacity to use knowledge and technology from outside, also the scientific research sector, represented by higher education, is characterised by similar results in this area.

From the analysis of the position of the observations in the coordinate system divided into three separate sectors we can draw similar conclusions – also here there is a strong link of the diversity of national innovation capacities represented by the activity of the business and higher education sectors with GDP *per capita* of individual countries and the lack of that link in the case of

the government sector for both analyzed periods (Figures 1–6). But here the difference in the nature of these links is clearly visible. While the relationship between the diversity of the level of economic development and innovation capacities of the higher education sector is clear linear (Figures 2 and 5), in the case of the corporate sector a nonlinear dependence can be observed. Higher values of composite indexes describing the innovation capacities built in the corporate sector above a certain level are not connected with higher scores in the sphere of income per capita (Figures 1 and 4).

Table 2

Linear correlations of composite indexes describing innovation capacities of countries on the sectoral basis, and GDP per capita

	P 02-03	B 02-03	R 02-03	P 12-13	B 12-13	R 12-13
P 02-03	1,0000					
B 02-03	0,7486	1,0000				
R 02-03	0,3872	0,1311	1,0000			
P 12-13	0,9472	0,6652	0,3952	1,0000		
B 12-13	0,6825	0,8031	-0,0273	0,7014	1,0000	
R 12-13	0,2245	0,0011	0,8398	0,2285	-0,2016	1,0000
GDP 02-03	0,7099	0,6813	0,1489	0,6793	0,7401	0,0386
GDP 12-13	0,7575	0,6892	0,1804	0,7342	0,7426	0,0575

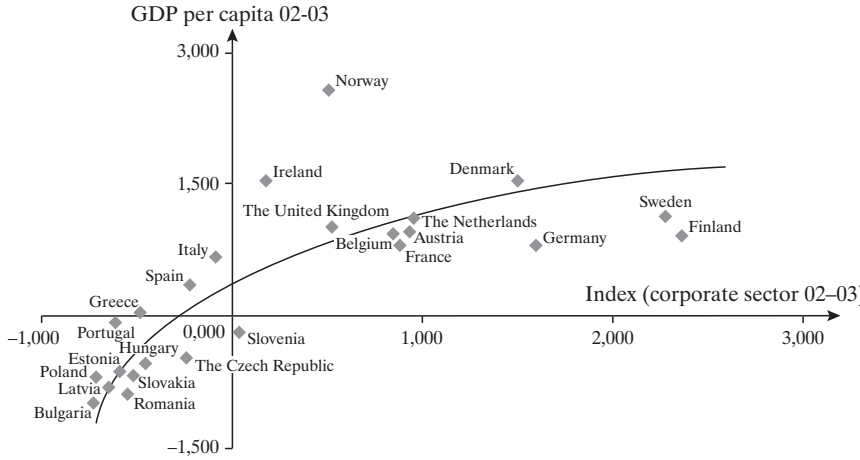
Source: own calculations based on the data from the source under Table 1.

The graphical interpretation of the analysis results also enables the ranking of individual countries depending on the obtained values of innovation capacity composite indexes and GDP *per capita*. In the first period of the analysis (2002-2003) countries of Central and Eastern Europe were generally characterised by the lowest level in terms of GDP *per capita* as well as of innovation capacity composite indexes of the corporate and higher education sectors, whereas countries of Western and Northern Europe fared the best in both respects. Countries of Southern Europe, especially Portugal and Greece, obtained similar results to the countries of Central and Eastern Europe. In the case of the analysis of composite indexes describing innovative capacity within the government sector and GDP *per capita* it is impossible to so easily distinguish groups of countries which share common characteristics, even though some developed countries reached high values of these indexes,

similar results were obtained by part of the countries of Central and Eastern Europe, including Bulgaria, characterised by the lowest level of GDP *per capita* among the analyzed economies (Figure 3).

Figure 1

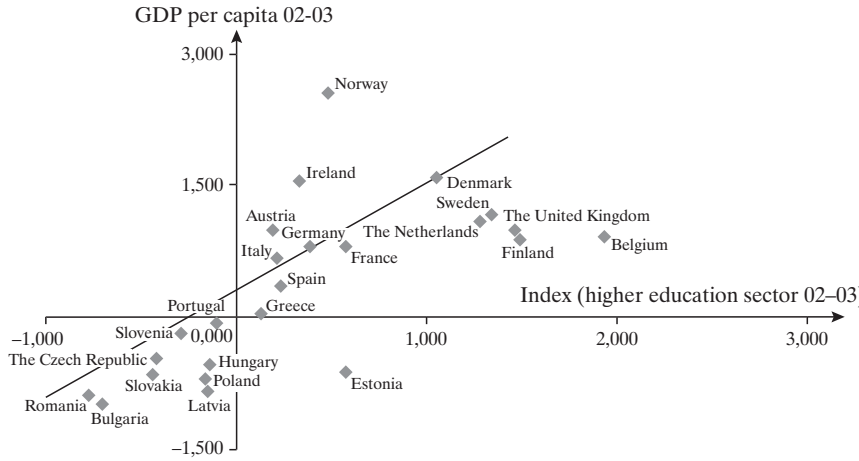
The value of the innovation capacity index of the corporate sector and GDP *per capita* for the period 2002–2003



Source: own study based on own calculations.

Figure 2

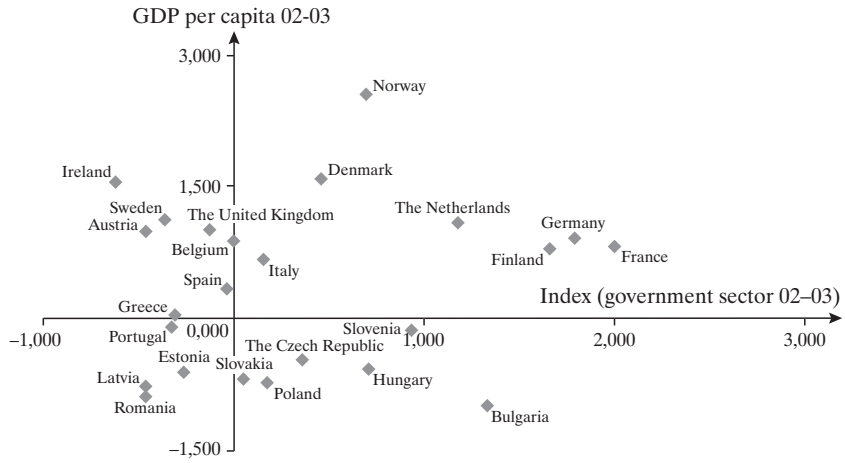
The value of the innovation capacity index of the higher education (scientific research) sector and GDP *per capita* for the period 2002–2003



Source: own study based on own calculations.

Figure 3

The value of the innovation capacity index of the government sector and GDP *per capita* for the period 2002–2003



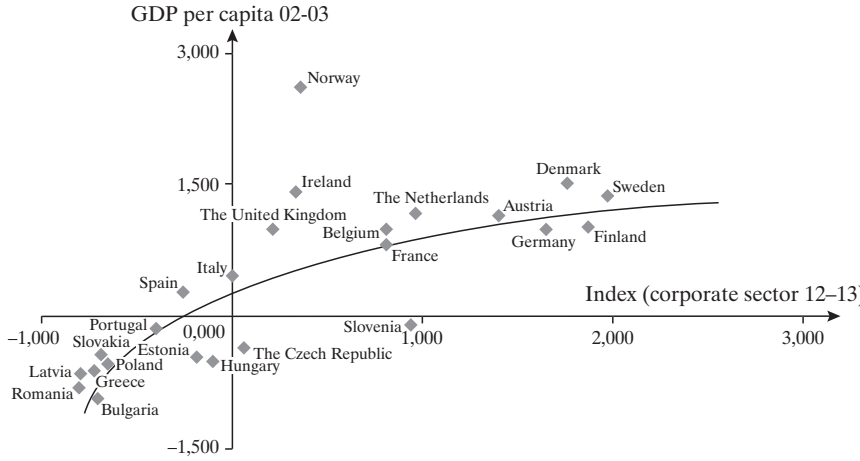
Source: own study based on own calculations.

The other period of the analysis (2012–2013) did not bring major changes either in the nature of relationships between the values of innovative capacity composite indexes or in the order of ranking of individual countries (Figures 4–6). Countries of Central and Eastern Europe, as a rule came at the end of the rankings, both in terms of the level of income per capita and innovation capacity on the sectoral basis, with the exception of the government sector. Countries of Western and Northern Europe maintained their high places, with visible small (except Denmark) shifts in the order of their ranking in the forefront.

In the case of the countries of Central and Eastern Europe, attention should be paid to two of them: Slovenia and the Czech Republic which showed relatively high improvement of their results in relation to the previous period in terms of the innovation capacity index values of the corporate sector, or as in the case of the Czech Republic – also the higher education sector (Figure 4). It should be acknowledged, however, that significant changes in the level of innovation capacity of individual economies across sectors did not appear in Europe within the 10 years.

Figure 4

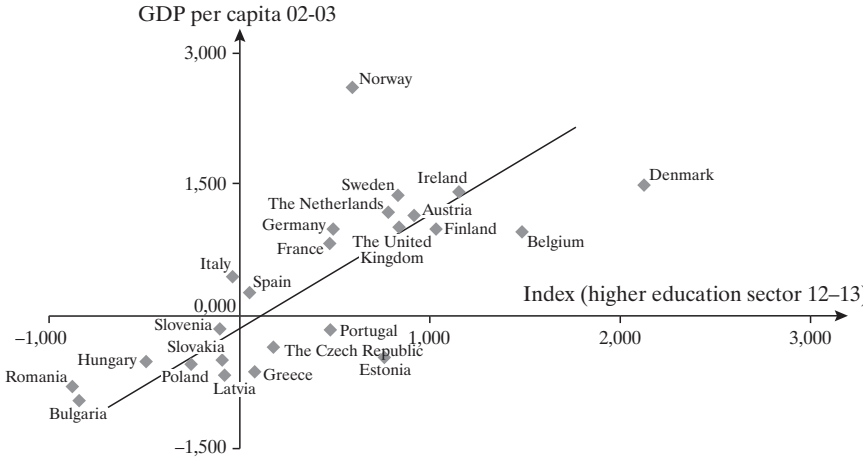
The value of the innovation capacity index of the corporate sector and GDP *per capita* for the period 2012–2013



Source: own study based on own calculations.

Figure 5

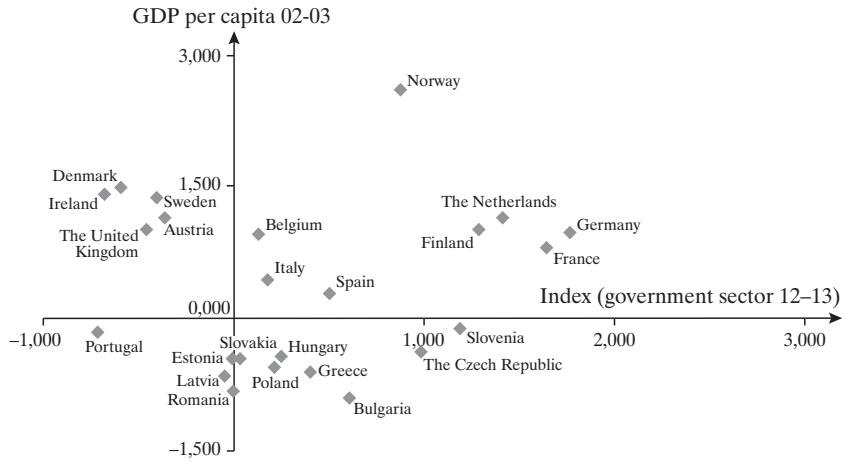
The value of the innovation capacity index of the higher education (scientific research) sector and GDP *per capita* for the period 2012–2013



Source: own study based on own calculations.

Figure 6.

The value of the innovation capacity index of the government sector and GDP *per capita* for the period 2012–2013



Source: own study based on own calculations.

CONCLUSIONS

The purpose of this article was to examine the importance of innovation capacity of European countries in the cross section of three sectors: enterprises, research (here represented by the higher education sector) and government from the point of view of their economic development. Thus, it aimed to verify the hypothesis that differences in the level of these capacities are related to the variation in GDP *per capita* in the examined European countries. The conducted analysis confirmed that the diversity of innovation capacities constituting the result of the activity of two sectors: business and higher education actually shows a connection with different levels of economic development of European countries. At the same time it revealed no such relation in the case of the government sector.

Attention was also paid to the diversity of the nature of the identified links in the case of innovation capacity within the business and higher education sectors. Whereas the relationship between different levels of innovation capacity of the latter and economic development had a clearly linear character, in the case of the corporate sector a nonlinear relationship could be observed. Higher values of composite indexes describing innovation

capacity built in the corporate sector above a certain level were not connected with higher levels of income per capita – this relationship was seen in both analyzed periods.

The research based on the collected statistical material lead to the statement that within these 10 years, namely between the two analyzed periods: 2002–2003 and 2012–2013, there were no significant changes on the map of Europe in terms of the countries which are innovation leaders characterised by the high level of innovation capacity in the corporate and higher education sectors, that is those which are important from the point of view of economic development. Countries of Central and Eastern Europe, including Poland, were generally characterised by low levels of both indicators describing the results of the processes of creating new knowledge and their ability to absorb new knowledge and technology from outside as well as GDP *per capita*.

Annex

Table A1

The list of European countries included in the analysis and substitution of data

Country	The substituted analysis period (year / period for which the data was adopted)	Number of the substituted indicator
Austria	2002–2003 (2002)	P2, P3, B3, R2, R3
Belgium		
Bulgaria	2008–2009 (2008)	B1
The Czech Republic		
Denmark		
Estonia	2000–2001 (2000) i 2008–2009 (2007)	R1
Finland		
France		
Greece	2002–2003 (2003)	B2, B3, R2, R3
Spain		
The Netherlands		
Ireland	2002–2003 (2002)	P3

Country	The substituted analysis period (year / period for which the data was adopted)	Number of the substituted indicator
Latvia	2000–2001 (B1 2000, R1 2002–2003), 2008–2009 (R1 2008)	B1, R1
Germany		
Norway		
Poland		
Portugal		
Romania	2000–2001 (2003) i 2008–2009 (2008)	R1
Slovakia		
Slovenia		
Sweden	2002–2003 (2003)	B2, B3, R2, R3
Hungary		
The UK	2002–2003 (2005–2006)	B2
Italy		

Source: own study

Table A2

Descriptive statistics of variables

No. of indicator	Average	Median	Standard deviation	Minimum	Maximum	Total
P1	73,22	34,26	87,35	0,13	258,30	1757,33
P2	0,448	0,368	0,333	0,055	1,195	10,750
P3	0,860	0,715	0,714	0,090	2,690	20,650
B1	1,367	0,498	2,238	0,026	10,016	32,815
B2	0,284	0,258	0,141	0,060	0,660	6,810
B3	0,340	0,325	0,195	0,050	0,790	8,170
R1	1,531	0,607	2,081	0,049	7,375	36,738
R2	0,140	0,128	0,067	0,050	0,315	3,355
R3	0,201	0,173	0,089	0,080	0,355	4,815
P1	71,35	46,48	77,40	1,06	235,72	1712,41
P2	0,587	0,565	0,373	0,095	1,270	14,090
P3	1,092	1,015	0,686	0,155	2,325	26,210

No. of indicator	Average	Median	Standard deviation	Minimum	Maximum	Total
B1	2,943	1,453	3,808	0,016	14,684	70,621
B2	0,367	0,365	0,137	0,095	0,690	8,800
B3	0,455	0,450	0,232	0,055	0,965	10,915
R1	2,215	0,884	3,672	0,045	14,102	53,171
R2	0,148	0,140	0,075	0,040	0,275	3,550
R3	0,207	0,193	0,087	0,070	0,420	4,975

Source: own calculations based on the data from the source under Table 1.

References

Abramovitz, M. 1986. Catching-up, forging ahead and falling behind. *Journal of Economic History*, vol. 46.

Abramovitz, M. 1994. The origins of the postwar catch-up and convergence boom. In: Fagerberg, J., Verspagen, B., von Tunzelmann, N. eds. *The dynamics of technology, trade and growth.* Aldershot: Edward Elgar.

Acs, Z.J., Anselin, L., Varga, A. 2002. Patents and innovation counts as measures of regional production of new knowledge. *Research Policy*, vol. 31.

Archibugi, D., Coco, A. 2004. A new indicator of technological capabilities for developed and developing countries (ArCo). *World Development*, vol. 32, no. 4.

Benhabib, J., Spiegel, M. 1994. The role of human capital in economic development: evidence from aggregate cross-country data. *Journal of Monetary Economics*, vol. 34.

Breschi S., Malerba, F. 1997. Sectoral innovation systems: technological regimes, Schumpeterian dynamics, and spatial boundaries. In: Edquist C. ed. *Systems of innovation: technologies, organisations, and institutions.* London: Pinter.

Freeman, C. 1987. *Technology policy and economic performance: lessons from Japan*. London: Pinter.

Carayannis, E.G., Campbell, D.F.J. 2009. 'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, vol. 46 (3/4).

Carayannis, E.G., Campbell, D.F.J. 2010. Triple Helix, Quadruple Helix and Quintuple Helix and how do knowledge, innovation and the environment

relate to each other? A proposed framework for a trans-disciplinary analysis of sustainable development and social ecology. *International Journal of Social Ecology and Sustainable Development*, vol. 1 (1), cited in Carayannis, E.G., Barth, T.D., Campbell, D.F.J. 2012. The Quintuple Helix innovation model: global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*, vol. 1 (2).

Carlsson, B., Stankiewicz, R. 1991. On the nature, function and composition of technological systems. *Journal of Evolutionary Economics,* no.1.

Castellacci, F., Natera, J.M. 2013. The dynamics of national innovation systems: A panel cointegration analysis of the coevolution between innovative capability and absorptive capacity. *Research Policy*, vol. 42.

Cohen, W.M., Levinthal, D.A. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, vol. 35**.**

Cohen, W.M., Levinthal, D.A. 1989. Innovation and Learning: The Two Faces of R&D. *The Economic Journal*, vol. 99.

Cooke, P. 1992. Regional innovation systems: competitive regulation in the new Europe. *Geoforum*, vol. 23.

Doloreux, D. 2002. What we should know about regional systems of innovation. *Technology in Society* no. 24.

Edquist C. ed. 1997. *Systems of innovation: technologies, institutions and organisations.* London: Pinter.

Etzkowitz, H., Leydesdorff, L. 2000. The dynamics of innovation: from national systems and 'Mode 2' to a Triple Helix of university-industry-government relations. *Research Policy*, vol. 29.

Etzkowitz, H., Leydesdorff, L. 1995. The Triple Helix-university-industry--government relations: a laboratory for knowledge-based economic development. *EASST Review*, vol. 14.

Faber, J., Hesen, A.B. 2004. Innovation capabilities of European nations. Cross-national analyses of patents and sales of product innovations. *Research Policy*, vol. 33.

Fagerberg, J., Srholec, M., Knell, M. 2007. The competitiveness of nations: why some countries prosper while others fall behind. *World Development*, vol. 35.

Fagerberg, J., Srholec, M. 2013. Knowledge, capabilities and the poverty trap: the complex interplay between technological, social and geographical factors In: Meusburger, P., Glückler, J., el Meskioui, M. eds. *Knowledge and the economy*. Springer.

Fagerberg, J., Srholec, M. 2008. National innovation systems, capabilities and economic development. *Research Policy*, vol. 37, p. 1419.

Fagerberg, J., Verspagen, B. 1996. Heading for divergence? Regional Growth in Europe reconsidered. *Journal of Common Market Studies*, vol. 34 (3).

Fagerberg, J., Verspagen, B. 2003. Innovation, growth and economic development: why some countries succeed and others don't. The article prepared for First GLOBELICS Conference: Innovation Systems and Development Strategies for the Third Millennium. Rio, 2–6 November, 2003.

Fagerberg, J., Verspagen, B. 2002. Technology-gaps, innovation-diffusion and transformation: an evolutionary interpretation. *Research Policy*, vol. 31.

Fischer, M.M. 2001. Innovation, knowledge creation and systems of innovation. *The Annals of Regional Science,* no. 35.

Freeman, C. 1987. *Technology policy and economic performance: lessons from Japan*. London: Pinter.

Freudenberg, M. 2003. *Composite indicators of country performance: a critical assessme*nt, OECD Science, Technology and Industry Working Papers, OECD Publishing, no. 16.

Fung, M.K., Chow, W. W. 2002. Measuring the intensity of knowledge flow with patent statistics. *Economics Letters*, vol. 74.

Furman, J.L., Hayes, R. 2004. Catching up or standing still? National innovative productivity among 'follower' countries, 1978–1999. *Research Policy,* vol. 33.

Furman, J.L., Porter, M.E., Stern, S. 2002. The determinants of national innovative capacity. *Research Policy*, vol. 31, p. 900.

Hollanders, H. El-Sadki, N. 2013. *Innovation Union Scoreboard 2013*, European Commission, Enterprise and Industry. [Online] Available at: http://dx.doi.org/10.1787/405566708255 [Accessed: 30 March 2015].

Jaffe, A.B., Trajtenberg, M., Henderson, R. 1993. Geographic localisation of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics*, vol. 108 (3).

Keller, W. 1996. Absorptive capacity: On the creation and acquisition of technology in development. *Journal of Development Economics*, vol. 49.

Kim, L. 1997. *Imitation to innovation: The dynamics of Korea's technological learning*, Harvard: Harvard Business School Press, p. 4 cited in: Fagerberg, J., Srholec, M. 2008. National innovation systems, capabilities and economic development. *Research Policy*, vol. 37.

Lall, S. 1992. Technological capabilities and industrialisation. *World Development*, vol. 20, no. 2, p. 170.

Leydesdorff, L. 2012. The Triple Helix, Quadruple Helix, …, and an N-Tuple of Helices: explanatory models for analyzing the knowledge-based economy? *Journal of Knowledge Economy*, vol. 3, pp. 32–33.

Lundvall, B.A. ed. 1992. *National systems of innovation: towards a theory of innovation and interactive learning.* London: Pinter Publishing.

Lundvall, B.A. 2002. *Innovation, growth, and social cohesion: the Danish model.* Edward Elgar Publishing.

Lundval, B.A. 1988. *Innovation as an interactive process: from user-producer interaction to the national systems of innovation.* In: Dosi, G., Freeman, Ch., Nelson, R., Silverberg, G., Soete, L. (eds.) *Technical change and economic theory*. London: Pinter.

Lundvall, B.A. 1985. *Product innovation and user-producer interaction*. Aalborg University Press.

Nelson, R.R. ed. 1993. *National innovation systems: a comparative analysis*. Oxford: Oxford University Press.

No, H.J., An, Y., Park, Y. 2014. A structured approach to explore knowledge flows through technology-based business methods by integrating patent citation analysis and text mining. *Technological Forecasting & Social Change*. [Online] Available at: http://dx.doi.org/10.1016/j.techfore.2014.04.007.

OECD. 1999. *Managing National Innovation Systems,* Paris: OECD, p. 23, cited in Box S. (OECD), *OECD work on innovation – a stocktaking of existing work*, Science and Technology Policy STI Working Paper 2009/2.

Pakes, A., Griliches, Z. 1980. Patents and R&D at the firm level: a first report. *Economics Letters*, vol. 5.

Papageorgiou, C. 2002. Technology adoption, human capital and growth theory. *Review of Development Economics*, vol. 6.

Park, G., Park, Y. 2006. On the measurement of patent stock as knowledge indicators. *Technological Forecasting & Social Change*, vol. 73.

Stokke, H. 2008. Productivity growth and organisational learning. *Review of Development Economics*, vol. 12 (4).

Verspagen, B. 1991. A new empirical approach to catching up or falling behind. *Structural Change and Economic Dynamics*, vol. 2 (2).

Innovative capacity and innovation systems and the economic development levels of European countries

Summary

The paper aims to study the relationship between differences in national innovation capabilities within three sectors, which are the main building blocks of an innovation system, and country variations in GDP *per capita*. Research in this area has previously focused mostly on the impact of differently defined innovation capabilities on the level of economic development of countries, neglecting innovation system sectors approach. The analysis conducted for this paper has allowed do confirm that there is a positive relationship between country variations in innovation capabilities within two of the sectors: enterprise sector and higher education sector, and national differences in GDP *per capita*. While the relationship between differences in innovation capabilities within the latter sector is linear in character, the interdependence between country variations in enterprise sector innovation capabilities and economic development are evidently non-linear. Values of composite indexes calculated for the enterprise sector innovation capabilities above a certain level have not been accompanied by corresponding higher values of GDP *per capita* – this relationship has been evident in both analysed periods. The study based on gathered statistical information has also allowed to conclude that during 10 years between 2002–2003 and 2012–2013 there have not been observed any significant changes on the Europe's map of innovation leaders.

Zdolności innowacyjne w przekroju głównych elementów systemu innowacji a poziom rozwoju gospodarczego krajów europejskich

Streszczenie

Przedmiotem artykułu jest zbadanie zależności pomiędzy zróżnicowaniem poziomu zdolności innowacyjnych gospodarek europejskich w układzie trzech sektorów stanowiących główne elementy systemu innowacji oraz zróżnicowaniem wartości PKB *per capita*. Do tej pory badania w tym zakresie koncentrowały się na podejściu przedmiotowym i realizowane były w przekroju różnie definiowanych zdolności innowacyjnych, podczas gdy niewiele miejsca poświę-

cono znaczeniu aktywności innowacyjnej głównych grup podmiotów systemów innowacji z punktu widzenia poziomu rozwoju gospodarek poszczególnych krajów. Przeprowadzona analiza pozwoliła potwierdzić, że zróżnicowanie zdolności innowacyjnych stanowiących rezultat aktywności jedynie dwóch sektorów: przedsiębiorstw i szkolnictwa wyższego, wykazuje powiązanie ze zróżnicowaniem poziomu PKB *per capita* krajów europejskich. Podczas, gdy zależność pomiędzy zróżnicowaniem poziomu zdolności innowacyjnych tego ostatniego oraz rozwoju gospodarczego miała charakter wyraźnie liniowy, w przypadku sektora przedsiębiorstw można było zaobserwować zależność nieliniową. Wartości złożonych indeksów opisujących zdolności innowacyjne budowane w sektorze przedsiębiorstw powyżej pewnego poziomu nie były powiązane z wyższym poziomem dochodu na mieszkańca – zależność ta była widoczna w obu analizowanych okresach. Badanie w oparciu o zgromadzony materiał statystyczny pozwoliło również na stwierdzenie, że w ciągu 10 lat, a mianowicie pomiędzy dwoma analizowanymi okresami: 2002–2003 oraz 2012–2013, nie nastąpiły żadne istotne zmiany na mapie Europy pod względem krajów liderów innowacyjnych.

Инновационный потенциал в разрезе главных элементов системы инновации и уровень экономического развития европейских государств

Резюме

Предметом статьи является анализ зависимости между дифференцированием уровня инновационного потенциала экономики европейских государств в системе трёх секторов, представляющих собой основные элементы системы инновации, и дифференцированием стоимости отечественного ВП (валового продукта) *per capita*. До этого времени исследования в данной области были сконцентрированы на мериторическом подходе и реализовались в разрезе различным образом определяемого инновационного потенциала, тогда как недостаточно внимания обращалось на значение инновационной активности основных групп субъектов инновационных систем с точки зрения уровня развития экономики отдельных государств. Проведённый анализ позволяет утверждать, что дифференцирование инновационного потенциала, представляющего собой результат активности только двух секторов: предпринимательского и высшего образования, выявляет связь с дифференцированием

уровня отечественного ВП *per capita* европейских государств. В то время как зависимость между дифференцированием уровня инновационного потенциала последнего, а также экономического развития, имела явно линейный характер, в случае предпринимательского сектора можно было наблюдать нелинейную зависимость. Показатели сводных индексов, описывающих инновационный потенциал, сформированные в предпринимательском секторе выше определённого уровня, сопряжены с более высоким уровнем дохода на душу населения – данная зависимость была заметна в обоих анализируемых периодах. Исследование, основанное на накопленном статистическом материале, позволяет также утверждать, что в течение десяти лет, а именно между двумя анализируемыми периодами: 2002–2003 и 2012–2013, не произошло никаких существенных изменений на карте Европы в отношении государств – инновационных лидеров.